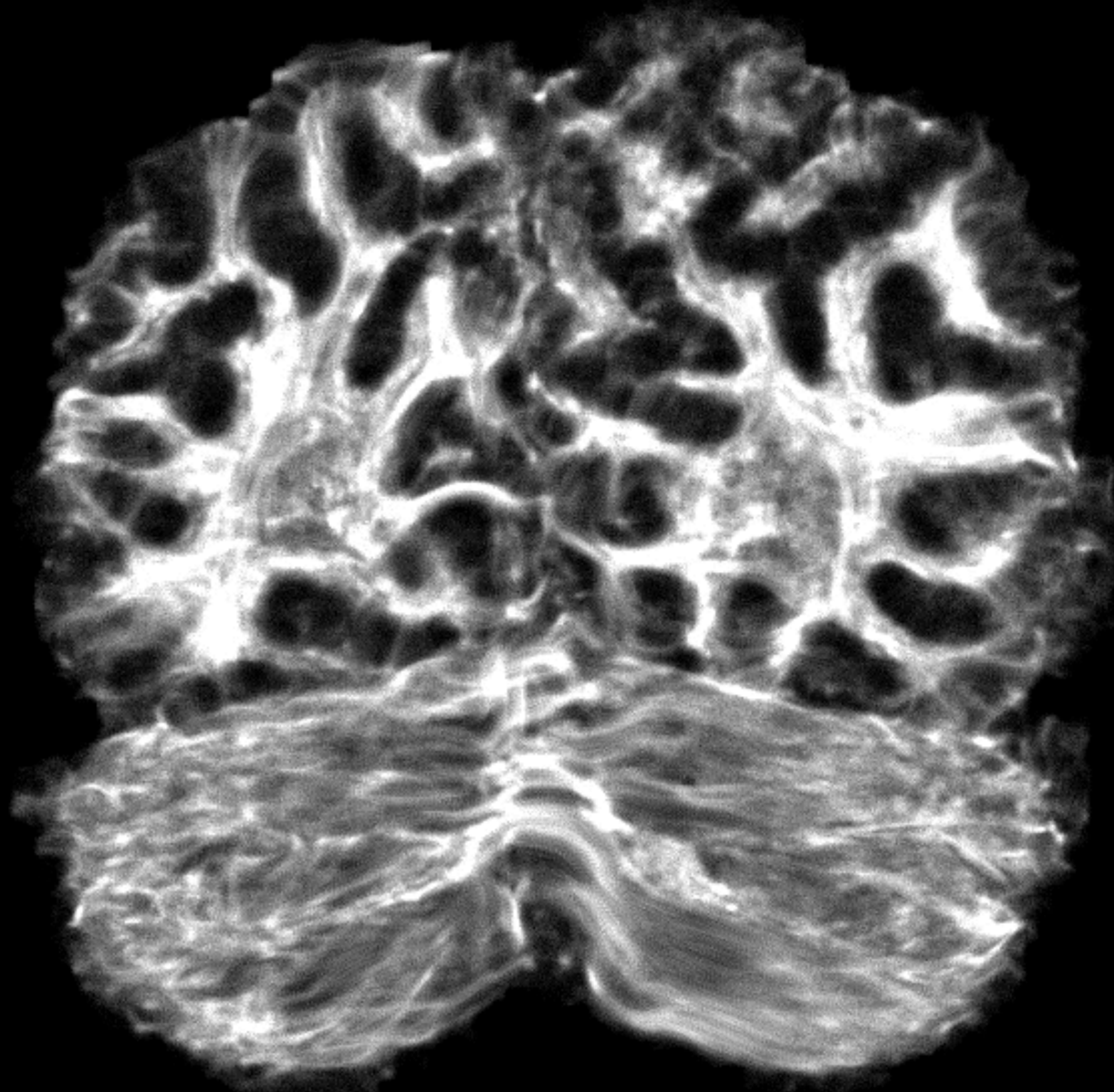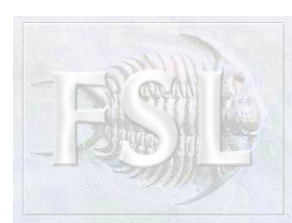Tract-Density Imaging
*[Calamante NeuroImage 2010]*

Single HCP subject
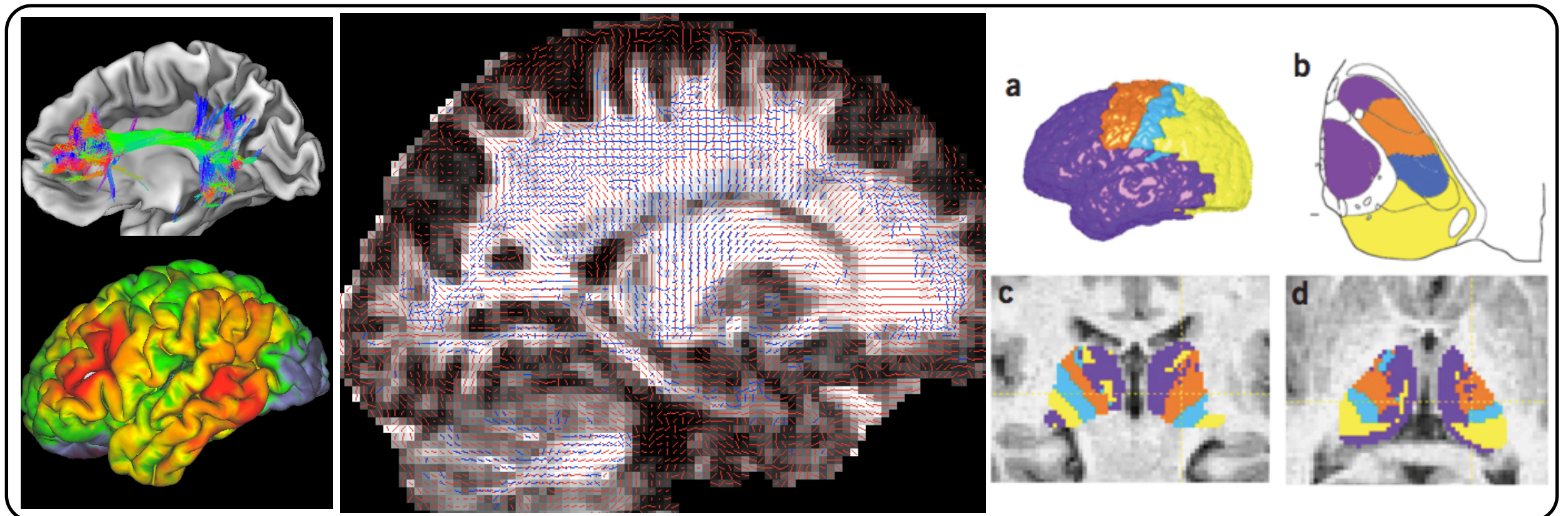TDI @ 0.2mm

# Diffusion Tractography

- Goal of tractography
- Estimating Fibre Orientations - BEDPOSTX
- Probabilistic Tractography - PROBTRACKX
- ProbtrackX outputs
- Tractography limitations

