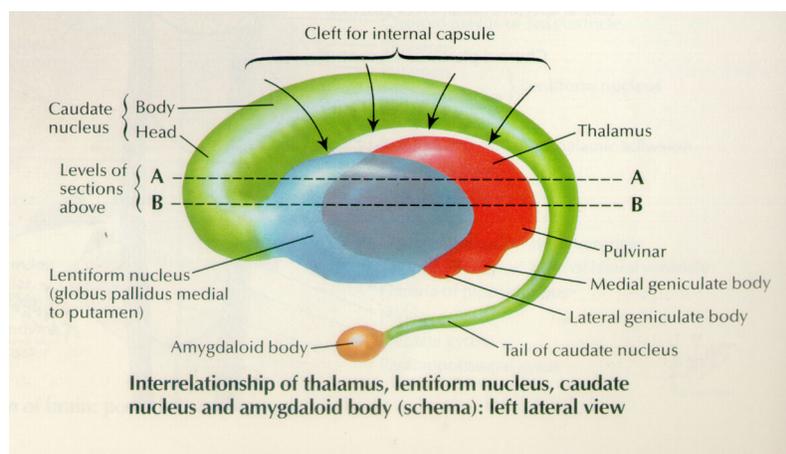


## Caudate Tracing Guidelines

### Introduction:

Situated adjacent and lateral to each lateral ventricle, the caudates on either side of the brain were first visible caudal to first visualization of the genu of the corpus callosum and the anterior horn of the lateral ventricle. For the purposes of this study (and, as coronal sections were used) caudates were not divided into their head/body/tail regions, but were traced on both sides, slice by slice, as single structures.



This diagram taken from Netter's *Atlas of Human Anatomy* demonstrates the 3-D structure of the basal ganglia. Notice how the caudate nucleus follows the exact curve of the lateral ventricle (Netter 104).

In his *Core Text of Neuroanatomy*, Carpenter provides an excellent description of the caudate nucleus:

The caudate nucleus is an elongated, arched grey mass related throughout its extent to the surface of the lateral ventricle. Its enlarged anterior portion, or head, lies rostral to the thalamus and bulges into the anterior horn of the ventricle. The head of the caudate nucleus and the putamen are separated by fibers of the anterior limb of the internal capsule, except rostroventrally where continuity is maintained. The body of the caudate nucleus extends along the dorsolateral border of the thalamus, from which it is separated by the stria terminalis and the terminal vein. This part of the caudate nucleus is regarded as supratthalamic. The tail of the caudate nucleus is the attenuated caudal portion that sweeps into the temporal lobe in the roof of the inferior horn of the lateral ventricle and comes into relationship with the central nucleus of the amygdaloid complex (Carpenter 327).

## Boundaries:

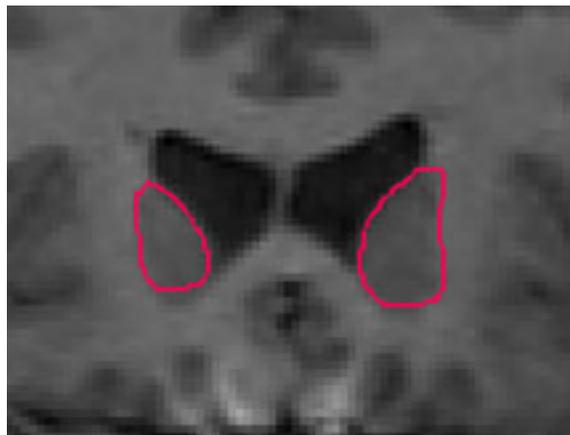
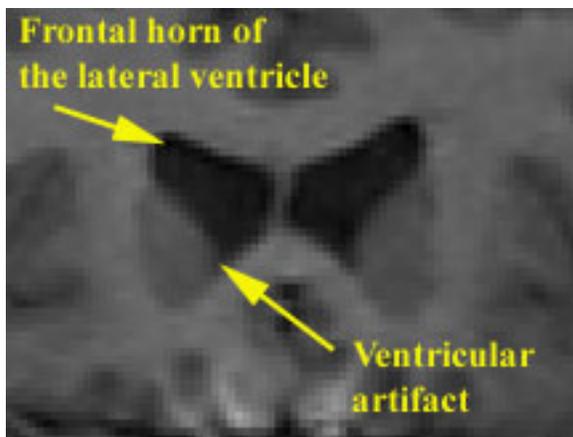
Beginning rostrally and ending caudally, the following guidelines were established:

