Neuroembryology

- Central questions
  - How do neurons segregate themselves into functionally distinct, appropriately sized, and appropriately interconnected populations?
  - What is the relationship between structure & function and how is the match between the two achieved?

Development of CNS

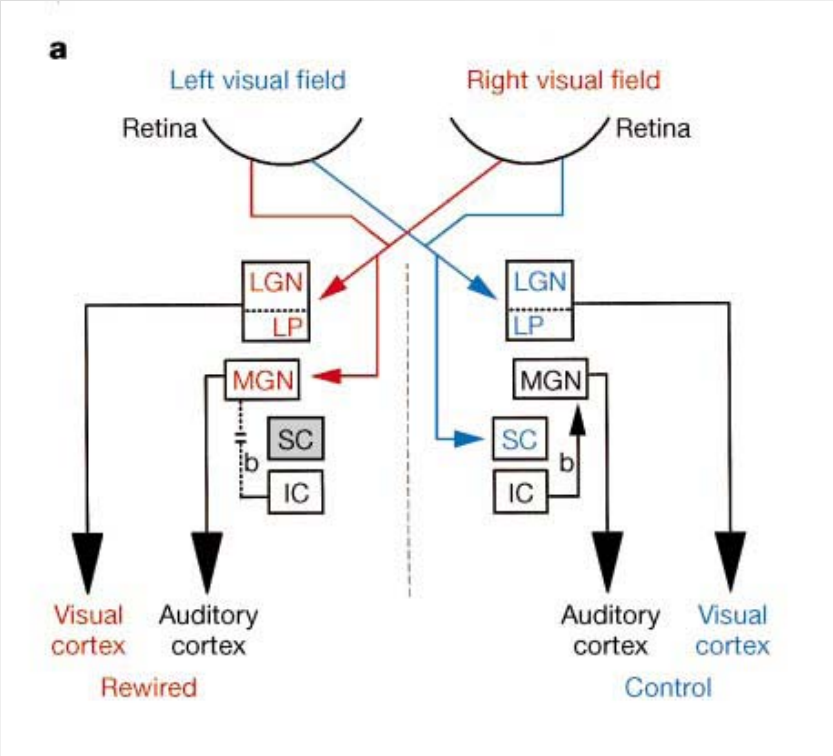
- What biological (intrinsic) factors contribute to the final form of the CNS?
  - **Overproduction -** neurogenesis "extra" neurons
  - **Neuron death (pruning) -** due to sensory input and experience in early development, neurons that are no longer needed are pruned; this may be underlying mechanism for ontogenetic adaptations
  - **Trophic factors** – help neurons get to their destination (e.g., nerve growth factor)
  - **Interactions** – cell-cell
  - **Selective activation or suppression** of different genes in each cell (all cells have a full complement of genes)
  - **Plasticity**

Development of CNS

- What environmental (extrinsic) factors contribute to the final form of the CNS?
  - **Sensory input**

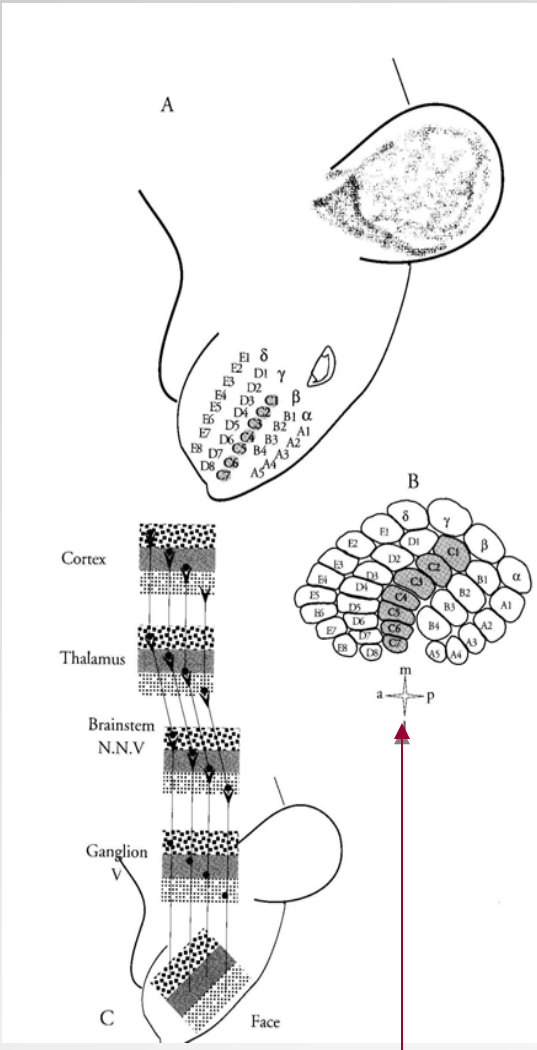
Prior to Birth - Prenatal Development

- Prenatal Development - Much ado about much!
- We have already seen the results from Sur's re-wiring studies of ferret brain showing that there is a great deal of plasticity in neural tissue

