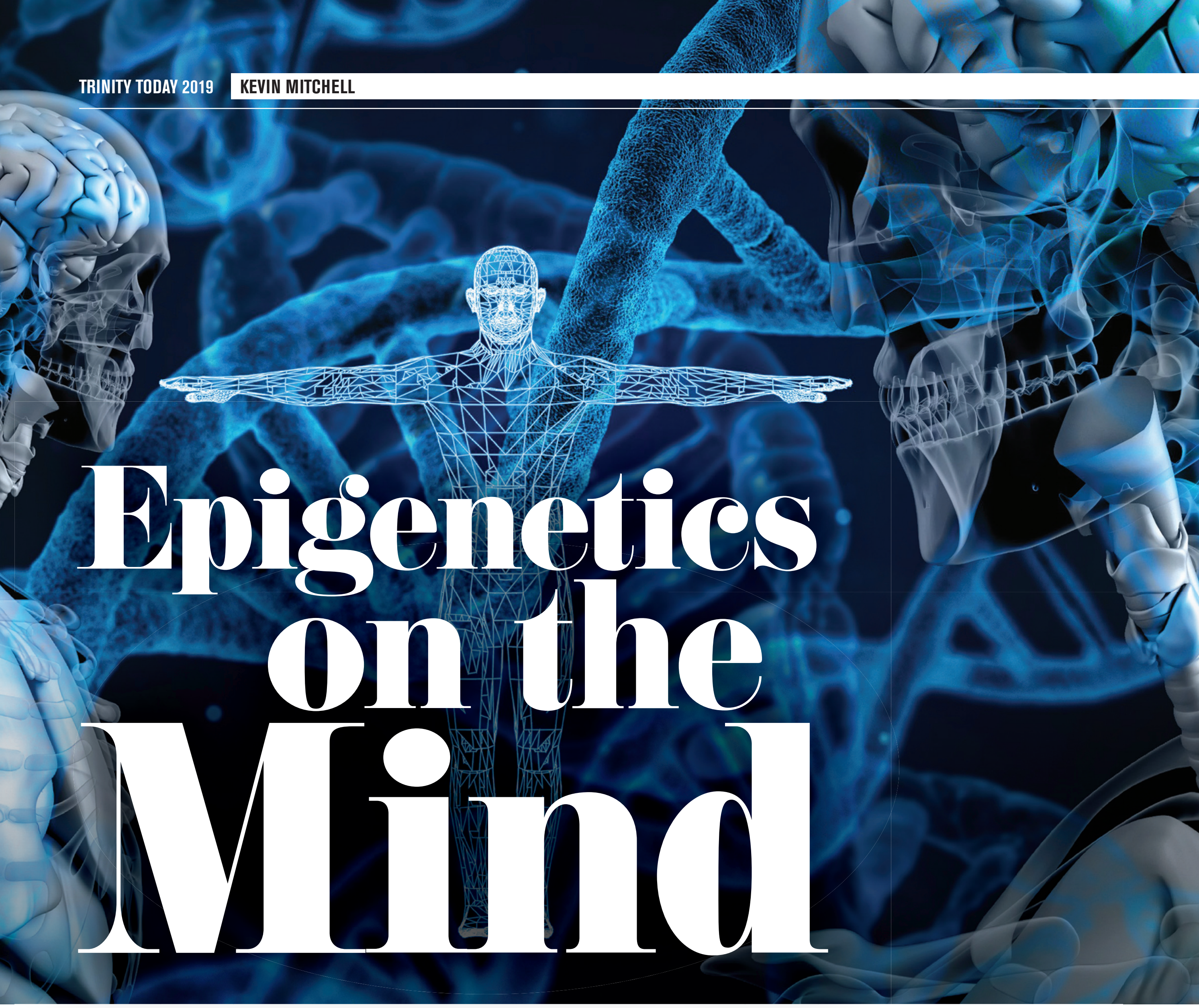


Epigenetics on the Mind

By Kevin J. Mitchell

Epigenetics is a cellular mechanism involved in the long-lasting regulation of profiles of gene expression. Does epigenetics offer an escape from genetic determinism?

In the battle of nature versus nurture, nurture has a new recruit: epigenetics. Brought in from molecular biology, epigenetics gives scientific heft to the argument that genes are not destiny. The overwhelming evidence for genetic effects on our psychological traits conjures up a fatalistic vision for many people, one in which we are slaves to our biology, not in control of our own psyche and our own behaviour. Epigenetics, a mechanism for regulating gene expression, seems to offer an escape from genetic determinism, a means to transcend our innate predispositions and change who we are.