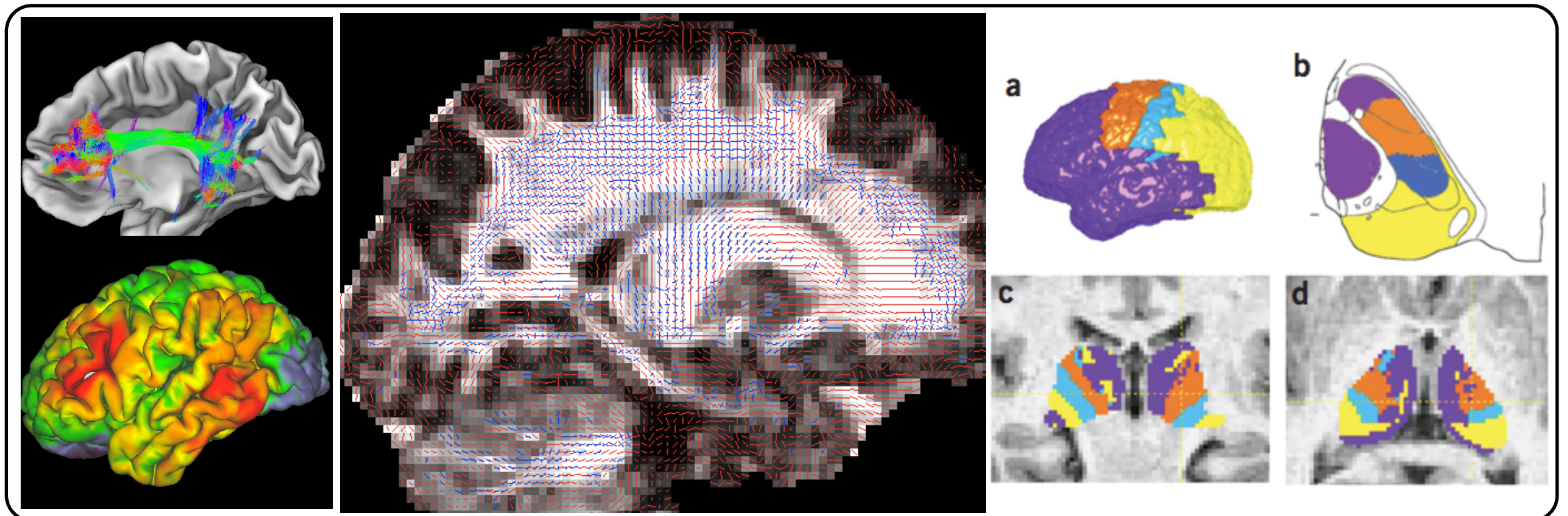# Diffusion Tractography

- **Goal of tractography**
- Estimating Fibre Orientations - BEDPOSTX
- Probabilistic Tractography - PROBTRACKX
- ProbtrackX outputs
- Tractography limitations
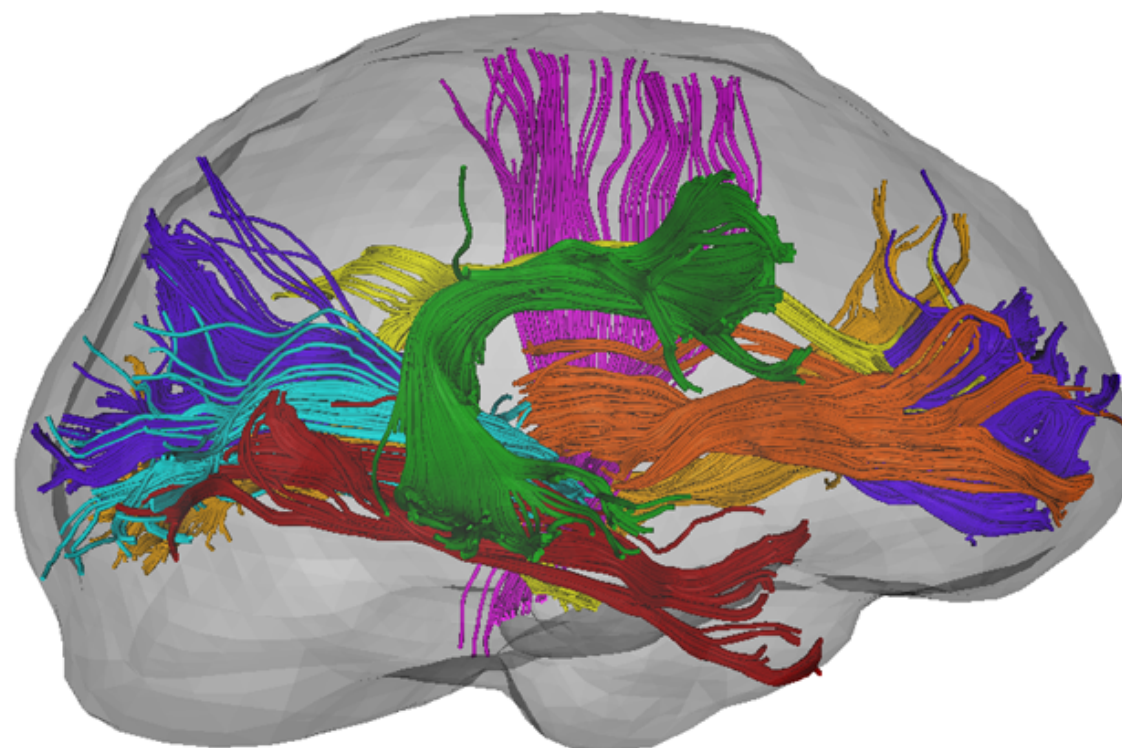
# What is Tractography?



Williams, Gluhbegovic, and Jew, "The Human Brain: Dissections of the Real Brain", Virtual Hospital, University of Iowa, 1997