- i. Care was taken not to include cerebrospinal fluid or meningeal artifacts on the medial aspect of each caudate.
- ii. The nucleus accumbens (abutting on the ventral aspect of the caudate and forming a bridge of tissue between the former and the lenticular nucleus, and first visualized with appearance of the putamen) was carefully excluded by attempting to differentiate between it and the caudate by comparing the different pixel intensities of the two structures. Appearing in the position formerly occupied by the nucleus accumbens (but in caudal traces, when the nucleus accumbens is no longer visible) the stria terminalis and terminal vein were noted and excluded in the same manner as the former.
- iii. Having described the medial (i) and ventral (ii) delineations of the caudate, the lateral delineation (the anterior, then -- caudally – posterior limb of the internal capsule) was somewhat easier to identify due to its distinctly lighter colored appearance. Lateral projections of caudate tissue (projecting towards and sometimes abutting on the putamen) were included in the traces.
- iv. The dorsal aspect of the caudate, surrounded by white matter has no adjoining structures that may be confused with it.
- v. The tail of the caudate was judged as terminating when it could no longer be clearly seen, not due to a cut off point determined by the appearance of another structure e.g. the velum interpositum or the posterior commissure.

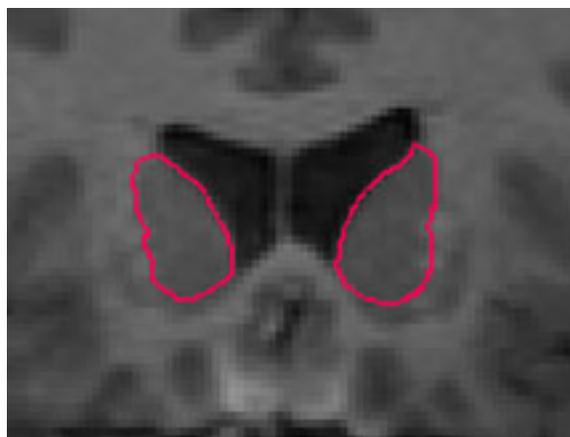
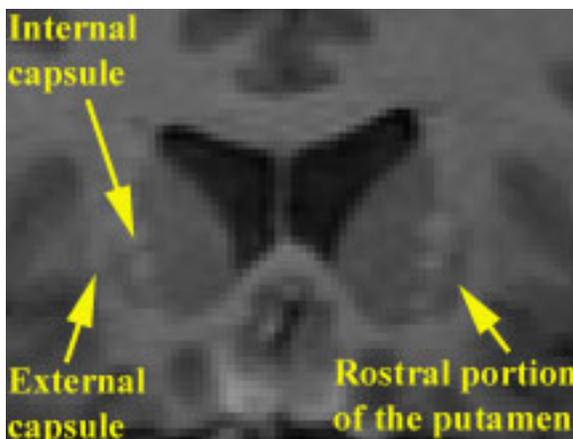
## Figures:

The figures that follow provide examples of the caudate as seen on the T1-weighted image. Appearing in pairs, these figures help to demonstrate the shape of the caudate. The first figure represents examples of important anatomical landmarks, while the second figure illustrates the boundaries of the caudate as it was traced in the coronal plane.

The caudate is first seen on coronal section separated from the claustrum by the white matter of the external capsule (Duvernoy 89). The caudate bulges into the frontal horn of the lateral ventricle which serves as its medial border.

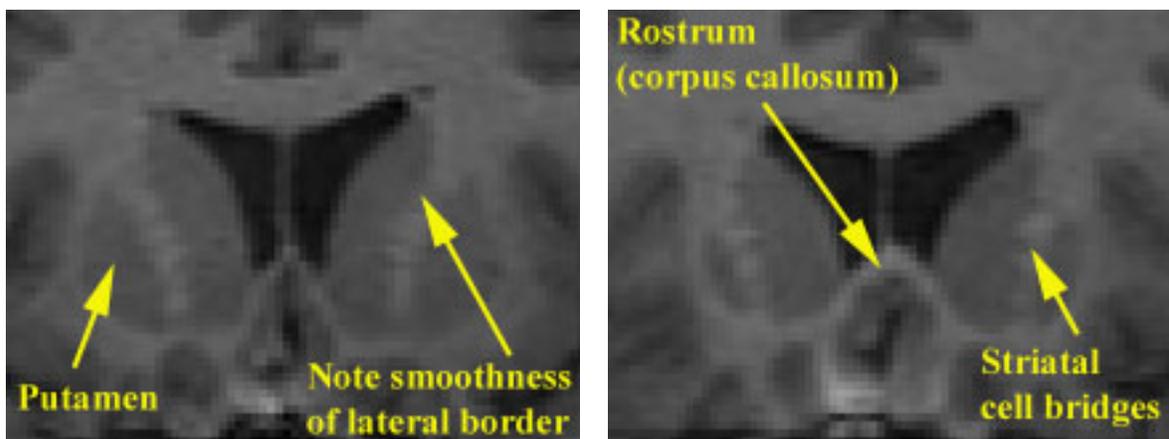


As one moves in a posterior fashion, the rostral portion of the putamen can be seen (Duvernoy 91). At this level, the putamen serves as a landmark. The white matter lateral to the putamen and medial to the claustrum is designated as the external capsule. White matter found medial to the putamen and lateral to the caudate nucleus is the internal capsule.

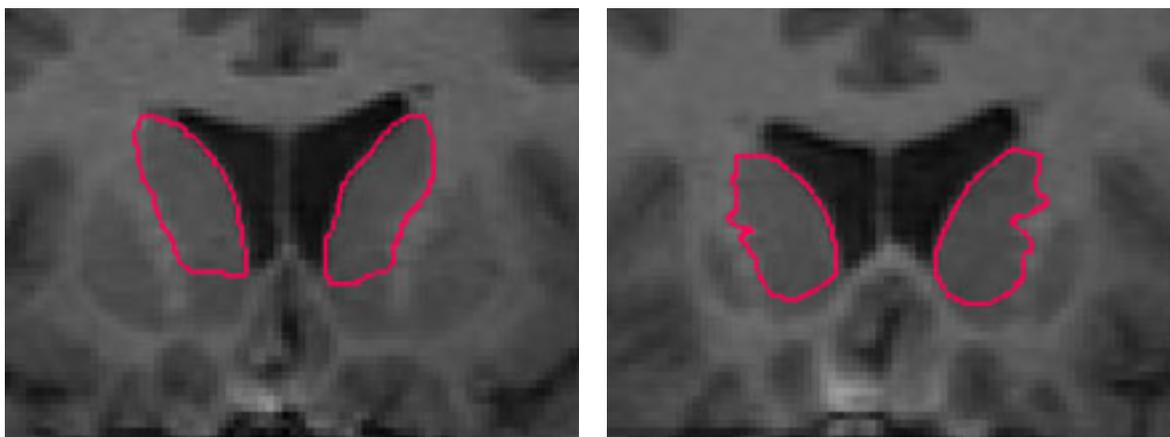


Moving posteriorly the previously well defined boundaries of the caudate, the putamen and the internal capsule become obscured by interconnections between the caudate and the putamen. The figures below illustrate the striatal cell bridges that exist between the caudate and putamen. In his *Neuroanatomy: Text and Atlas*, Martin remarks:

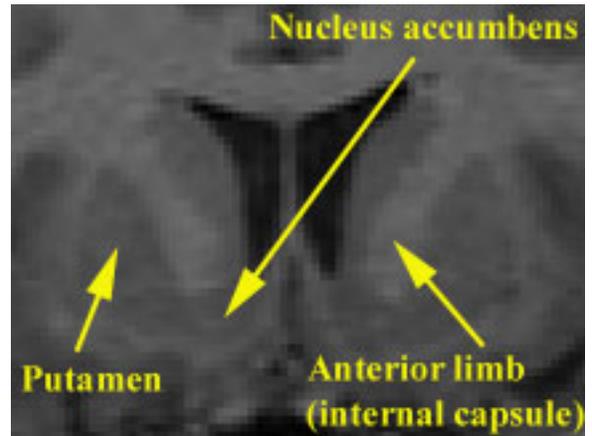
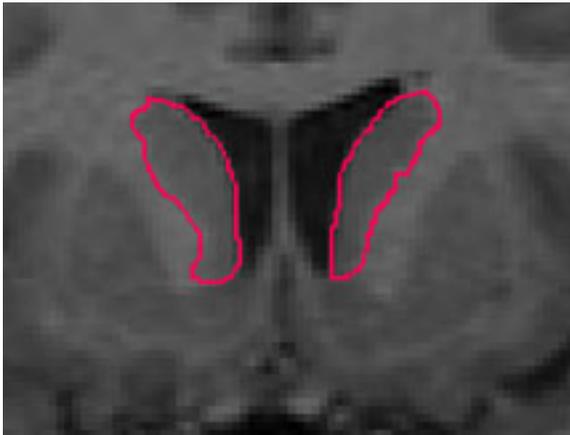
A coronal slice through the anterior limb of the internal capsule reveals three components of the striatum: (1) caudate (at this level, the head of the caudate nucleus), (2) putamen, and (3) nucleus accumbens. Although the internal capsule courses between the caudate nucleus and the putamen, striatal cell bridges connect the two structures. The cell bridges are a reminder that, in the developing brain, axons coursing to and from the cortex divide the group of immature neurons in the floor of the lateral ventricle that give rise to the striatum (Martin 278).



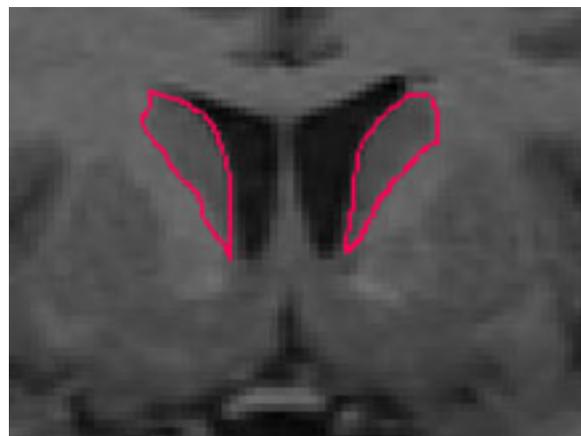
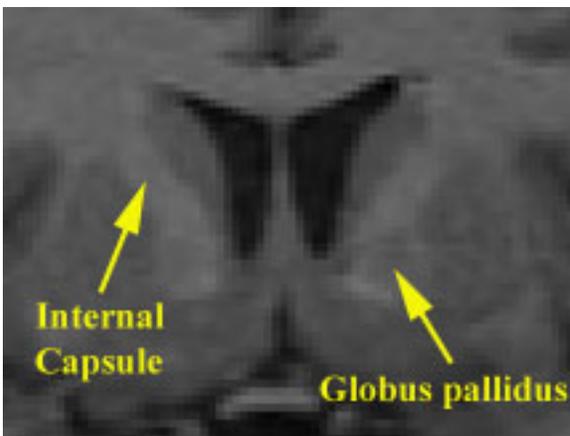
These striatal cell bridges are included in the caudate trace when they extend more than three pixels from the previously smooth border of the caudate, thus making their borders visible on MRI (Duvernoy 93).

