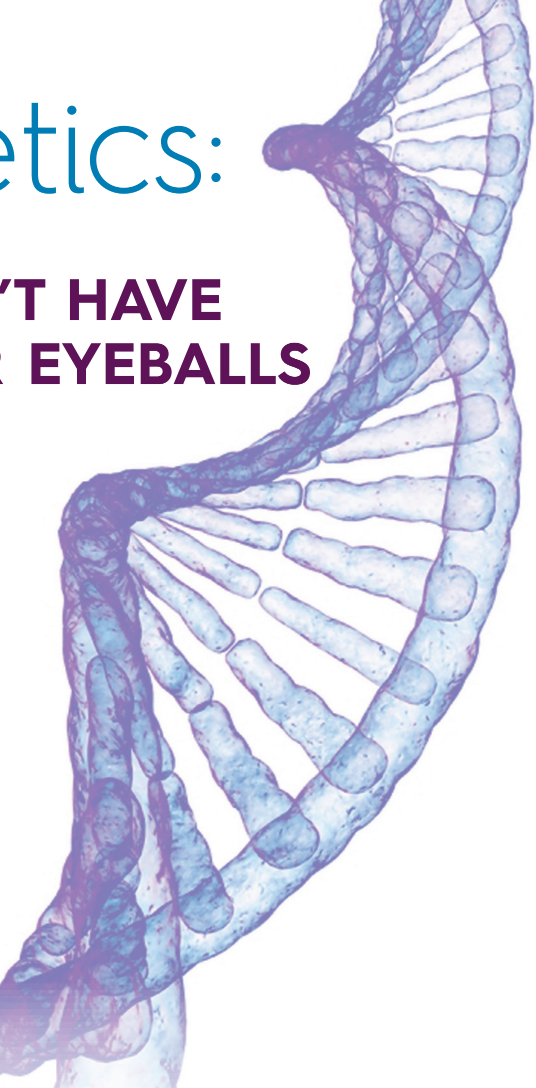
Epigenetics:

WHY YOU DON'T HAVE TEETH IN YOUR EYEBALLS



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FEBS

WELCOME TO TODAY'S EVENT

Have you ever wondered why you can tell identical twins apart, why a caterpillar looks so different from a butterfly, or how your teeth know they should grow in your mouth but never in your eyeballs?

With the study of epigenetics scientists are beginning to understand the molecular reasons behind these and many other events.

Today's speakers Bryan Turner (University of Birmingham) and Nessa Carey (Pfizer) and Chair Alice Roberts (University of Birmingham) will explore the answers to these questions and more.

We hope you enjoy the lively talks and thought-provoking discussion.

EPIGENETICS: NATURE VERSUS NURTURE

In the last century, the question of how much nature vs nurture influences our development from embryo to adult has been debated furiously. Is our development driven solely by our genetic code, or is it influenced by environmental pressures? This is the question epigenetics seeks to answer.

Imagine the genetic code as a script, outlining which genes we should express. Epigenetics is the study of how this gene expression is regulated by environmental factors.

The environmental factors can range from the signals produced by neighbouring cells in a developing embryo to pollutants in the atmosphere. The importance of epigenetics can be demonstrated by the ways in which it influences health and disease. Scientists working in epigenetics have revealed that gene regulation via epigenetics can contribute towards mental health conditions, the likelihood of developing various cancers, drug addiction and respiratory diseases, to name just a few. Epigenetics allows for our genetic script to be interpreted in many different ways. This happens because of modifications that are placed on our genes.

These modifications coat the genes and act as epigenetic tags, labelling genes which need to be turned "on" or "off". This means different genes can be expressed without affecting the genetic code.

It is not fully understood how or why epigenetic changes occur. Studies are starting to show that interactions with our environment are a contributing factor. For example, your food intake, the amount of exercise you do, if you smoke and what kind of toxins and chemicals you are exposed to can all result in epigenetic changes to our genetic material, and can thereby influence how our cells and ultimately our bodies behave.

THE POTENTIAL IMPACT OF EPIGENETICS IS ASTONISHING

The study of epigenetics has transformed our thinking about how heritability and the environment can cause disease leading to exciting possibilities for new treatments.

Until recently, many diseases such as cancer, diabetes and obesity were thought to be a result of one, two or maybe three genes, but studies have shown it could be close to 500 in some cases.

Subtle changes in the expression of these genes, as a result of different epigenetic modifications, can alter the patterns of gene expression in a tumour. By understanding how and what genes affect these diseases, we can start to treat them properly. There are already some drugs licensed for use in specific cancers which work by targeting epigenetic changes, and others are in development.

One way scientists have been trying to understand and monitor epigenetics, is by observing identical twins. Identical twins are conceived from a single egg, so they have the same genome. This makes them ideal candidates for genetic and epigenetic studies. By studying the epigenetic variation between twins, scientists are hoping to answer a question that has puzzled us for centuries. Since twins have identical DNA, why do we frequently find that only one twin in a pair develops a disorder such as cancer or schizophrenia, even when the two people have been raised in a really similar environment?

Heritability

These studies have raised further questions, such as how heritable are epigenetic modifications? During the Dutch Hunger Winter (November 1944-May 1955) a bitter cold descended on towns and cities already devastated by war, drastically reducing food supply. In the western Netherlands, still occupied by German forces, food was so scarce the residents there were surviving on 30 percent of the normal caloric intake. The survivors of this catastrophe have been monitored over the years and scientists have been able to study the long term effects of malnutrition on the population.

Women in the last months of pregnancy during the famine gave birth to smaller babies. Astonishingly, these babies remained small all their lives and showed lower rates of obesity. The effects of malnutrition remained with them throughout their lives. Conversely, children born to mothers malnourished at the start of pregnancy showed higher rates of obesity compared to the rest of the population. Further studies revealed the grandchildren of mothers malnourished in early pregnancy showed these same effects. Similarly, a case study in Cambodia focussing on mothers exposed to starvation during early pregnancy show their children are more likely to develop diabetes. Studies like these suggest some epigenetic changes are heritable and can be passed on to subsequent generations.

Cancer

Scientists have also identified links between epigenetics and cancer. Genetic mutations and epigenetic changes, whether working separately or together, can lead to the inappropriate function of genes responsible for promoting or inhibiting cell growth. Control over cell growth is lost and this results in the development of cancer. Recently, scientists at Baylor College of Medicine have released the results of a study focussing on the methylation of gene P16 in mice. As the mice aged, increased methylation of P16 resulted in an increase of cancers and reduced survival. By discovering which genes affect various cancers and whether their expression is brought about by genetics or epigenetics, improvements to the prevention and treatment of cancer could be achieved.

Medicine

Unlike genetic mutations, epigenetic changes are potentially reversible. Currently, researchers are working towards developing DNA demethylating agents such as Azacitidine as anti-cancer drugs, amongst other potential treatments.

Large scale projects such as the Human Epigenome Project aim to “identify, catalogue and interpret genome-wide DNA methylation patterns of all human genes in all major tissues.” In doing this, scientists hope to uncover how genetics, the environment and disease are linked to further our understanding and diagnosis of human disease.

FIND OUT MORE

To find out more about this fascinating field of study visit:

Johns Hopkins University: http://epigenetics.jhu.edu/

Human Epigenome Project: http://www.epigenome.org/index.php

Nessa Carey: http://www.nessacarey.co.uk/

The Biochemical Society blog:
http://biochemicalsociety.wordpress.com/2013/01/15/epigenetics-beautiful-science/