Post-mortem dissection of some white matter fibre bundles (tracts)
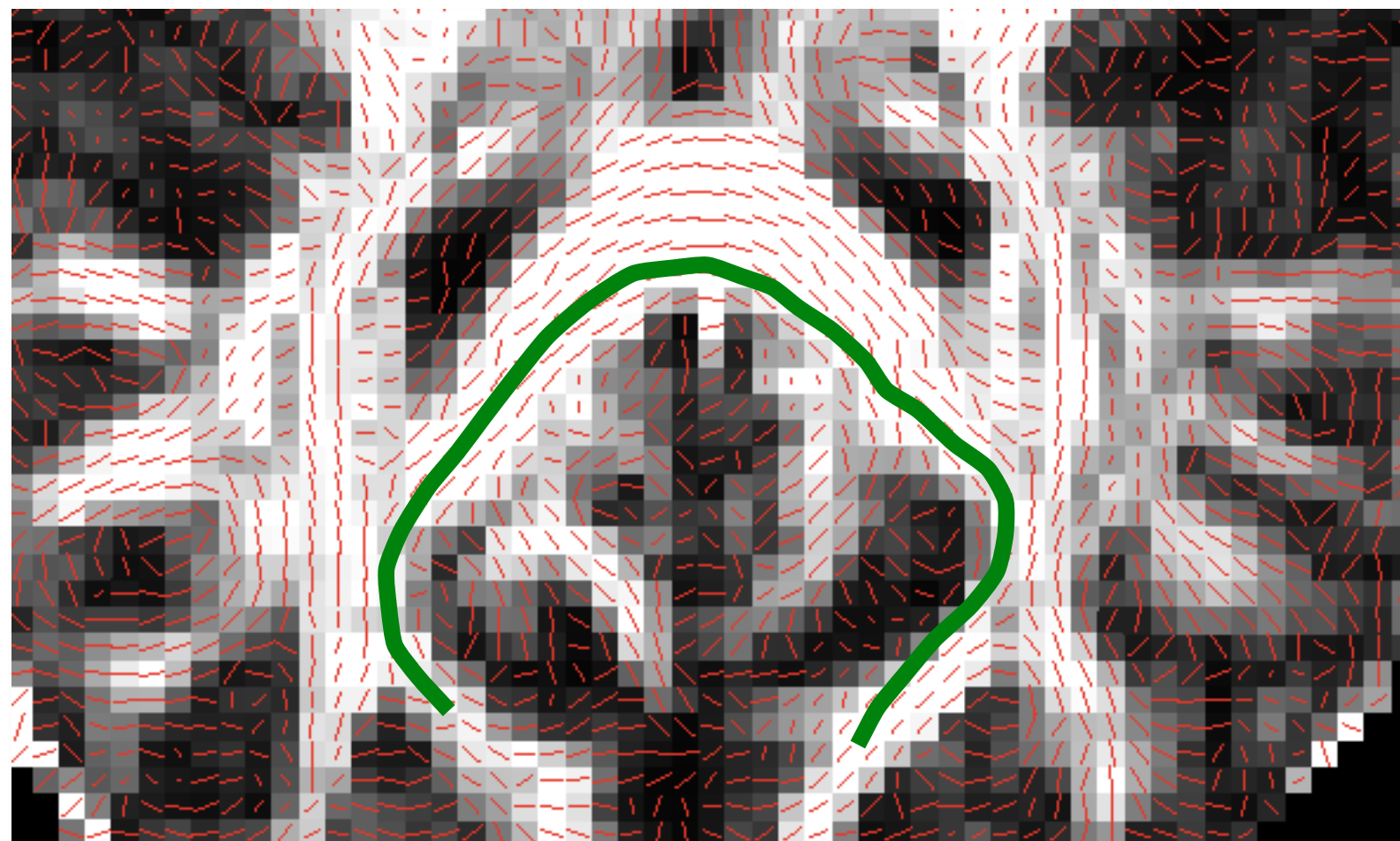
**Tractography**
The post-imaging reconstruction of fibre bundles/anatomical connections in the brain using a set of DW images.
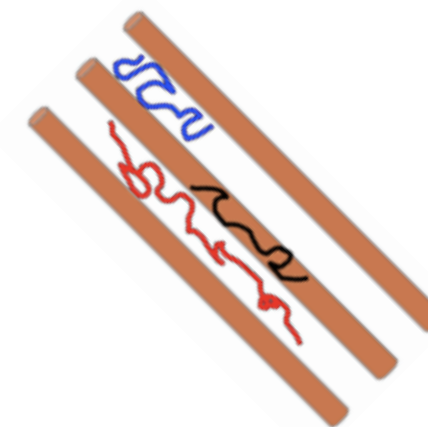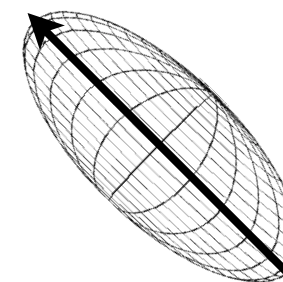(in-vivo virtual dissection)

# DTI tractography

$\mathbf{v}_1$ map
Principal Diffusion Direction

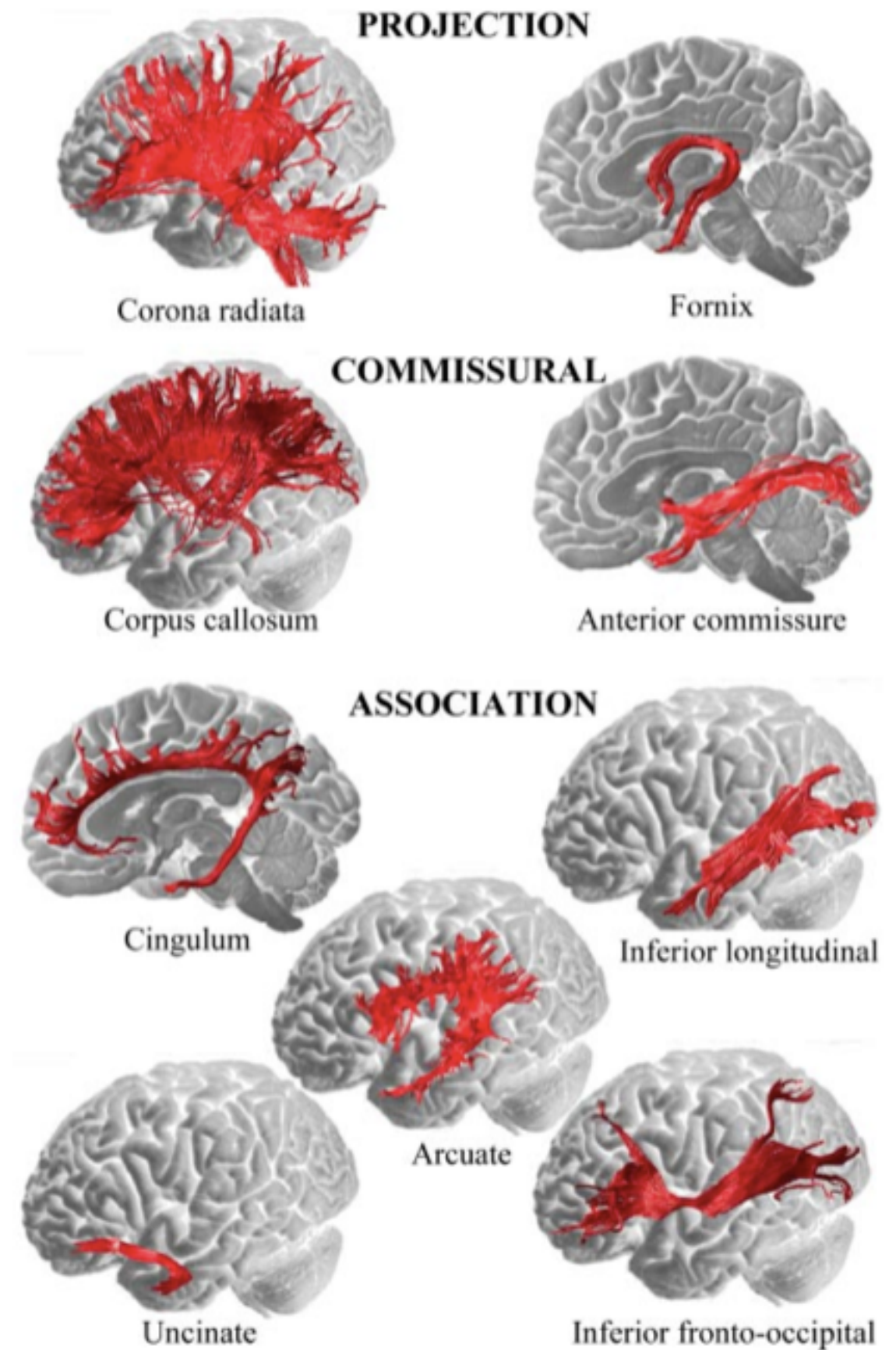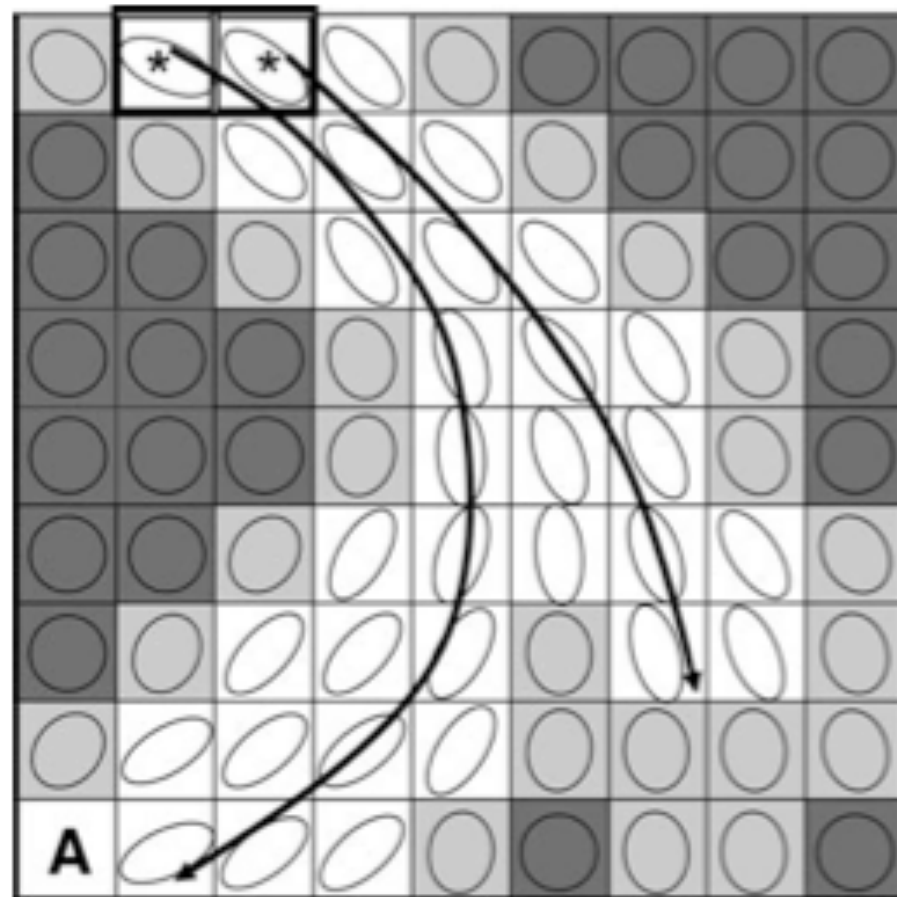Principal Diffusion Direction



