CORTEX

I. GENERAL CONSIDERATIONS
   a. Cerebral cortex = grey matter
   b. Lobes and functions:
      i. Frontal – motor processing
         1. Prefrontal – executive functioning (planning, recognizing consequences)
      ii. Parietal – somatosensory processing
      iii. Occipital – vision
      iv. Temporal – audition (lateral); limbic (medial)
      v. Limbic lobe – interconnecting deep brain structures (smell, emotion, motor, behavior, autonomics)
   c. Amount of cortex increases across phylogeny, depends on need for that function (ie in humans, prefrontal cortex is largest area)

II. TYPES OF CORTEX
   a. **Neocortex** – most abundant (90% of cortex); 6 layers; evolutionarily newer
   b. **Allocortex** – primarily in limbic structures (hippocampus, subiculum, entorhinal area); 3-5 layers, evolutionarily older

III. CELL TYPES
   a. Pyramidal cells
      i. Found in layers 2-3, 5-6
      ii. Pyramidal-shaped body, **apical dendrite** (extends to layer 1, branches into **apical tuft)**, **basal dendrites** (extend laterally), all have dendritic spines
      iii. Axon extends down into white matter, many have collateral arbors
      iv. Excitatory, use Glu (and sometimes Asp)
      *__spiny stellate cells__ – type of pyramidal cell without apical dendrite
   b. Nonpyramidal cells
      i. Found in all layers
      ii. Not spiny
      iii. Main axons near cell bodies, do not project out of cortex, can synapse with different postsynaptic elements
      iv. Inhibitory, use GABA (can use Gly – in spinal cord)
      v. **Chandelier cells**: powerful inhibitors, axon-axon synapses, horizontal with little vertical branches (like a chandelier), pleiomorphic residues
      vi. Others: bitufted cells, basket cells, double-bouquet cells
   c. **Interneurons**
      i. Layers 1-6
      ii. Wide variety – action depends on where they synapse
      iii. Many connect via gap junctions (electrical synapse)

IV. CYTOARCHITECTURE

a. Laminar patterns

i. **Layer 1** (**molecular layer**) –small and few neurons; contains mainly apical tufts

ii. **Layers 2 &3** – small pyramidal cells – do not project outside of cortex

iii. **Layer 4** – many small spiny stellate cells; main input layer for thalamocortical axons; do not project out of cortex (project to other nearby layers)

*Striate (primary visual cortex) –complicated L4 because inputs are segregated

iv. **Layer 5** – large pyramidal cells, project very long distances to subcortical targets (ie spinal cord, superior colliculus, pons)

v. **Layer 6** – medium pyramidal cells – medium distances to subcortical structures (ie back to thalamus)

For each layer, know:
1) What cells
2) Input
3) Output
4) Associated functions

*Prominent layer 4 in primary sensory areas = **granular cortex**
(regions that lack prominent layer 4 = **agranular**)

b. Myelin Stains (ie Weigert stain)

i. **Vertical bundles** – radiate through cortex, contain efferents to white matter

1. Adjacent cortical columns – have different receptive field properties

ii. **Horizonal bands**: outer (L4) and inner (L5) **Bands of Baillarger** – allow communication between and within cortical areas

***Line of Gennari –** prominent outer band of Baillarger in primary visual cortex

V. CYTOARCHITECTONICS

a. Brodmann's areas – based on cellular size and distribution across cortices (52 areas)

b. Important numbers:

i. Areas 1, 2, 3 = somatosensory cortex

ii. Area 4 = motor cortex

iii. Area 17 = primary visual cortex

iv. Area 41 (42) = auditory cortex

c. Some boundaries are obvious (ie expansion of L4 between area 17 and 18), some not

VI. CONNECTIONS

a. Inputs to cortex

i. Thalamus → L4, collateral branches to L3 and L6 - excitatory

ii. Transcortical (association input)→ L3 and L1 (feedback) - excitatory

iii. Callosal (commissural) inputs → L3 (interconnect homologous areas in two hemispheres)

*area 17, hand area of somatosensory cortex have NO callosal connections

b. Outputs to cortex

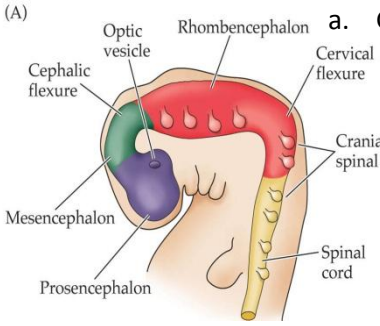
i. Transcortical and callosal efferents: from L3 (go to L3, L1)

ii. Long projection pathways: from L5 to brainstem, spinal cord

iii. Feedback to thalamus: any cortex with thalamic input feeds back through L6

* all excitatory (from pyramidal cells)

VII. DEVELOPMENT



a. General development
   i. Lateral "bubble-like" outgrowths from prosencephalon → cerebral hemispheres (hollows → lateral ventricles)
   ii. Prosencephalon divides into telecephalon and diencephalon
   iii. **Insula** = first part of telecephalon to develop (overlies developing basal ganglia)
      1. Eventually covered up by temporal lobe
      2. Function = gustatory, auton; ?consequences of actions (risky decision)?
   iv. Everything grows around insula (fixed) → hemispheres become C-shaped

b. Neuronal development
   i. Generation
      1. Neuroepithelium = **marginal zone** (cell-sparse, near pia) zone, **ventricular zone** (cell-dense, consists of **neuroblasts**)
      2. Neuroblasts are polarized, span epithelium – as it divides, nucleus translocates up to marginal zone and back down to ventricular zone
      3. Division – depends on plane of cleavage (different TFs present)
         a. Vertical → both dtr cells = neuroblasts (notch-1 and numb TFs)
         b. Horizontal → top cell (notch-1) = neuron/glial cell; bottom cell (numb) = neuroblasts

   *Gliogenesis continues throughout life, Neurogenesis = not sure

   ii. Migration
      1. **Radial glia** (first neuroblasts to stop dividing) span epithelium
      2. New neurons can move up radial glia to cortical plate
      3. In-out migration pattern: 1st neurons to migrate= layer 6;later neurons move past = L2/3 (sparse layer 1 = marginal zone)

      *Non-pyramidal cells (inhibitory) – from neuroepithelium of ganglionic eminence – migrate <u>laterally</u> through intermediate zone before moving up to cortical plate to become interneurons

   iii. Differentiation
      1. Migrating cells = bipolar; then send out dendrites that elongate, branch
      2. Axons send out branches, start to synapse with developing dendrites → induces dendrite to develop spine
      3. Radial glial cells become **astrocytes**
   iv. Formation of synapses
      1. Overproduction of synapses
      2. Patterns of activity, competition → "pruning" of synapses

c. Development of cortical areas
   i. Theory 1: Protomap – fate of neurons determined before migration from VZ
   ii. Theory 2: Protocortex – cortical areas develop as a function of anatomical input
   iii. Organization: primary cortical areas, adjacent unimodal association areas (ie areas, 18/19, 5/7, 22), then multimodal association areas

*Cortical architecture is ridigly specified, but function is plastic – rewiring during "critical period"

Lissencephaly: nonmigration - no gyri
Polymicrogyria: too many gyri on surface
Periventricular heterotopia: too many gyri on ventricular (deep) surface