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Unraveling the gene-environment interaction

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A special issue of the journal *Child Development* reports on studies that take important new steps in understanding how genes and the environment interact in shaping child behavior.

The field of epigenetics focuses on how the blueprint provided by genes is actualized, examining how experiences influence the way genes manifest themselves or are "expressed." Using the tools of epigenetics, the studies in the special section move beyond the perspective that either genes or the environment are most important in shaping children's development, to an intensive focus on how children's experiences actually affect the way their genes function.

All of the studies in the special section look at the epigenetic mechanism of "gene methylation." Gene methylation is described by Lester in the special section introduction as a kind of dimmer switch: "If all of the cells associated with a particular gene are unmethylated, the population of cells can produce the amount of protein consistent with a fully active gene. Conversely, if the gene is fully methylated it will produce very little or none of the protein..." resulting in a gene that is switched off.

The studies reported on in the special section provide evidence that methylation of specific genes is associated with important aspects of children's development from the prenatal period through young adulthood. The studies indicate that gene methylation can be affected by physical factors in children's environments (such as exposure to cigarette smoke) as well as social factors (such as the experience of severe stress). The studies identify linkages between gene methylation and a range of

important developmental outcomes.

For example, regarding prenatal experiences, Darlene Kertes and colleagues studied exposure to chronic stress and war trauma among mothers in the Democratic Republic of Congo. They found that maternal stress was linked with epigenetic changes in genes that regulate the body's response to stress. These epigenetic changes, in turn, predicted lower birth weight. "Stress, especially traumas experienced by women living in war and conflict zones, do not just impact the health and well-being for people who experience it directly," said Kertes. "It can potentially have long-term consequences for future generations."

Laura Stroud and colleagues examined the role of epigenetic changes in placental DNA in explaining why smoking during pregnancy is associated with behavioral differences during the newborn period. This study found that smoking during pregnancy was associated with epigenetic changes in glucocorticoid receptor DNA from the placenta; changes that in turn were associated with newborns' ability to stay alert, stay soothed, and pay attention.

Focusing on early childhood, Parade and colleagues note that early adversity places children at risk for problems with their health and development. Yet, it remains unclear how early adversity contributes to poor outcomes. Their study examined whether methylation of a gene that regulates the body's response to stress, the glucocorticoid receptor gene, is linked with the development of behavior problems among preschoolers. The findings confirm that methylation appears to be an important mechanism linking early adversity to behavioral difficulties, specifically internalizing behavior problems such as irritability and social withdrawal.

Looking at development from middle childhood through young adulthood, Elena Grigorenko and colleagues conducted a 15 year

longitudinal study in which DNA methylation patterns were studied in relation to children's perceptions of the parenting they were experiencing as well as their psychological well-being and interpersonal relationships. Children's increased perception of negative parenting practices by their mothers over time was associated with epigenetic modifications. Specific epigenetic modifications, in turn, were associated with the personal adjustment and relationships of the children as young adults. According to the authors "Our study provides one of the first glimpses into the modulating role of DNA methylation in the association between parenting and children's outcomes in adulthood."

The articles in this special section are early studies that advance science by demonstrating how epigenetic methodology can be applied to important questions about children's development.

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