**Assumption**:

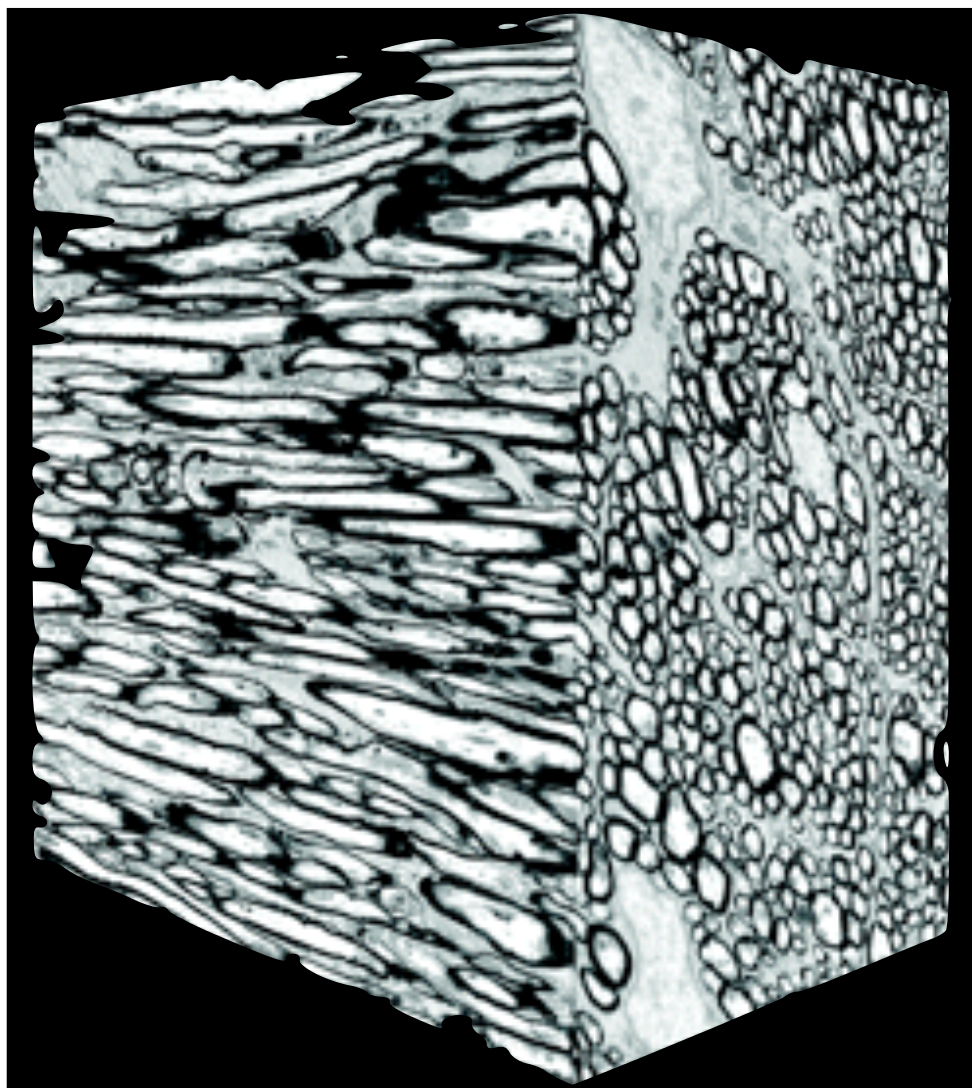**Direction of maximum diffusivity** (in anisotropic voxels) is an **estimate** of the major fibre orientation.
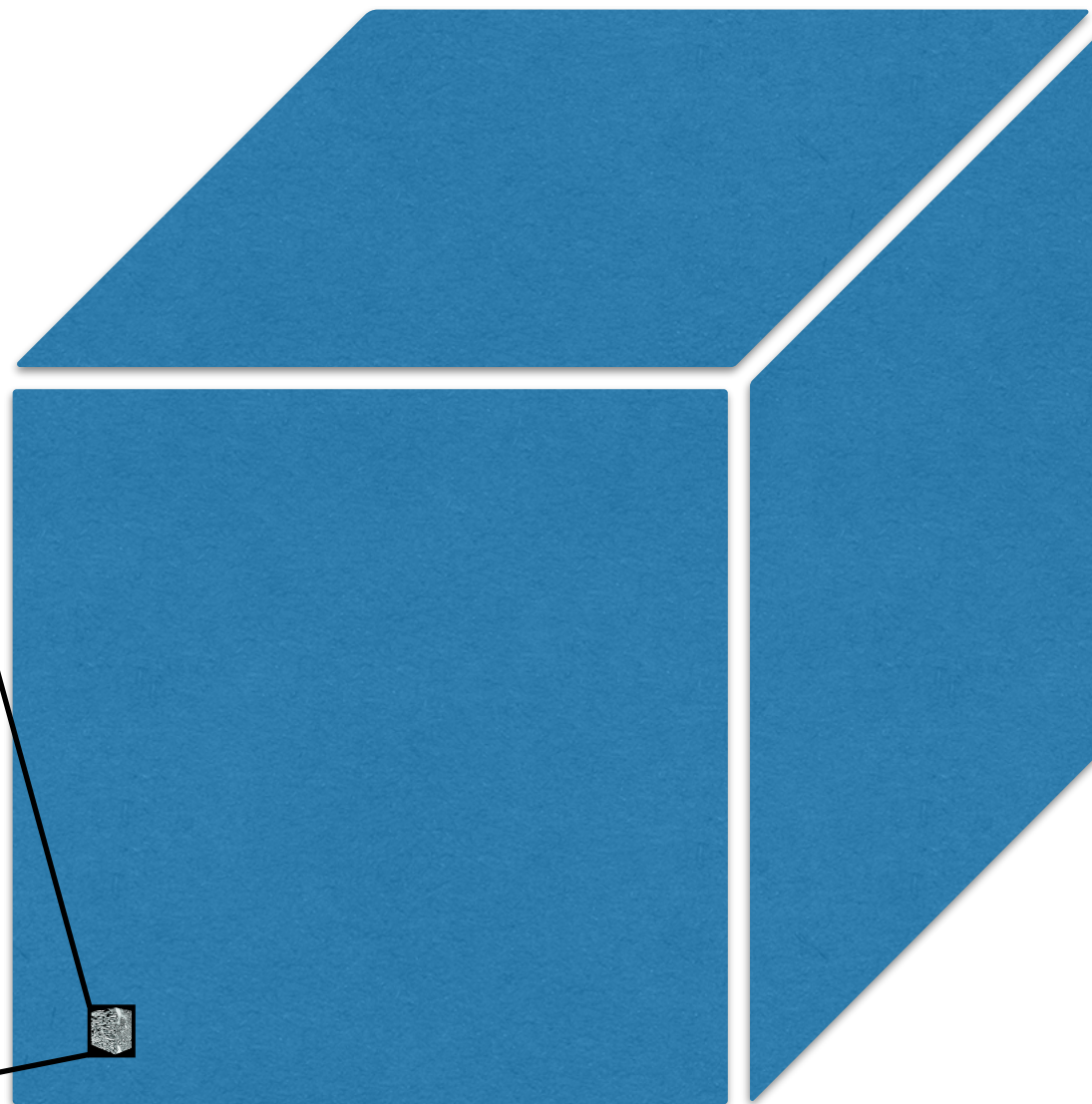
# DTI tractography