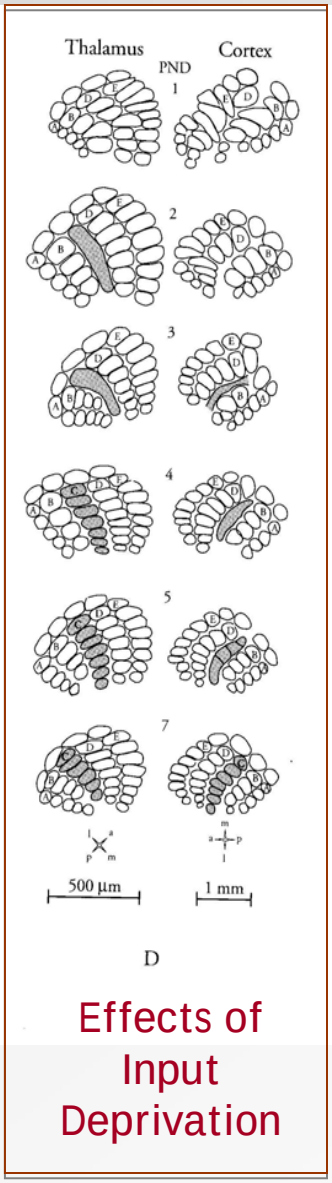


CNS Plasticity & Reorganization Due to Sensory Input

- Example of plasticity in somatosensory cortex after birth
  - Removal of whiskers before 7 days of life in rodents leads to elimination of barrel cells in cortex and reorganization of cortex (Woolsey et. al., 1981)
  - In adult owl monkeys, somatosensory cortex that receives projections from the hand becomes reorganized as a function of experience
    - E.g., denervation leads to invasion of cortical tissue by other parts of hand (Kaas, 1991)
    - Extra stimulation of digits leads to expansion of stimulated area on cortex (Merzenich et. al., 1984)