This view is well represented by Deepak Chopra MD and Rudolph Tanzi MD, Professor of Neurology at Harvard Medical School, who write:

"Every day brings new evidence that the mind-body connection reaches right down to the activities of our genes. How this activity changes in response to our life experiences is referred to as "epigenetics". Regardless of the nature of the genes we inherit from our parents, dynamic change at this level allows us almost unlimited influence on our fate."

Epigenetic mechanisms involve packaging the DNA into active or inactive states, such that the initial profiles of gene expression put in place in the developing embryo are maintained over the lifetime of the cells.

This hope arises from research that suggests that certain types of experiences in animals can indeed result in an epigenetic mark being attached to certain genes, with long-lasting effects on behaviour. Epigenetics thus gives some mechanistic credentials to the idea that we can override or overwrite the genes that would otherwise dictate our innate traits and predispositions.

To evaluate the claims that epigenetics can break us free from our predetermined psychological traits, we need to look at the details of how our genes affect those traits, and what epigenetics really entails.

We all have encoded in our genome a programme for making a human being, with a human brain, that confers our general human nature. But that programme varies between people because of the many millions of genetic differences we all carry. So the programme for making my brain differs from the programme for making yours. And the precise way that the programme plays out varies from run to run, so the outcome differs even between genetically identical twins. Our individual nature is thus a unique variation on a general theme.

We come wired differently, with innate predispositions affecting our intelligence, personality, sexuality and even the way we perceive the world. These innate psychological traits do not necessarily determine our behaviour on a moment-to-moment basis, but they do influence it, both at any given moment and by guiding the development of our habits and the emergence of other aspects of our character over our lifetime. Can epigenetics really overwrite these genetic effects on our psychology?

In molecular biology, epigenetics refers to a cellular mechanism for controlling the expression of genes. It is particularly important for the generation of different types of cells during embryonic development. All our cells contain the same genome, with about 20,000 genes, each encoding a specific protein, such as collagen, liver enzymes or neurotransmitter receptors. Different types of cells need a different subset of those proteins to do their respective jobs. So, in each cell type, some genes are "turned on", that is, the gene is transcribed by an enzyme into messenger RNA, which is then translated into the appropriate protein. Others are "turned off", so that piece of DNA is just sitting there and the protein is not actually being made.

Photo: Paul Sharp

Associate Professor Kevin J. Mitchell

Epigenetic mechanisms involve packaging the DNA into active or inactive states, such that the initial profiles of gene expression put in place in the developing embryo are maintained over the lifetime of the cells. So it acts as a kind of cellular memory. The epigenetic state of a cell can even be passed down through cell divisions.

Unfortunately, several terms in that description are open to misinterpretation. First is the term "gene" itself. The original meaning of the word came from the science of heredity and referred to some physical thing that was passed from parents to offspring and that controlled some observable trait. We now know that genes in the sense of heredity are actually variations in the sequence of DNA coding for some protein. For example, the "gene for" sickle-cell anaemia is really a mutation in the gene that encodes the protein haemoglobin.

Second, and related, when we say a gene is "expressed" we mean that in terms of molecular biology. It may sound as though it is meant in terms of heredity, as though it refers to the effect of a genetic variation on some trait being either evident or not. But these are not at all the same thing. In reality, the relationship between expression levels of any given gene and our traits is typically highly complex and indirect. This is especially true for psychological traits.

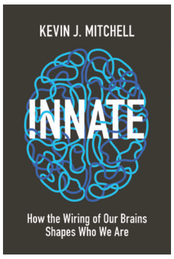
Third, the term "cellular memory" inevitably suggests that epigenetics may underlie psychological memory and so form the basis of our response to experience. Though dynamic changes in gene expression are required for the formation of memories to happen, there is no evidence that the memories themselves are stored in patterns of gene expression. Instead, they are embodied in changes in the strength of connections between nerve cells, mediated by very local, subcellular changes in neuroanatomy.

Finally, the idea that epigenetic modifications of the DNA can be "passed down" is intended in terms of cell division but makes it sound like epigenetic responses to experience can be passed down from an organism to its offspring. Though such a mechanism does exist in plants and nematodes, there is no convincing evidence that this is the case in mammals, especially not in humans.

Overall, there is thus no reason to think that epigenetic mechanisms somehow can alter our innate predispositions.

However, none of this means that we are genetically programmed automata whose behaviour is hard-wired from birth. We certainly have innate predispositions, but these provide only a baseline for our behaviour. We are, in fact, hard-wired to learn from experience – that is how we adapt to our particular circumstances and how our patterns of behaviour emerge. But this occurs through changes in our neuroanatomy, not in our patterns of gene expression.

Nor are those structures fixed. Change remains possible. We can still control our behaviour. We can work to overrule and reshape our habits. We can to some degree transcend our own subconscious inclinations. This requires self-awareness, discipline and effort. The one thing it does not require is epigenetics.



Available from Princeton University Press.

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