**PROJECTION**

Corona radiata    Fornix

**COMMISSURAL**

Corpus callosum    Anterior commissure

**ASSOCIATION**

Cingulum    Inferior longitudinal

Arcuate

Uncinate    Inferior fronto-occipital

[Basser et al, Magn Reson Med, 2000]                    [Catani et al, NeuroImage, 2003]

# Problems of scale

Microscopic view of white matter
axon size (~μm)
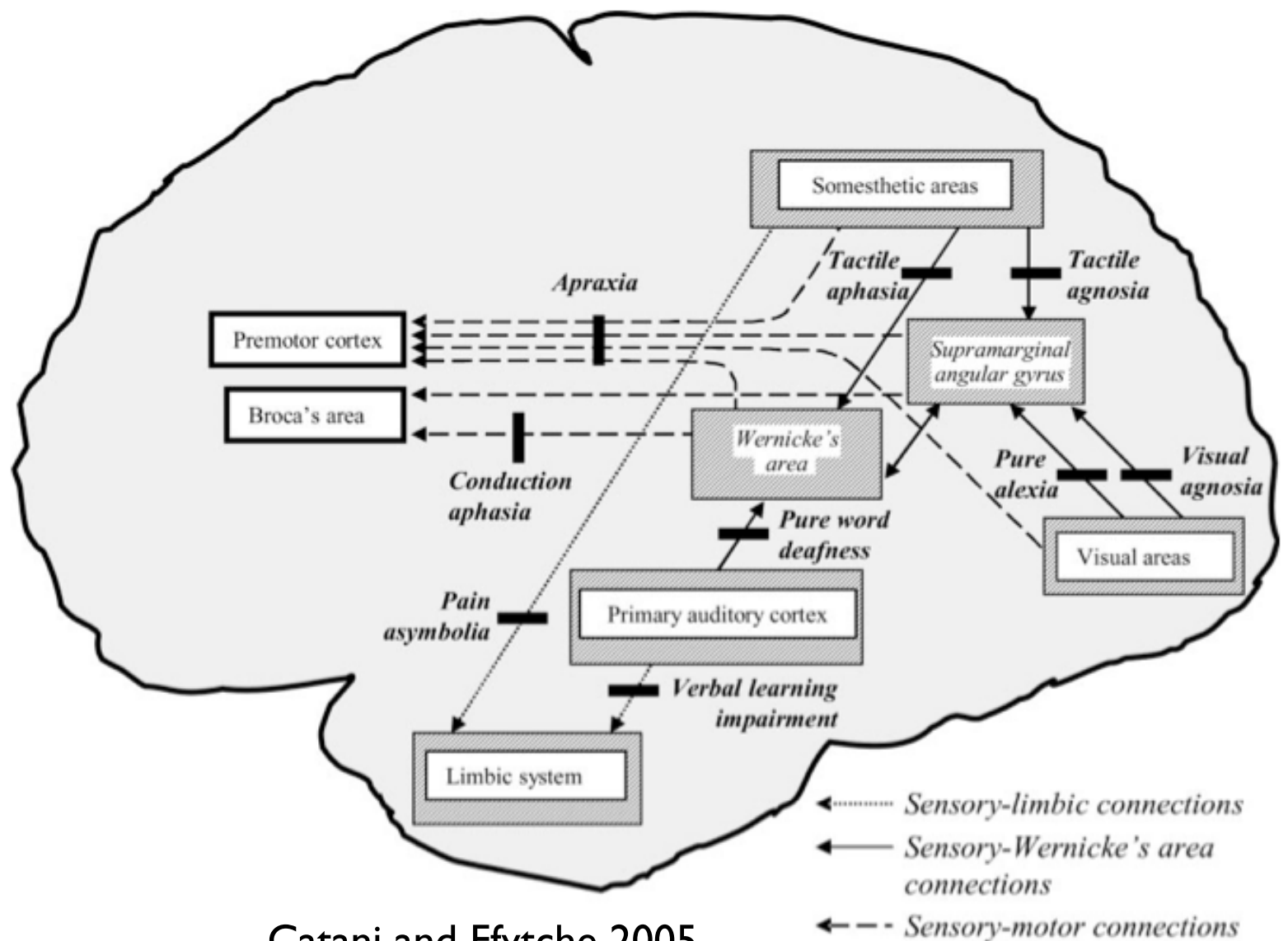
Voxel size (~1-2 mm)



