DEVELOPMENT of the NERVOUS SYSTEM

Introduction:

100 billion neurons in adult brain
x 10-100 glial cells
ENDODERM – internal organs
MESODERM – muscles
ECTODERM – neurons, glia, sensory receptor cells, glands
skin, hair, feathers, horns, nails
MEITOSIS

1. INDUCTION OF NEURAL PLATE

STEM CELLS, BLAST CELLS (from blastula)
NEUROBLASTS, NEUROGLIA
Dorsal surface of embryo
NEURAL PLATE (3 weeks conceptual age)
NEURAL GROOVE
NEURAL TUBE (6 weeks conceptual age), 125 K cells, hollow
Ventricles (brain), Central Canal (spinal cord)
Filled with Cerebrospinal Fluid (CSF)
NEURAL TUBE DEFECTS (NTDs)
Spina Bifida, Anencephaly
Vitamin B's deficiency (esp. B12, B6, B9 folic acid)
For women who are sexually active, 0.4mg/day B9
Brewer's yeast, liver, fruits, leafy vegs, oranges, rice, soybeans, wheat
Take at least through first trimester
3 swellings, FOREBRAIN, MIDBRAIN, HINDBRAIN
by end of 6 weeks conceptual age, at anterior/cephalic end of neural tube
rest of neural tube forms spinal cord
NEURAL CREST tissue --- peripheral nervous system

2. CELL PROLIFERATION & GROWTH

rapid meitosis, esp. in VENTRICULAR ZONE
    250k-300k/minute new cells during first two trimesters
risk of viral infections & high fevers (e.g. rubella, influenza)
    resultant brain damage, sensory impairment

3. NEURAL MIGRATION

RADIAL GLIA
    VENTRICULAR ZONE --- CORTEX
EPENDYMAL LINING of VENTRICLES
Failure to migrate properly…dyslexia, schizophrenia
3 models: Chemoaffinity, Blueprint, & Topographic Gradient

4. CELLULAR AGGREGATION

Functional clumps of like-purpose cells (e.g. same neurotransmitters)
NCAMs (nerve cell adhesion molecules)
Form Nuclei (CNS) and Ganglia (PNS)
    e.g. amygdaloid nucleus, dorsal root ganglion

5. DIFFERENTIATION

Growth of AXONS & DENDRITES off of the SOMAS
"GROWTH CONES" off of the soma
And continuation of the chemoaffinity, "follow the leader", etc.
    chemical signals/pathways as axons begin to grow toward
        "target cells"
Axons grow first, dendrites later on as growing axons approach

6. SYNAPTOGENESIS

Rapid formation of synapses
"Rule" of Connect or Die
Competitiveness of axons, NEURAL DARWINISM
Synaptogenesis continues through out lifetime, but rate slows
and may require more "repetitions"
Rapid formation of synapses continues into post-natal life,
esp. during first 3 years post-natal (PET scans, very high rate of glucose uptake)
ALTRICIAL vs. PRECOCIAL species
e.g. kittens vs. chicks
Long infant-dependancy period
More "plastic" nervous system, flexibility of connections
More affected by experience/learning vs. "hard-wired"

7. NEURON DEATH & SYNAPSE REARRANGEMENT

"PRUNING" of superfluous neurons (neural Darwinism)
APOPTOSIS – active process, cell "suicide"
Vs. Necrosis (passive cell death)
Part of the "connect or die" rule
NEUROTROPHINS/NERVE GROWTH FACTORS
Come from cell that axon has made connection with
No connection to another neuron --- no neurotrophins
No connection to an organ/gland in SNS --- no NGFs
As apoptosis continues, neurons & their connections/pathways become INCREASINGLY SELECTIVE
Mean average of 50% of cells lost (range 15% - 85%)
Over vs. Under "pruning"

8. POSTNATAL CEREBRAL DEVELOPMENT

Brain of human species develops the slowest of all species

Not fully developed until late teens/early 20's

esp. in **prefrontal cortex**

e.g. 350 gm at birth vs. 1350 gm as adult (x4)

myelination, dendritic branching, # synapses, axon growth, soma size (**not** to increase in # of neurons)

myelination first noted on spinal cord axons, next on hindbrain, then midbrain, and last on forebrain axons

may take many years of myelinate NS

sensory areas develop faster than motor areas are myelinated first

"association" areas still later on (e.g. prefrontal areas at age 18-20 years)

dendritic branching occurs first in deeper layers of cortex, then in more superficial areas

High rate of synaptogenesis postnatal--- greater recovery from early vs. later brain injuries

But early damage may also have very large effects that are **not** seen in behavior till later on…

High rate of synaptogenesis continues until 36 months postnatal (**PET scan** data)

Postnatal environmental conditions (e.g. "enriched" vs. "impoverished" rearing conditions) and nervous system

e.g. Berkeley rats and Headstart programs

e.g. monocular/monaural conditions

cataracts, **amblyopia**, unilateral deafness, etc.

e.g. pre- & early postnatal brains are more vulnerable to toxic effects (ETOH, 2nd hand cigarette smoke/anoxia, malnutrition, cocaine, etc.)

9.FETAL CELL BRAIN TRANSPLANTS