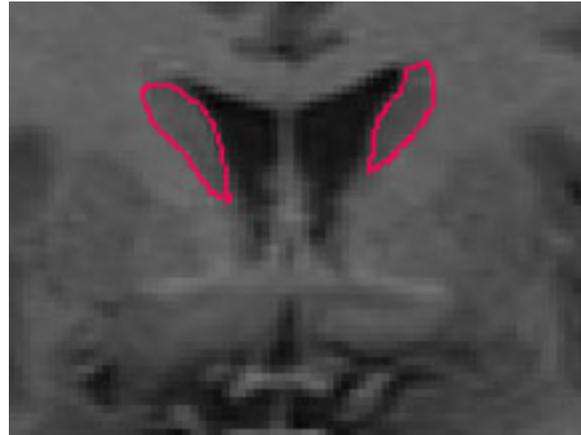
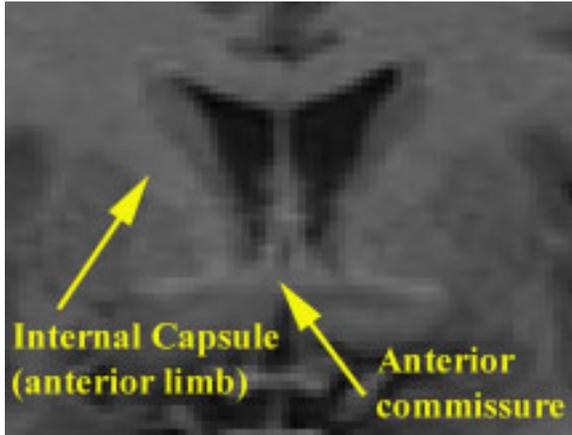


As the putamen comes into view in the coronal plane it is separated from the caudate nucleus by the anterior limb of the internal capsule. At this level, the nucleus accumbens “connects” the putamen and the caudate at their inferior poles (Duvernoy 95).



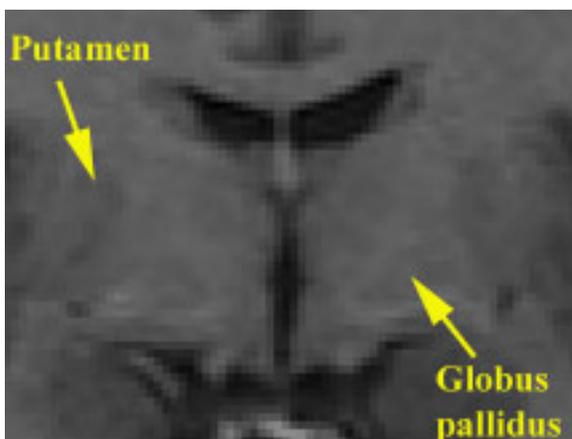
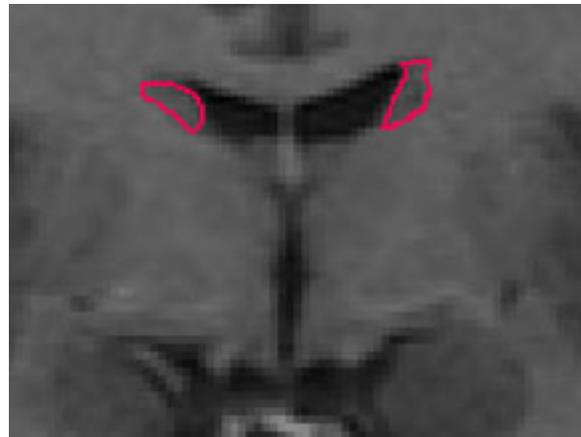
The putamen and the nucleus accumbens persist coronally until one passes beyond the level of the nucleus accumbens. It is at this level that the globus pallidus is first seen, beginning with its pars lateralis and progressing to include its pars medialis (Duvernoy 105).



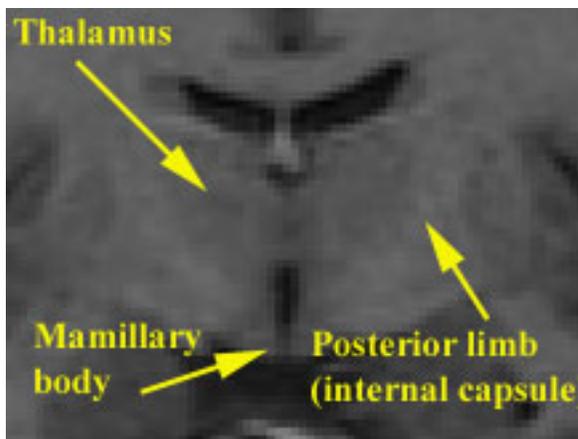
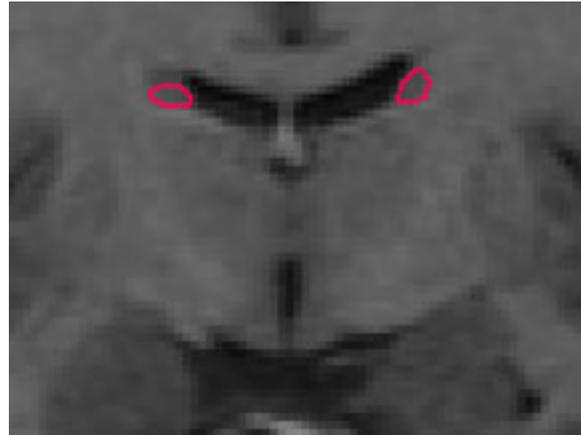