Ohno et al. 2013

# Connectivity - Why do we care?

- White matter (dys)connectivity is thought to form the substrate for many different neurological and psychiatric disorders.
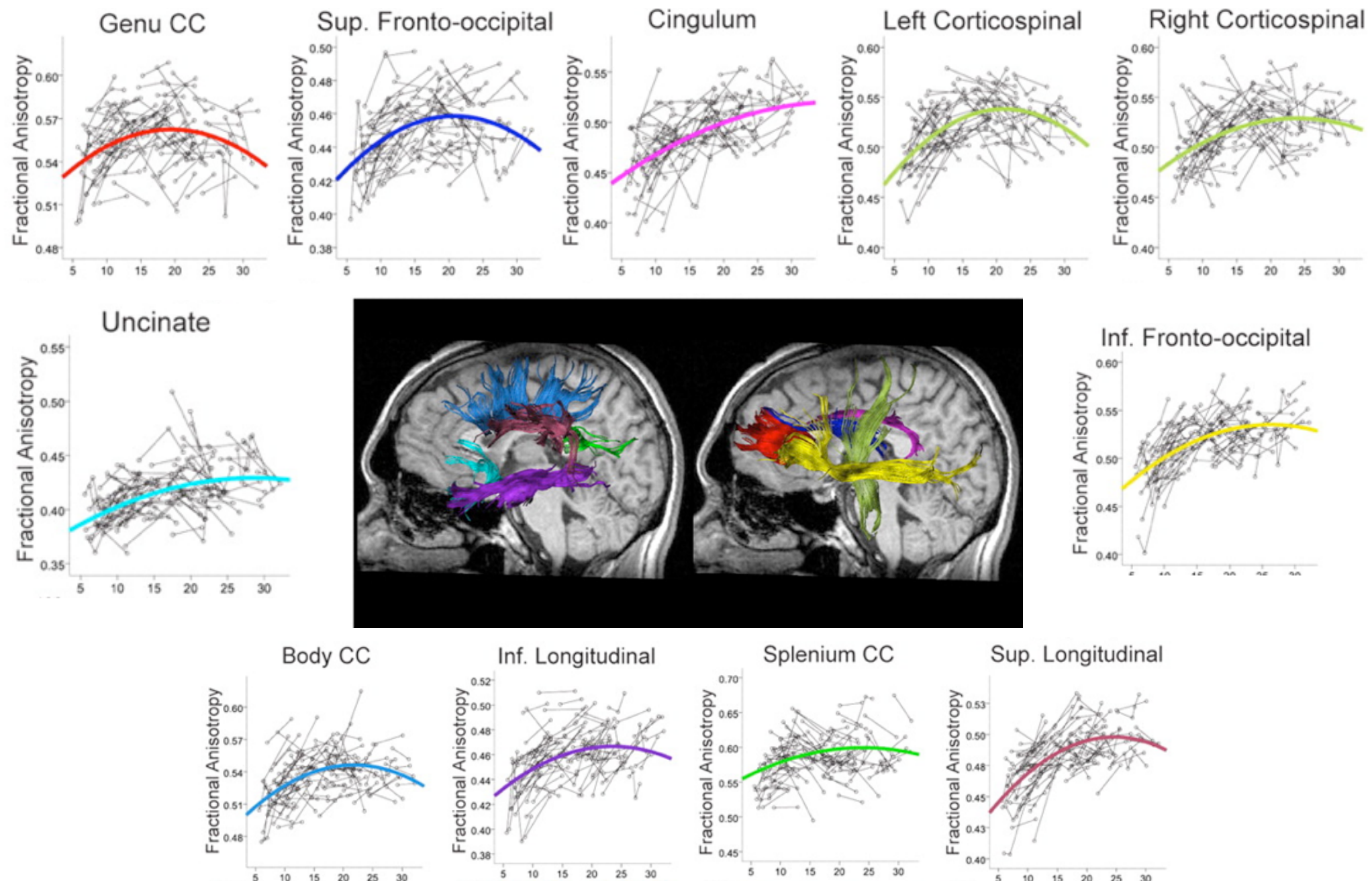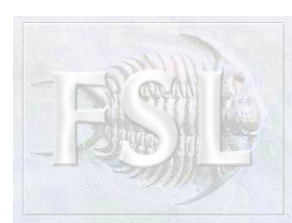


