Lecture 15
Experience Can Affect Brain Development by Altering Gene Expression

Review

Research indicates that exercising, socializing, and mental stimulation facilitates the growth of new brain neurons in adulthood, which is called brain _____.

Synapses that become stronger or weaker depending on their effectiveness in driving their target cell are known as _____ synapses.

Review

Research indicates that exercising, socializing, and mental stimulation facilitates the growth of new brain neurons in adulthood, which is called brain neurogenesis.

Synapses that become stronger or weaker depending on their effectiveness in driving their target cell are known as Hebbian synapses.

Experience Can Affect Brain Development by Altering Gene Expression

The Road Ahead:

- Describe how the environment can regulate gene expression and how experience and genes interact to affect behavior.
- Define epigenetic changes, and explain how they might play a role in the interaction of genes and the environment.
- Describe the mechanism by which rodent dams can alter their offspring's lifelong stress response.

Genotype Is Fixed at Birth, but Phenotype Changes throughout Life

Genotype—the sum of an individual's intrinsic, genetic information; constant

Phenotype—the sum of an individual's physical characteristics; changes constantly based on extrinsic effects on genes

- Genes are intrinsic factors that develop within the cell—all other influences are extrinsic.
- Identical twins: Differences in neural phenotypes produce different behaviors.
- Example: **phenylketonuria** (**PKU**)

Experience Regulates Gene Expression in the Developing and Mature Brain

Clones are asexually produced organisms that are genetically identical.

Epigenetics is the study of the factors that change gene expression without changing the gene sequences.

- Genetically identical mice raised by different mothers show different behaviors.

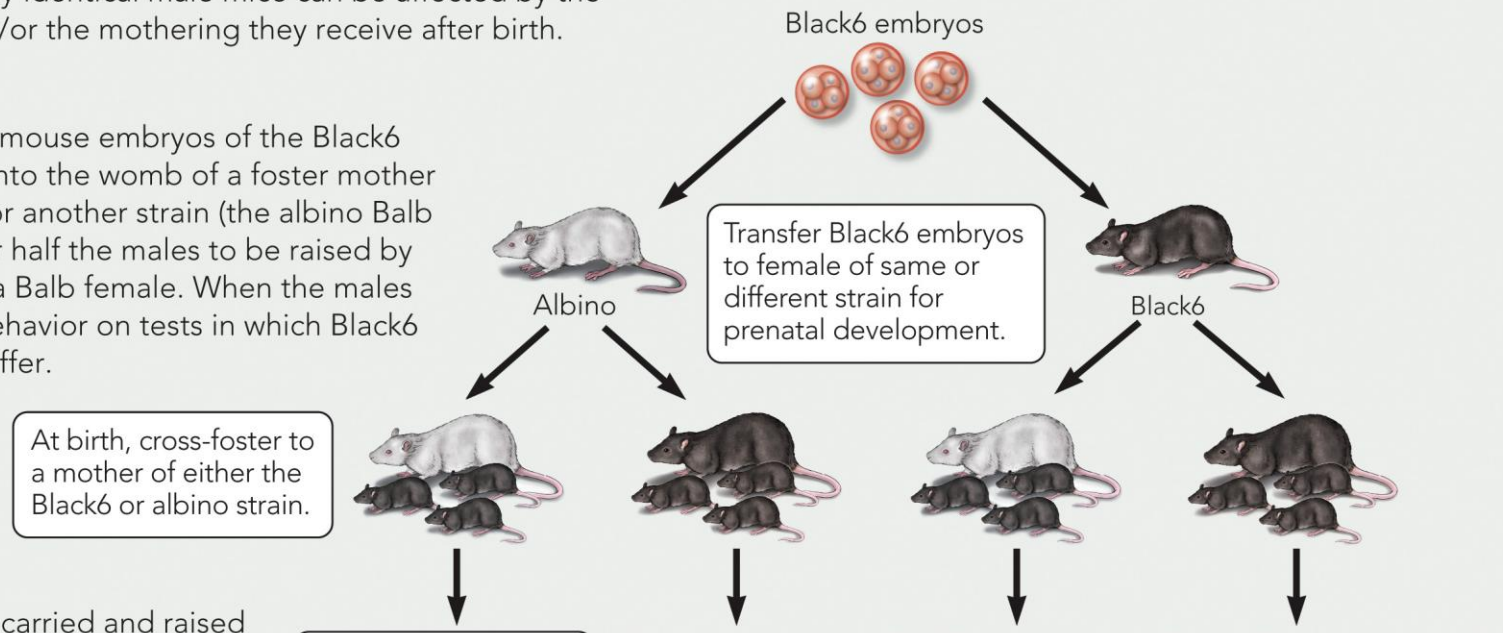
Figure 4.14 Epigenetic Effects on Mouse Behavior

Hypothesis

The behavior of genetically identical male mice can be affected by the prenatal environment and/or the mothering they receive after birth.

Experiment

Take genetically identical mouse embryos of the Black6 strain, and implant them into the womb of a foster mother of either their own strain or another strain (the albino Balb strain). After birth, transfer half the males to be raised by either a Black6 female or a Balb female. When the males grow up, measure their behavior on tests in which Black6 and Balb mice normally differ.



