Chapter 5: Evolving Brains: Neural Development, Neuroplasticity, and Recovery of Function

# Brain Scene Investigation: Traumatic Brain Injury and an Unlikely Neurochemical Intervention

Case about Mark, who received progesterone as part of treatment for TBI. Although animal studies have been largely successful, clinical trials have not been optimistic.

# Building Brains

## Recurring Evolutionary themes

The nervous system across vertebrates shows a large amount of conservation. The general structure of the cortex across mammals is similar, but the amount of cortex devoted to particular senses reflects ecology demands of the particular species.

## The Importance of Play Behavior in Developing Brains.

Neuroethology is the study of the neural basis of animals’ natural behavior. Play helps animals learn about their physical and social environments, and is more common in juvenile mammals than adults. The core driver of play is likely subcortical (mesolimbic dopamine system; thalamus; periaqueductal gray). Dopamine, serotonin and endogenous opioids are all involved in play behavior. Reduction in play behavior has been suggested as a contributor for ADHD and even visual acuity.

## Is the Human Brain Unique?

Compared with other mammalian brains, the proportion of cerebral cortex mass to total brain mass in the human brain is impressive but not particularly distinctive. Taking into account its larger size, the human brain does not appear much denser, but the cortex does have a large total number of neurons. Elephants have very dense cerebellums, but do not necessarily show comparatively advanced cognitive abilities.

## Epigenetics: How Lifestyles Influence Inheritance

Conditions in our environments can impact how we develop and which genetic information is passed along generations. Environmentally-impacted maternal behavior can modify gene expression. Epigenetic processes allow for faster behavioral changes than would be possible by natural selection.

# Neural Development

## A Brain Is Born: Neuroplasticity in Action Fundamentals of Neurogenesis

The brain “swell” is visible three weeks after fertilization. Pluripotent cells are able to become many different kinds of cells; progenitor cells are more specialized. Neuronal development starts with neurogenesis, then migration, aggregation/differentiation, synaptogenesis and circuit formation, apoptosis, and finally synapse rearrangement. Glial cells can guide neurons to their destinations. Sometime plasticity is achieved by growing new neurons, other times be “renovating” existing neurons.

## Fundamentals of neurogenesis

Two main areas of the (mouse) brain in which neurogenesis occurs: the sub granular zone of the dentate gyrus in the hippocampus and the subventricular zone of the lateral ventricle. Can take up to a week for new cells to begin showing evidence of maturation and several weeks before the cells are classified as mature neurons.

## The Human Adolescent Brain

Human brains mature slowly – we spend a long time in adolescence. Response inhibition is defined as ability to inhibit irrelevant responses that interfere with the completion of the task. Success in tasks requiring response inhibition (and often involving the ACC, DLPFC) increases with age. Generally speaking, limbic regions of the brain mature faster than the prefrontal areas leading to increased emotional/reward function without the necessary regulatory features, thus increasing high levels of risk-taking are observed during this time.

## The Aging Brain

Scientists now accept that the brain is constantly changing, rather than being fixed after development. Sensory receptive fields can change as response to injury later in life or as a result of extended practice. Senses and cognitive abilities decline with age.

# Context matters: Aging: Is it in our blood?

When the blood of old mice was transfused into younger mice, neurogenesis declined to a level comparable to that of the old mice; when the blood from young mice was transfused into old mice, neurogenesis rates increased to a level comparable to that of young mice.

# Recovering from Brain Injury

1.7 million TBIs a year in the USA

## Damage Control in Injured Brains

After brain injury, stopping blood flow to a region can lead to cell death. Astrocytes can help remove excess glutamate released during injury. If a TBI results in loss of a function in, for example, the right arm, constraint-induced therapy can be used to force the individual to use the right arm. Younger brains may repair better than older brains.

## A Case to Consider: Repetitive Head Injuries in Athletes

Chronic traumatic encephalopathy resulting from repetitive head injuries is associated with memory loss, atrophy to several brain regions, behavioral/personality changes, and movement difficulties. Brain damage is cumulative, and can be dramatic even in the absence of concussions or specific major injuries. Better helmet technology can help, but probably not eliminate the risk of CTE in American Football.

# Laboratory Exploration: Behavioral profiling and genetic engineering: In search of animal models for autism spectrum disorder

Animal models are often created by genetically modifying mice and observing phenotypic behavior consistent with a human disorder. BTBR mice exhibit compromised social interactions such as diminished reciprocal social interactions, delayed approaches to mouse peers, decreased evidence of social communication, and repetitive self-grooming