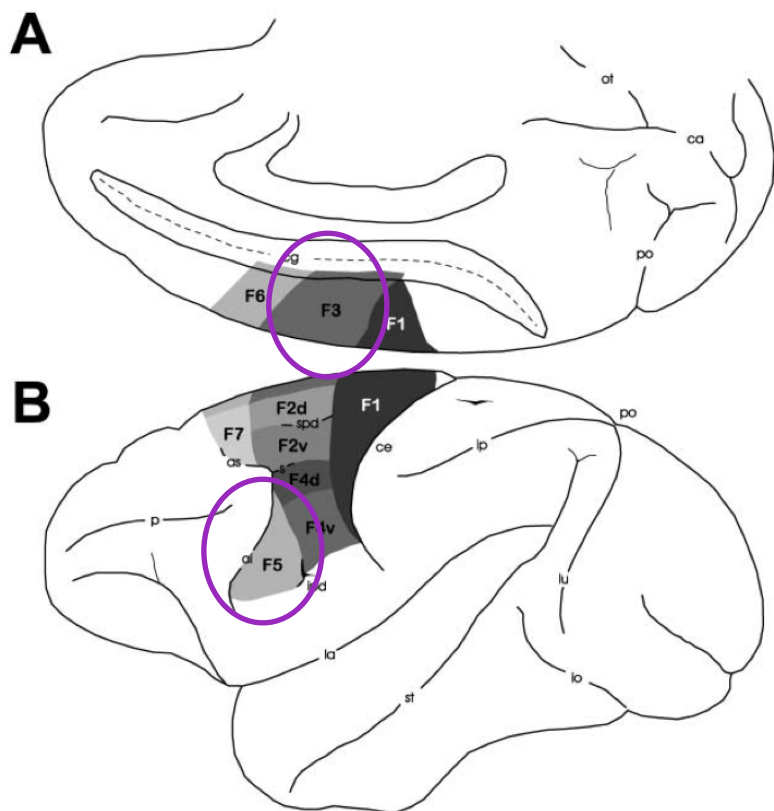Catani and Ffytche 2005

# Connectivity - Why do we care?

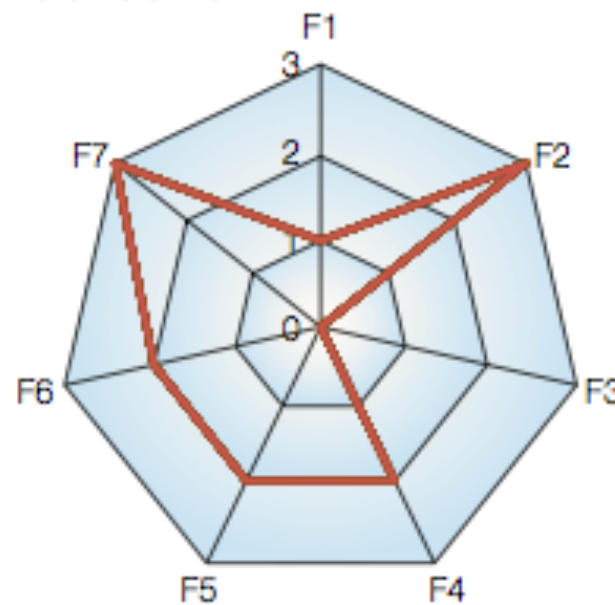- Tractography provides non-invasive localisation and semi-quantitative biomarkers
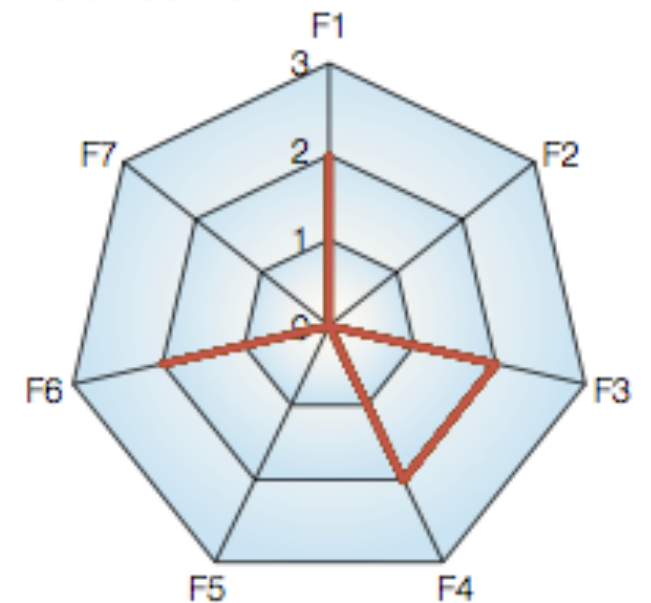
# Connectivity - Why do we care?

- Connections constrain function

- Different regions have distinct connectivity fingerprints



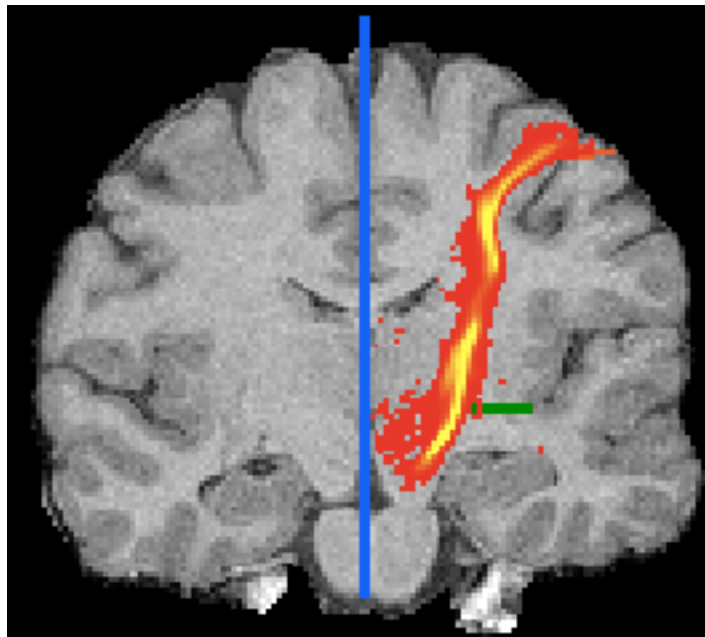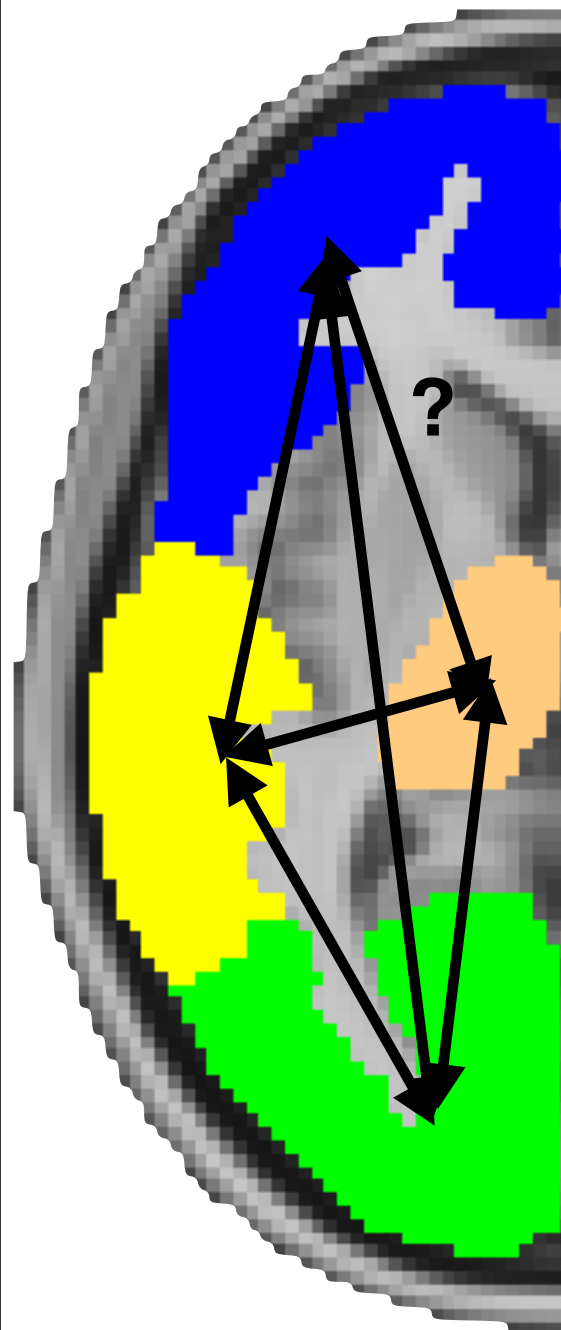Passingham et al. 2002