Result

Males of the Black6 strain carried and raised by mothers from the albino strain show significant differences in several behaviors (Francis et al., 2003), including maze running and measures of anxiety (**Figure 4.14**).

Conclusion

Since the various males are genetically identical to one another, their different behaviors must be due to the effect of different prenatal environments and postnatal experiences, such as the mothering they received, on how those genes are expressed.

After D. D. Francis et al., 2003. *Nat. Neurosci.* 6: 445.

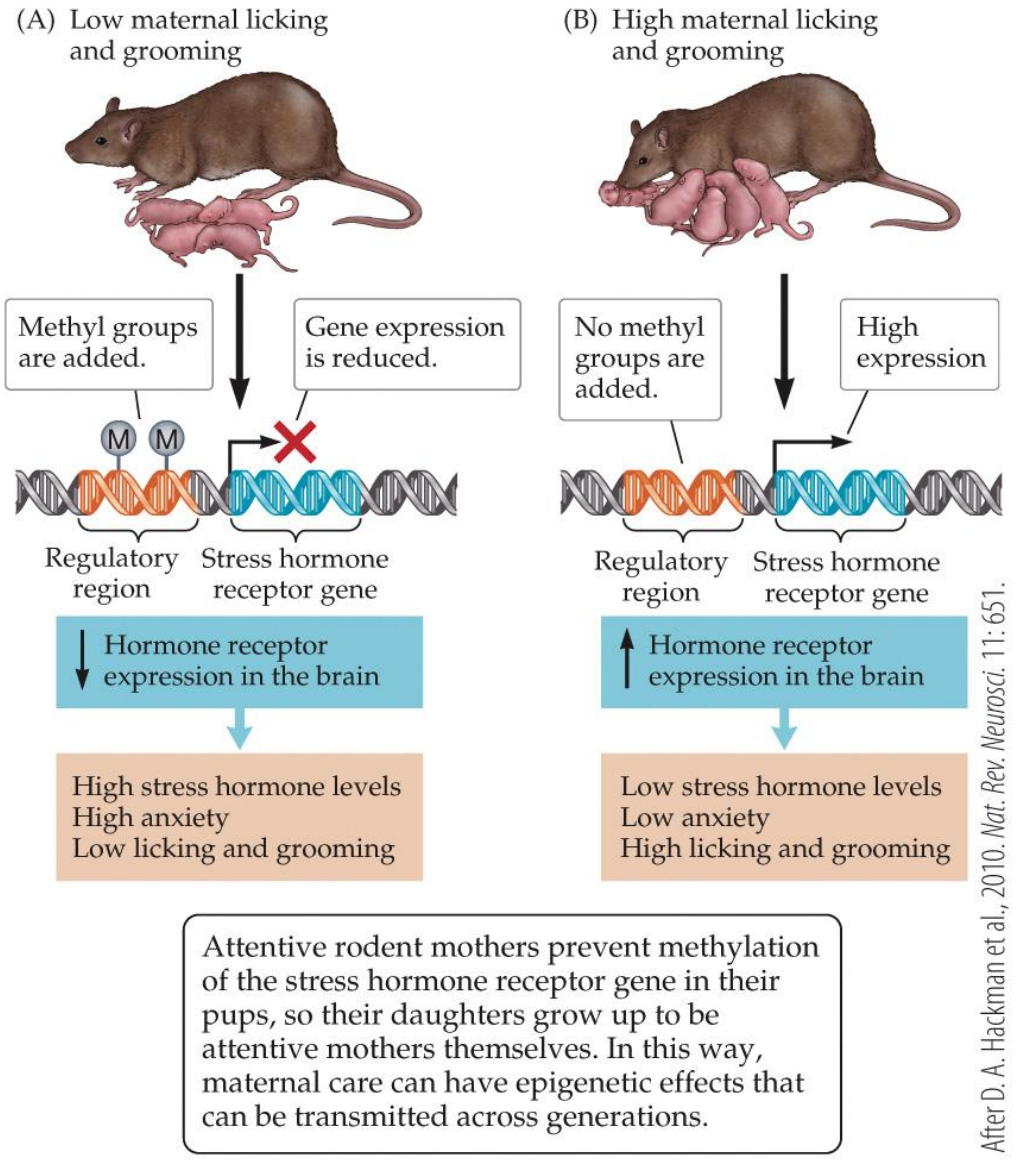
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Gene Expression in the Brain Can Be Affected by Mothering

Methylation is a chemical modification of DNA without changing the nucleotide sequence; these genes are then less likely to be expressed.

- Poor maternal care induces methylation of the glucocorticoid receptor gene in the brain.
- Rodent pups become hyperresponsive to stress for the rest of their lives.
- In humans, this same gene is methylated in those who suffer childhood abuse.

Figure 4.15 Early Experience Imprints Genes to Affect the Stress Response in Adulthood



THE MIND'S MACHINE 4e, Figure 4.15

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