



## Exploring Epigenetics

### Teacher Notes: The Scientific Investigator

#### Overview

This on-line interactive animation allows students to complete a laboratory investigation into epigenetic changes affected by the environment. They use scientific skills of observation and data interpretation, then synthesise an understanding of how environmental factors influence epigenetic modifications, in turn affecting the heritable phenotype of mice.

After modelling how epigenetic modifications can alter transcription and therefore gene regulation, this on-line interactive animation provides an opportunity for students to use their scientific skills and work like a scientist to discover what epigenetic changes to gene regulation might look like in the laboratory.

Students can access the on-line, interactive 'Scientific Investigator' [here](#).

The animation consists of 4 parts:

1. An **introduction** to the field that they will be working in, their role and aim
2. A **simple experiment** to introduce the way students can analyse results
3. An **advanced experiment** where students can alter the environment and analyse results
4. A **report screen** where students can enhance their scientific literacy skills by summarising the variables, their observations and interpretations for printing

To assess student understanding and skills in scientific literacy, students can print their report summary for self-assessment / peer-assessment, or submit their report as a teacher-assessed piece of work. There are also Multiple Choice Questions provided in a downloadable document that can be used to assess student understanding. (MCQ answers are at the end of this document).

#### Learning objectives

Recall:

- (1) Epigenetic modifications do not alter DNA sequence
- (2) The environment does affect the type and location of epigenetic modifications

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## Preparation

Students will need access to a computer. The website should allow students access to the interactive animation through all modern browsers (Chrome, Firefox, Safari).

**Make sure that students are aware of the school postcode, as they will need to enter this to enable access.**

## Expected outcomes

In the final part of the interactive on-line animation, students complete a report summarising their findings. You can choose for these to be self-assessed, peer-assessed or teacher-assessed. Ideas of the content that students should include in their report are given below.

Students are intended to analyse the experimental data, enabling them to articulate:

- Variables (independent and dependent)
- Observations
- Interpretation of DNA sequence, based on experimental data and scientific understanding
- Interpretation of epigenetic modifications, based on experimental data and scientific understanding



## Task set at the end of the interactive, online animation

Can you now explain to 'The Principal Investigator' what caused the incredible difference in phenotype of the mice born to Abby and Tasha, mice from the same litter, mated with the same male? Make sure you use scientific language in your answers, including words like DNA sequence, epigenetic modification, DNA methylation, phenotype, genotype, transcription and environment.

### Variables

- **The independent variables.** There were 3 possible environmental variables to explain the different phenotypes of offspring from the 2 mice:
  - (i) diet of green vegetables or pellets,
  - (ii) material of water bottle being glass or plastic, and
  - (iii) position in light or dark.
- **The dependent variables.** There were 2 changes to the appearance of offspring:
  - (i) fur colour of brown or yellow, and
  - (ii) normal weight or overweight.

### Observations

- **Observations of phenotypes.** Offspring from the mouse (Tasha) given green vegetables, a glass water bottle and kept by the window were brown and a healthy weight. Offspring from the mouse (Abby) were yellow and overweight.
- **Observation of DNA sequence.** The sequence of the Agouti gene is unchanged by any of the environments in any of the mice.
- **Observation of epigenetic modifications 1.** In the brown mice of normal weight the Agouti gene is methylated.
- **Observation of epigenetic modifications 2.** Both a diet of pellets and a water bottle made of plastic (containing bisphenol A) cause a reduction in methylation and result in yellow, overweight offspring.
- **Observation of epigenetic modifications 3.** Whether mice are kept in the light or dark makes no difference, the Agouti gene is methylated.
- **Observation of epigenetic modifications 4.** The maternal environment can alter DNA methylation in offspring.

### Interpretation of DNA sequence

- **Understanding of genotype.** The Agouti gene is involved in determining both fur colour and weight in mice.
- **Interpretation of DNA sequence.** A change (mutation) to the Agouti gene is not responsible for the phenotypic differences.

**\*LO1\* Epigenetic modifications do not alter DNA sequence**



## Interpretation of epigenetic modifications

- **Understanding of DNA methylation.** Increased DNA methylation prevents transcription factors from binding to DNA and decreases acetylation of histones. Both of these mechanisms reduce or prevent transcription.
- **Interpretation of epigenetic modifications 1.** In mice of normal phenotype (brown and normal weight) the Agouti gene is methylated. This prevents transcription factors from binding to DNA and / or decreases acetylation of histones, which means that transcription will be reduced or prevented, and the Agouti gene will not be expressed.
- **Interpretation of epigenetic modifications 2.** When fed an unusual diet for mice (pellets), or when given a water bottle made of plastic (containing bisphenol A) there is a reduction in methylation of the Agouti gene. This will allow transcription factors to bind to DNA and / or increase histone acetylation, meaning that Agouti gene is expressed, making the offspring yellow and overweight.

### \*LO2\* The environment affects the type and location of epigenetic modifications.

- **Interpretation of epigenetic modifications 3.** Whether mice are kept in the light or in the dark does not affect the methylation of the Agouti gene, which remains methylated. This prevents transcription factors from binding to DNA and / or decreases acetylation of histones, which means that transcription will be reduced or prevented, and the Agouti gene will not be expressed under both of these conditions.
- **Interpretation of epigenetic modifications 4.** To fully understand how the maternal environment alters DNA methylation in offspring, students will need to extend their reading. If you have students who wish to learn more than there is great information about this on a number of websites, including: <https://learn.genetics.utah.edu/content/epigenetics/nutrition/>  
<https://www.nature.com/scitable/topicpage/obesity-epigenetics-and-gene-regulation-927>  
Simply put, the developing embryo has greater variation in levels of DNA methylation in response to environmental variables, compared with the mother's cells. So the conditions encountered by the mother during pregnancy, will affect the level of DNA methylation, and consequently gene expression, in their offspring.

### \*LO2\* The environment affects the type and location of epigenetic modifications

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## MCQs (with answers) for the end of the interactive, online animation

In this experiment, which of the environmental variables altered the Agouti gene sequence?

- Diet
- Water bottle material
- Placement of cage in light / dark
- None of the above

In this experiment, which of the environmental variables altered the Agouti epigenetic modifications? (Choose all that apply)

- Diet
- Water bottle material
- Placement of cage in light / dark
- None of the above

What was the phenotype of the offspring when the mother was fed on green vegetables, used a glass water bottle and was kept by the window?

- Brown and overweight
- Brown and healthy weight
- Yellow and overweight
- Yellow and healthy weight

What was the phenotype of the offspring when the mother was fed on pellets, used a plastic water bottle (containing bisphenol A) and was kept in the dark?

- Brown and overweight
- Brown and healthy weight
- Yellow and overweight
- Yellow and healthy weight

How did the epigenetic modifications in brown mice of healthy weight affect their expression of the Agouti gene?

- Most of DNA methylated, reducing Agouti gene expression
- Most of DNA methylated, increasing Agouti gene expression
- Little DNA methylation, reducing Agouti gene expression
- Little DNA methylation, increasing Agouti gene expression

How did the epigenetic modifications in yellow, overweight mice affect their expression of the Agouti gene?

- Most of DNA methylated, reducing Agouti gene expression
- Most of DNA methylated, increasing Agouti gene expression
- Little DNA methylation, reducing Agouti gene expression
- Little DNA methylation, increasing Agouti gene expression