# Tractography outputs
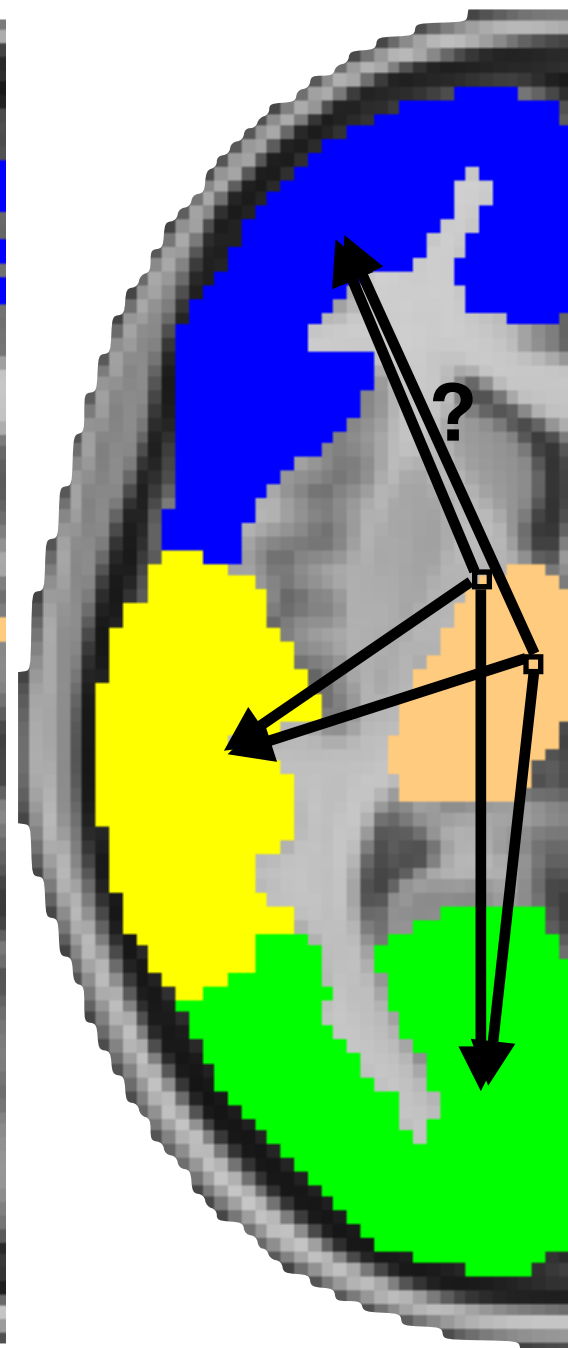
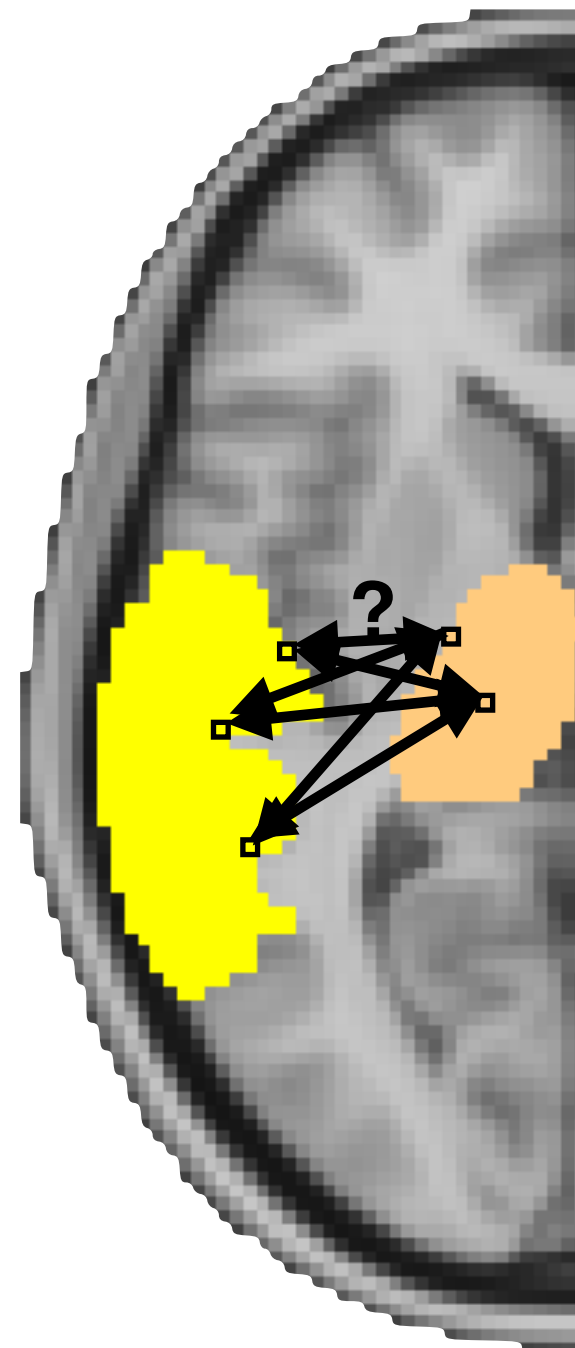## Known white matter tracts



## Connectivity matrices

### ROI by ROI



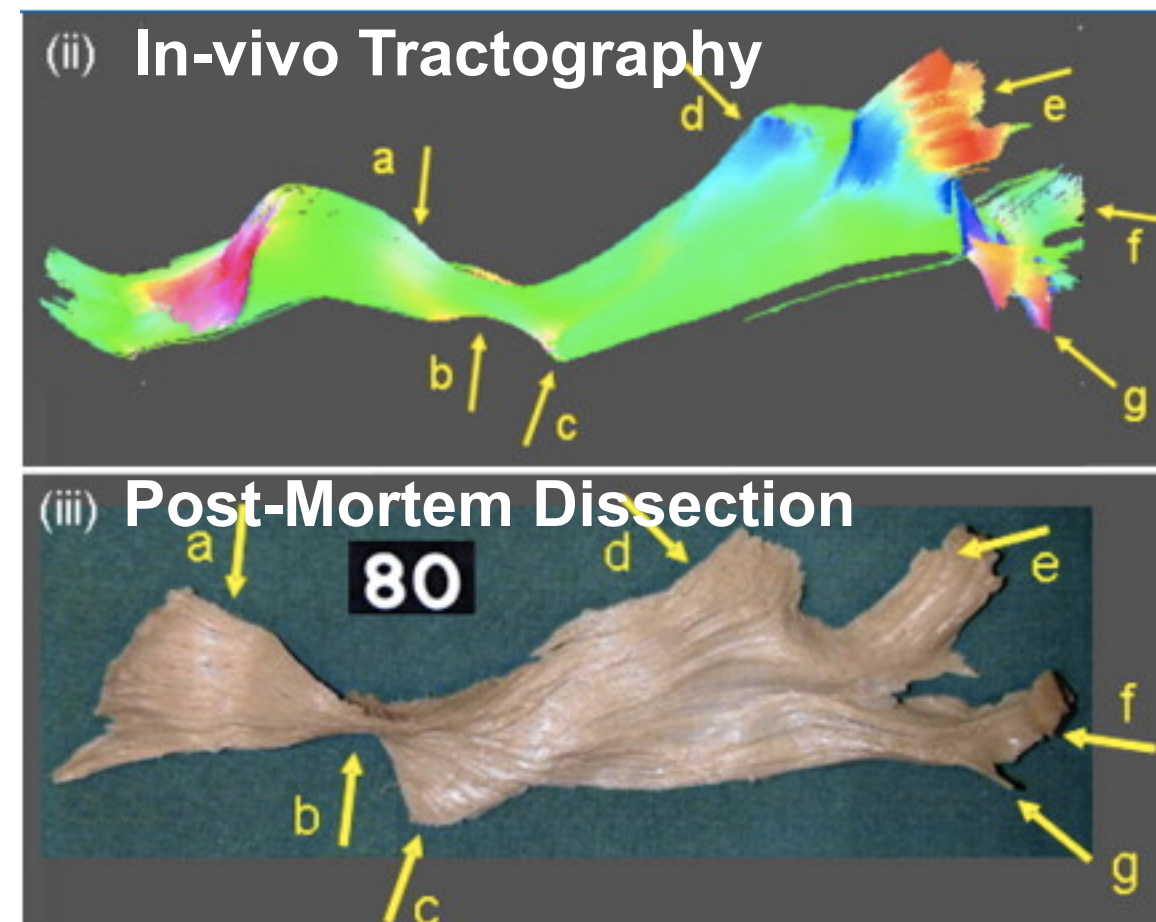### voxel by ROI



### voxel by voxel

# What does tractography offer?

+ non-invasive
+ in-vivo
+ whole brain
+ can address new questions



Lawes et al. 2008

...But
- low resolution (large bundles)
- indirect (diffusion paths)
- error prone (MRI is noisy)
- difficult to interpret quantitatively