Modes of division
ES cells

Embryoid bodies
- FGF2, FGF2, EGF, PDGF
- BMP4 or ascorbate
- RA, db-CAMP
- M-CSF, IL3, IL1
- c-Kit, EPO
- RA

- Oligodendrocytes
- Astrocytes
- Ectoderm
  - Skin
- Smooth muscle
  - Macrophage
  - Mesoderm
- Erythrocytes
  - Endoderm

- Adipocytes

In vivo
- Tissues and organs
- Multipotent

In vitro
- Progenitors

Cell type
- GABAergic neurons
- Glial precursors
- Dopaminergic neurons
- Cardiomyocytes
- Hematopoietic precursors
- Hepatocytes
- Undifferentiated ESCs

Transplantation into
- Rodent model

Striatum of rat model for Huntington disease
Brain of myelin-deficient rat (Pelizaeus-Merzbacher disease)
Striatum of rat model for Parkinson disease
Myocardium of dystrophic mice
Irradiated mice: myeloid and lymphoid engraftment
CCl4 intoxicated liver damage mice
Myocardium of infarcted rats
Potential Stem Cells with Neural Capability

<table>
<thead>
<tr>
<th>Restriction</th>
<th>Cell</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>totipotent, non self-renewing</td>
<td>zygote</td>
<td>zygote</td>
</tr>
<tr>
<td>pluripotent, self-renewing</td>
<td>embryonic stem cell</td>
<td>blastocyst</td>
</tr>
<tr>
<td>broad potential, self-renewing</td>
<td>multipotent stem cells</td>
<td>embryo or adult brain, blood (?)</td>
</tr>
<tr>
<td>limited potential, limited self-renewal</td>
<td>neural progenitor</td>
<td>brain or spinal cord</td>
</tr>
<tr>
<td>limited division, non-functional</td>
<td>neuronal progenitor</td>
<td>brain subregion</td>
</tr>
<tr>
<td></td>
<td>glial progenitor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>neuron</td>
<td>specific brain sites</td>
</tr>
<tr>
<td></td>
<td>glia</td>
<td></td>
</tr>
</tbody>
</table>
In adult centers, the nerve pathways are something fixed and immutable; everything may die; nothing may be regenerated.

Ramon y Cajal (1913)
Methods

Ming, G and Song, H, 2005
Neurospheres

red- immature neuron marker; green - glial marker
Methods for labeling potential stem cells

$^3$H-T/BrdU

Retroviral

Specific markers
Methods

<table>
<thead>
<tr>
<th>PRINCIPLE</th>
<th>IMAGING</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Based on incorporation of nucleotide analogs</td>
</tr>
<tr>
<td>b</td>
<td>Based on genetic marking by retroviruses</td>
</tr>
<tr>
<td>c</td>
<td>Based on expression of specific markers</td>
</tr>
</tbody>
</table>

| Birth dating | good | good | poor |
| Tracing | permanent | permanent | transient / permanent |
| Cell Population | whole population | limited cells | whole population |
| Visualization | fixation / processing | direct | processing / direct |
| Morphology | nuclear | whole cell | cellular / whole cell |
| Concerns | DNA repair | invasive | specificity |

Ming, G and Song, H. 2005
Sites of neurogenesis in the adult
Sites of neurogenesis in the adult brain
Neurogenesis in the subventricular zone
Rostral migratory stream
Incorporation of new neurons in the OB
Neurogenesis in the hippocampus
A unique niche for neurogenesis in the adult?