Anterior to the appearance of the pars medialis in the coronal plane, the anterior commissure emerges. Moving posteriorly it forms its perfect arch and then retreats from the midline allowing for visualization of the pars medialis (Duvernoy 107-111).

With the disappearance of the anterior commissure, the genu of the internal capsule comes into full view, separating the caudate from its neighboring putamen and globus pallidus (Duvernoy 112).

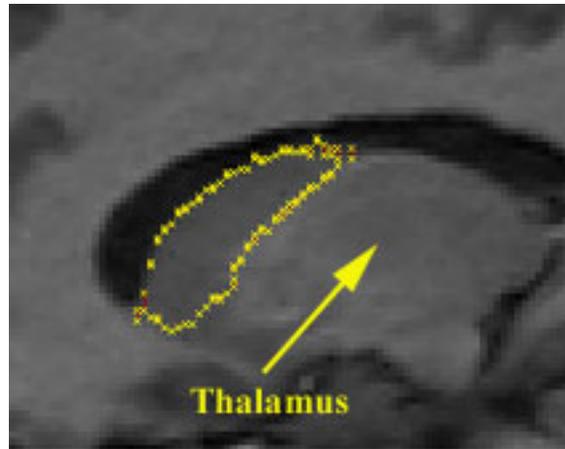
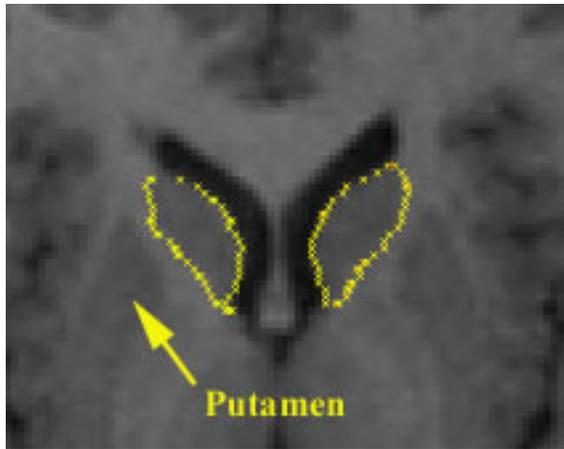


As the caudates begins to diminish coronally, the mamillary bodies and the thalamus come into view. With the appearance of thalamus, the posterior limb of the internal capsule can now be identified separating the caudate and the thalamus from the lenticular nucleus (Duvernoy 121).



The body of the caudate continues on for several slices, running posteriorly with the substantia nigra and the nucleus rubor, as well as the medial and lateral geniculate bodies of the thalamus. (Duvernoy 123-143). Although visualization of the caudate on histological sectioning concinues beyond the level of the thalamus, tracing of the caudate nucleus on MRI terminates prior to the disappearance of the pulvinar nucleus (Duvernoy 146).

The figures below demonstrate the capability of BRAINS2 to “telegraph” ROIs (regions of interest) created in the Z plane to both the Y and X planes, respectively. The diagram on the left allows for visualization of the caudate trace in the axial plane, whereas that on the right allows for visualization in the sagittal plane. Note how the outline of the caudate produced by the coronal ROI’s appears to give it different shapes in different planes while the three-dimensional borders of the caudate remain unchanged.



## Works Cited

Carpenter, Malcolm B. Core Text of Neuroanatomy. Baltimore: Williams & Wilkins, 1991.

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Martin, John H. Neuroanatomy: Text and Atlas. New York: Elsevier Publishing Co., Inc., 1989.

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