Primate Brains are **larger** than other mammals of similar size, Cortex (esp visual) particularly well developed
- See next lecture for discussion of brain size comparisons

**Sensory Motor Integration**

- **Auditory:** Air vibrations pass into Inner Ear, set up vibrations along neuro-receptors of the **Cochlea**
  - These receptors arrayed from low to high frequency; Hearing range: **0.2-20kHz**
  - Primates make fine discriminations between tones up to ~4kHz
  - **Medulla** in Hindbrain, combines input from 2 ears (binaural) to localize source of sound
  - **Inferior Colliculus** in Midbrain, coordinates auditory localization with visual from Superior Colliculus
    - In Primates, (auditory) Inferior Colliculus is somewhat smaller than (visual) Superior Colliculus
  - **MGN** (Medial Geniculate Nucleus of the Thalamus) in Forebrain projects freq & amp maps to …
  - **A1** (Auditory 1) in Cortex, Frequency-by-Amplitude maps, in Dorsal-Medial Temporal Lobe
- **Higher Auditory Cortex:**
  - Info on Identity of call/caller in Anterior (rostral) Sulcus, adjacent to A1; Connects esp to Frontal lobe
  - Info on Location of call in Posterior (caudal) Sulcus (also "higher" aud cortex), connecting esp to Parietal
  - Auditory system very like typical mammal, less specialized or complex than Vision
  - Altho see notes on Human specializations (language) in “Lateralization” section below

- **Visual:** Principal sensory system;
  - Unlike Audition, no Hindbrain synapses; Most input directly to forebrain, prominent in Cortex
  - Eyes to **LGN** (Lat Genic Nuc of Thalamus) to **V1** of Cortex (rear of Occipital lobe, aka Striate Cortex)
  - In Cortex, topological maps of Retinal surface, **Fovea** (high acuity receptors) greatly MAGNIFIED
- **Crossover:** **Right Visual Field** falls on Left Half of both Retinas, processed by **Left Brain** (& y-v)
  - e.g. Left **Superior Colliculus** maps primarily right visual field, Right maps primarily left
  - Minimal overlap aids Primates orienting to center of field, e.g. for aiming a reach or jump
- **Dorsal Pathway** “**Where/How**” Path, V1 to Parietal, for localizing, tracking, interacting w/objects
  - Begins at periphery of Retina, where receptors more sensitive to Motion, broad outline
  - Unlike Ventral Path, some to Midbrain’s **Superior Colliculus** (Localization, Blindsight, Co-ord w/Aud)
    - **WHERE:** **MT** (Medial Temporal), adjacent to Parietal, find direction-sensitive **Motion Detectors**
    - **MST** (Medial Superior Temporal), Optic Flow detectors respond to forward/backward locomotion
    - **Disparity Detectors** (diff in locus of image on left vs. right eye) in Parietal for depth perception
  - **HOW:** **CIP** (Caudal Intra-Parietal) integrates shape & location of object
    - **AIP** (Anterior Intra-Parietal) How does shape/location of object afford grasping/manipulating
- **Ventral Pathway** = “**Who/What**” Path, V1 to Temporal Cortex, for identifying objects
  - Begins at **Fovea** with its high concentration of receptors for detail discrimination
  - Details preserved in maps up pathway, altho reps become less dependent on Retina’s point of view
  - **Color** (esp in **Old World primates**) via 3 types of “**Cone**” Receptors that together code each color
  - **IT** (Inferior Temporal Cortex), specialized for object and face recognition
  - **STS** (Superior Temporal Sulcus) cells respond to Biological Motion (e.g. changes in face orientation)

**Somatosensory:** “**S1**” in Cortex, along Post-Central Gyrus of Parietal Lobe
- “**Penfield Map**” there shows face, hands magnified (indicates greatest innervation, highest acuity)
  - Contributes to high level Visio-Spatial & Visio-Haptic Mapping in Parietal Lobe (see above & below)
  - e.g. Localizing objects/events in immediate and distant space, Hand/eye coord, Object manipulation, etc.

**Visio-Haptic (eye-hand) Coordination**

- **Primary Motor Cortex** Map commands motor neurons in Brainstem & Spinal Cord to move body
  - Pre-Central Gyrus in Frontal Lobe, across Central Sulcus from Somatosensory cortex
- **Premotor Cortex**, anterior to Primary Motor, active during “preparation to move” – plans activity
  - **Mirror Cell System:** co-activation of **Premotor (F5) and Parietal** Cortex in primates
- Mirror Cell System is activated when Primate sees own, or other’s, hands performing familiar task
  - Enables understanding action via translating visual input into motor plan
  - Often goal-dependent: Need to see hand movement and target object
    - May fire at different hand movements accomplishing same goal
  - Probably mediates **imitation** (learn to do by watching)

- **Air vibrations pass into Inner Ear, set up vibrations along...**
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Some Areas Mediating Social Cognition

**Limbic System** – also called Rhinencephalon (“Nose Brain”) since major olfactory input (e.g., Olfactory Bulb)
- In primitive and ancestral mammals, does much of decision making, often smell-mediated
- In Primates, less nose-driven, still critical in evaluating/learning about/reacting to what “matters”
- Olfaction, though declined in importance, can still be potent!
  - Complex pathways, include projections to Orbito-Frontal cortex, for social assessments
  - As in other areas, vision has become more important input (e.g., sight of face, visual sexual signals)
- **Anterior Cingulate Cortex (ACC)** – also part of Limbic System, for +/- evaluation
  - Anterior part of Cingulate Gyrus, concerned with Social Assessment (of self and others)
  - E.g., Active in empathy, deception, guilt, embarrassment, etc
  - Also involve in risk assessment (e.g., when to switch responses under uncertainty)
  - Probably implicated in “checking for cheaters”, sanction, retaliation etc.
- **Amygdala** – In Primates, role in generating and interpreting facial expressions of emotion
  - Damage => inability to produce/judge esp fear, anger, untrustworthiness in faces
  - Part of circuit (w/Orbitofrontal) for “**Theory of Mind**” – postulating what others are thinking, feeling
  - These connections particularly well developed in Humans, but built on basic primate pattern

Related Cortical areas
- **Orbitofrontal Cortex** – Many descending & reciprocal fibers to/from Limbic System
  - Higher primates esp. show increased, mostly inhibitory connections to Limbic System
  - Evaluate, set priorities, delay gratification, suppress (learned) inappropriate behavior, etc.
  - Reciprocal connections with Amygdala probably mediate primate precursors of “Theory of Mind”
- **Frontal Insula (FI)** – Insula = medial surface of Lateral Fissure between Temporal and Frontal lobes
  - Part of pathway between Amygdala and Orbitofrontal
  - Includes sensory projection for Taste, generates disgust/desire re consumables >> social others
  - Some cells involved in spontaneous production & interpretation of emotional expression
  - Implicated in helping produce/read pro-social and anti-social responses
- **Von Economo Neurons (VEN)** – In primates, found only in Apes and Humans
  - Unlike more typical Pyramidal cortical cells with widely-branching dendrites, VEN cells have long, unbranched, symmetrical processes (Axon and Dendrite)
  - Large cells, for rapid transmission of minimal local info to other areas
  - Possibly for fast, intuitive judgments of social situations?
  - Found in ACC & FI (above)

Some REFERENCES:
