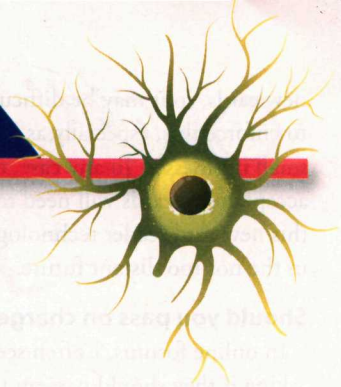

Bringing the laboratory into the office: How epigenetics can inform counseling practice

If the story being told in this article had been written 30 years ago, it might have been the focus of a creative science fiction thriller in which aliens eager to conduct experiments in gene transformation abduct thousands of humans. In this multimillion-dollar blockbuster, the humans are transported to the distant planet Xeno, where they are divided into groups, each forced to live in engineered communities designed to test the limits of genes to adapt to strange and threatening environments. The aliens find that by manipulating environments, they are indeed able to transform the function of genes and, within a single generation, create people with distinct sets of characteristics shaped by the specific experimental conditions. In the most successful experiments, the genetic transformation is carried into future generations, even when the humans are brought back to Earth.

If we fast-forward and return to 21st-century reality, we find that in the dynamic, fast-paced world of molecular genetics, what would once have been considered science fiction has become the subject of a rapidly developing field of science known more broadly as epigenetics. The term *epigenetics* is used to describe a wide array of mechanisms in which aspects of the environments around us are able to make their way into the inner reaches of our genes to manipulate, at the molecular level, who we are as human beings. What makes epigenetics so different from what was previously known about how genes work is that the actual epigenetic molecular processes that manipulate the genes do not change their actual composition — we still retain the same basic genetic code. Instead, epigenetic mechanisms work to take our existing genes and cleverly change the ways in which those genes are expressed.

The most important takeaway for counselors regarding the brave new world of epigenetics is that strategically employing appropriate counseling interventions can shape healthier genetic responses to the environment for clients. This can play a key role in both prevention and intervention, particularly in cases of trauma and chronic exposure to poverty and marginality.

Terms to know

To grasp a somewhat technical explanation of how epigenetics can inform the work of counselors, several terms are essential, including the following:

Gene: Genes, which are composed of DNA, carry the codes or blueprints that tell the body how to make the proteins that allow the body to develop and function. Each individual gene is designed to direct the building of one particular type of protein. Humans have a total of 30,000 to 40,000 genes.

Chromosome: To keep the large number of genes ordered (imagine having to sift through a sea of 40,000 genes to find the one you need at any given moment), they are joined together in a specific order to make chromosomes. Humans have 23 different chromosomes, and a specific gene (let's say for wavy or straight hair) can always be found on the same spot of the same chromosome.

Phenotype: This is the observable product of a gene. If we are looking, for example, at a gene that controls whether hair is wavy or straight, the actual appearance of the hair is considered to be the phenotype. Thus, the phenotype is a tangible, observable outcome of the gene protein product. Hair is made primarily of protein, and the protein for straight hair is slightly different from the protein for wavy hair. Often, especially in the case of human behavior controlled by genes, phenotypes are the manifestation of an array of genes, each contributing its own product to create the final phenotype. In this case, the phenotype is a patchwork of several gene products.

Central dogma: This important concept helps to explain why epigenetics represents such a dramatic scientific breakthrough. In 1956, Francis Crick, a giant figure in our current understanding of molecular genetics, asserted that the process genes use to direct the manufacture of proteins involves several steps that invariably occur in the same lockstep order. Going back to our gene that determines whether we will have straight or wavy hair, this process involves the following.

1) We are immediately faced with the dilemma that genes, which are compartmentalized in a part of the cell called the nucleus, are in a location that is incapable of actually manufacturing (aka synthesizing) proteins. This means

that we have the instructions to make a protein (in this case, either a wavy protein or a straight protein) but neither the materials nor the machinery necessary to carry out the process of protein synthesis.

2) We now have to find a way to get the instructions on how to make the protein to the actual site where proteins can be synthesized. The place in the cell where the protein is actually made is called the ribosome. Unfortunately, the gene can't leave the nucleus, so a mechanism needs to be put in place to carry the protein blueprint to the site of synthesis. The ingenious solution to this dilemma is to take the instructions from the gene and hand them over to a messenger (called messenger RNA) that takes them to the protein manufacturing machines present in the ribosomes. The process of creating the messenger is called transcription.

3) Through a complex series of molecular mechanisms, the instructions are used to put the components of the protein together to make a complete protein molecule. The process of synthesizing the protein from the RNA template is called translation. Once the messenger RNA gets to the ribosome, it actually hands the blueprint over to another type of RNA, called transfer RNA, which transfers the blueprint to the actual protein synthesis apparatus.

A firm belief lasting almost a half-century and termed the *central dogma* held that these three steps — gene, RNA, protein — which could occur only in this direction, represented the whole of gene expression.

Defying the central dogma

Now that you have sifted through the laborious details of gene expression, prepare to have everything you just learned turned on its head. In reality, the rigid sequencing in the central dogma is a dramatically simplified representation of genetic expression. This is particularly true when we talk about human behavior, especially regarding the kinds of psychological challenges that counselors encounter when clients have endured years of adversity attributable to a multitude of systemic factors such as poverty, racism and familial psychopathology.

The majority of environmentally induced psychological suffering that we encounter as mental health professionals is, in fact, the indirect outcome of multiple genes interacting with the environment through mechanisms that *defy* the central dogma. Through a variety of related processes — the best known of which is termed *epigenetics* — the environments in which we live find ways to insert themselves at the level of the gene, thus altering the quality and quantity of phenotype.

This fluid picture of phenotype is termed *phenotypic plasticity*. It is evidence that humans are truly social beings designed to quickly adapt to an array of environments simply by changing phenotypes. Although some of these changes are elegantly designed to help us survive across a wide array of environmental challenges, others impart certain phenotypic outcomes that create the kinds of psychological struggles — depression, various forms of anxiety, conduct and attention problems — typically seen in counseling practices.

It isn't necessary to understand the details, at the molecular level, of how phenotypic plasticity is achieved to appreciate epigenetics and the profound impact that environment can have on gene expression. However, a short explanation follows for readers interested in the details.

Briefly, phenotypic plasticity is achieved through the action of small extra-DNA molecules (small molecules separate from the DNA) that facilitate the dialogue between gene output and various environmental conditions (environment can include everything from the social environment to the environment within a cell). The most widely studied of these extra-DNA molecules, of which there are many, is termed a *methyl* group, which is a very tiny molecule composed of one carbon atom with three attached hydrogen atoms. In the world of molecules involved in human physiology, a methyl group can be considered a tiny giant — diminutive in stature but central to the control of genetic expression. The process of *methylation*, or attaching a methyl group to various parts of the gene, has the ability to initiate myriad changes in the gene's function. Together with other epigenetic mechanisms too numerous to mention, DNA transcription can be promoted or impeded, the message carried into the protein synthesizing apparatus can be qualitatively altered, proteins can be modified while being synthesized in the translation process and various molecules can be added to the protein after synthesis is complete (post-translational protein modification).

The influence of environmental conditions

All of this talk about environments, extra-DNA molecules, methylation and phenotypic plasticity probably seems murky at best. To get a clearer picture of how an environmental condition, particular one as broad as those that contribute to the problems seen in a counseling setting, can insert itself at the level of gene expression, it may be helpful to walk through an example.

Consider a child who has spent all of her life living under the conditions of poverty. Her family is plagued by food insecurity and intermittent homelessness. A perpetual threat of harm exists from adult and teenage criminal activity in the neighborhood, making it difficult for her to get to and from her failing school and restricting her ability to be with friends or get involved in interesting activities. Her winter clothing offers little protection against the elements. Most of the adults in her life are unemployed and living with chronic illness or addiction.

The child can make meaning out of her experiences in this environment in a number of ways. If she perceives her surroundings as a source of danger, however, this perception will set into motion a typical neuroendocrine stress response that, because of the relentless nature of the threat, will eventually become chronic (for an extended discussion of this fight-or-flight response, see the October 2014 Neurocounseling column).

It has long been established that chronic stress is toxic, but epigenetics now offers us insight into some of the psychological assaults that can accompany chronic stress. For example, we are learning from animal models that in chronic stress, brain-derived neurotropic factor (BDNF), a substance essential in neuroplasticity, is suppressed through an epigenetic mechanism that tells the BDNF genes to slow production. This suppressed BDNF is associated with the kinds of psychological symptoms — anxiety, depressed mood, social withdrawal, anhedonia — that we see in humans who are chronically stressed.

In an interesting extension of this research, the introduction of antidepressants restored the BDNF to normal levels, but the molecular damage remained when the antidepressant was withdrawn. BDNF levels thus returned to their lower premedication levels. (For a deeper understanding of some of the potential psychological outcomes of chronic stress and ways that counselors can intervene, see the March 2015 Neurocounseling column.)

Chronic stress is one of many examples of epigenetic action relevant to counseling practice. To bring the importance of epigenetics into greater focus, several compelling examples of epigenetic action are described below. Each is accompanied by a suggestion of how the knowledge concerning epigenetic action can be used to inform counseling practice. We begin with what can be considered seminal work in the field of epigenetics. It emerged as the result of a tragic twist of fate in which human good grew out of intense suffering.

The Dutch *Hongerwinter*

During World War II, in a Nazi-occupied part of the Netherlands in the winter of 1944-1945, a series of events took place that became known as the Dutch *Hongerwinter* (hunger winter). During this time, in response to attempts by the Dutch to aid Allied efforts, the Germans launched a targeted offensive in which they cut food and fuel supplies to the heavily populated western portion of the Netherlands. The area was home to some 4.5 million people who subsequently endured conditions of starvation and brutal cold. The death toll estimates from this ordeal ranged from 18,000 to 22,000 people, most of whom were elderly.

Although unquestionably tragic, the *Hongerwinter* became a laboratory for scientists interested in the long-term impact of nutritional deprivation. A group of victims who became the subject of considerable scrutiny included those who were in utero during the period of starvation. Researchers followed members of this group for longer than a half-century. The researchers found that an astonishing array of physical and mental health problems appeared in the group over time and were likely attributable to epigenetic mechanisms triggered by famine conditions. Common health problems in this population of now older adults include heart disease, stroke, hypertension, diabetes, cancers and inflammatory disorders. The mental health outcomes for this group have been equally compelling and dramatic. Depression, anxiety disorders, schizophrenia, schizotypal disorder and various dementias have all emerged at higher rates among these adults who experienced prenatal exposure to famine.

What are the implications of the Dutch *Hongerwinter* studies for counseling? Most directly, this knowledge could play

a major role in prevention. Consider, for example, the array of conditions seen in counseling practice that could result in sustained nutritional deprivation for a growing fetus. The list, which is by no means exhaustive, includes pregnant women with addictions, depression, various eating disorders, some forms of anxiety and chronic stress. Intervention addressing the psychological dimensions of these problems would be an essential component of a comprehensive management strategy by an integrated health care team that would include counseling, prenatal education and dietary consultation.

The epigenetics of trauma

The field of epigenetics holds considerable promise in our attempts to understand development of the lifelong psychological challenges related to early childhood trauma. Considerable evidence derived from animal, postmortem and other studies points to the notion that childhood trauma results in enduring epigenetic changes in neuroendocrine physiology and substances such as BDNF that typically regulate brain growth and development in ways that support emotion and cognition. Current evidence suggests that a multiplicity of epigenetic changes may result in many of the problematic emotional and behavioral patterns experienced by older children, adolescents and adults as a result of early trauma. These emotional and behavioral problems include mood disorder, conduct issues, attention problems, addiction, learning difficulties and suicidality.

Counselors working with troubled families are well-positioned to aid expectant parents and parents of young children in preventing epigenetic changes. These changes have the potential to cause lifelong emotional struggles that have a negative impact on relationships, achievement, steady employment, parenting and general well-being. Using empirically supported interventions such as interpersonal therapy or cognitive behavior therapy to help parents cope with depression and anxiety could circumvent the many maladaptive behaviors and poor parenting choices that emerge when these problems go unchecked.

Approaching at-risk parents with the knowledge that their own histories may have included early traumatic events and helping them manage some of the resulting hypervigilance and anger control issues through stress reduction techniques, anger management strategies and mindfulness could also be helpful. In addition, educating parents regarding the risks of early childhood trauma on the developing brain and providing them with appropriate referrals or resource materials related to effective parenting skills may help them to become partners in an overall strategy to protect the mental health of their children. When working with parents at risk for injurious parenting, it is also important to consider the role of substance abuse in their lapses in judgment and other limitations related to parenting.

Intergenerational trauma

Some of the most exciting work in epigenetics is uncovering ways in which the epigenetic changes resulting from

trauma can then be "inherited" by future generations. It was found, for example, that a heritable epigenetic change associated with dysregulation of the stress system was significantly lower in the offspring of healthy parents than in the children of Holocaust victims suffering from posttraumatic stress disorder.

This work has many implications related to key social justice issues that are important to counselors. For example, it offers affirmation of the notion of "posttraumatic slave syndrome," in which individuals descended from enslaved parents, even several generations later, still suffer from some of the effects of their ancestors' trauma. Likewise, children whose parents were themselves abused; offspring whose parents immigrated illegally and experienced arrest, deportation and family dissolution as a result; and children whose parents endured multiple foster placements because their own families were lost to violence, incarceration or addiction may all be at risk for inherited intergenerational trauma driven by epigenetic changes.

New frontiers in epigenetics

As the field of epigenetics grows, we will undoubtedly learn more about how environmental factors intimately control human behavior, emotion and cognition. Research that is very promising for those of us in the counseling profession involves looking at the ways that epigenetic action can be reversed through interventions that counselors commonly use. In any case, the findings emerging from laboratories during the past decade have been particularly affirming of the core counseling belief that working with an eye toward social justice has transformative power.

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