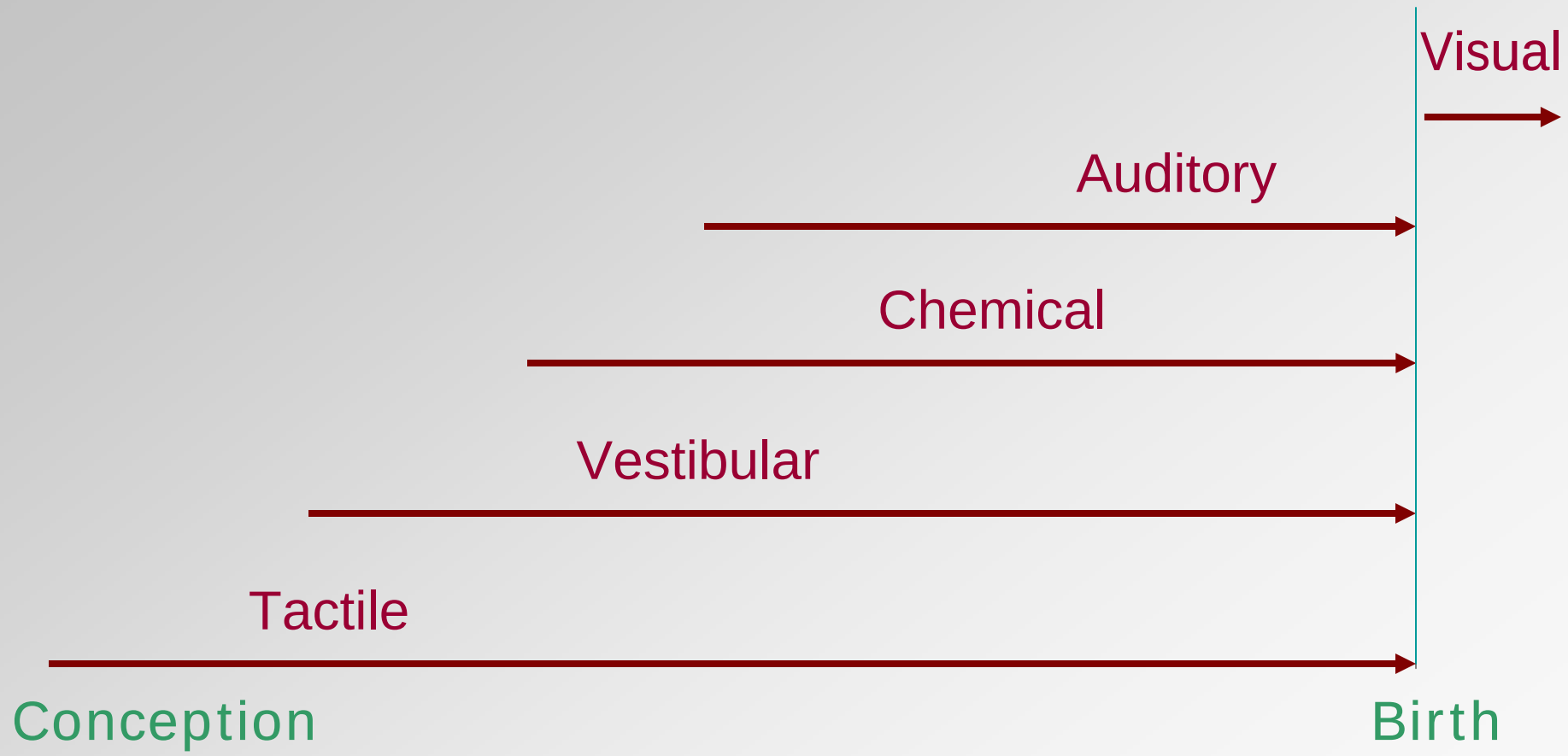
Mature Cortical Representation



Effects of Input Deprivation

Development of Sensory Systems

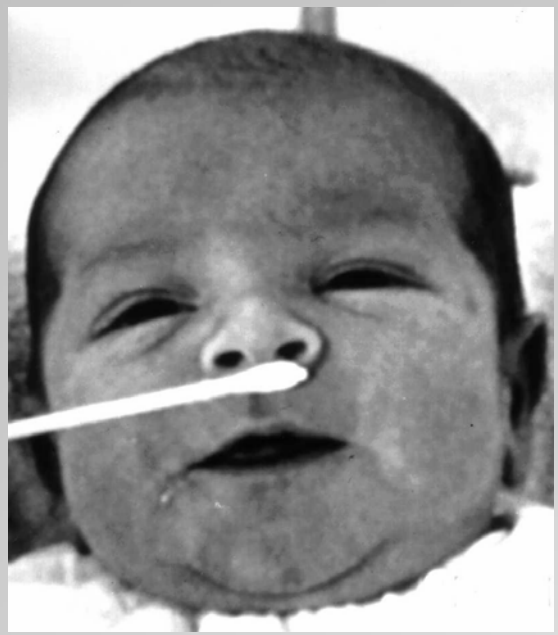
- Except for vision, sensory systems begin their development prior to birth, emerge sequentially, and gain important stimulative experience before birth



After Gottlieb, 1991

Newborns Exhibit Behavioral Reactions to Smells

Sweet



Sour

- Facts:
  - Newborns exhibit differential reactions to different smells (Steiner, 1977, 1979)
  - This is probably due to prenatal experience with amniotic fluid (Marlier & Schaal, 2004)
  - These reactions cannot be interpreted as reflecting “emotional” reactions because decorticate infants show similar reactions

Experimental Designs

- Longitudinal
  - Follow a single group (a cohort) of infants for some period of time
  - Study how certain behavior(s) change over that period of time
- Cross-sectional
  - Study different groups of infants at different ages
  - Study given behavior(s) to determine if they change and how they change over time
- Mixed longitudinal & cross-sectional
  - Study all available infants over time. This means that some will be tested more than once whereas others may only be tested once.

Advantages vs. Disadvantages

- Longitudinal
  - Advantages
    - Permits developmental inferences about continuity & stability of a particular behavior because the same infants are followed through time
  - Disadvantages
    - Expensive
    - Practice effects
    - Slow data collection (months or years!)
    - Subject loss due to move, illness, scheduling problems
    - Introduces possible systematic bias because only certain types of subjects may drop out over time resulting in biased rather than representative sample

Advantages vs. Disadvantages

- Cross-sectional
  - Advantages
    - Data collection faster than with longitudinal method
    - No subject loss
    - No practice effects
  - Disadvantages
    - Can only infer age differences, not continuity
    - Cannot say anything about individual differences
    - Age differences may be due to “cohort effects”