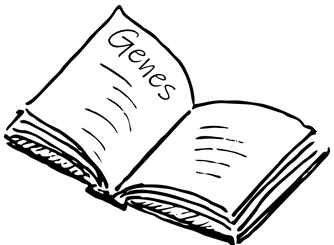
**Genes**

**Part 1**

Some children have been learning about genes.



The table shows some of their notes about genes.

Some of the notes are **right** and some are **wrong**.

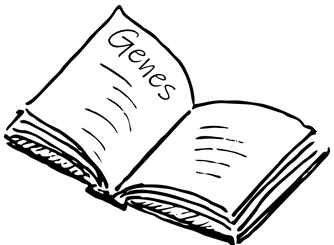
Tick **one** box for each note.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Note** | | I am **sure** this is right | I **think** this is right | I **think** this is wrong | I am **sure** this is wrong |
| **1** | Genes and characteristics are the same thing. |  |  |  |  |
| **2** | Genes are made of genetic information. |  |  |  |  |
| **3** | Genes are regions of the DNA in your genome. |  |  |  |  |

**Genes**

**Part 2**

Some children have been learning about genes.



The table shows some of their notes about genes.

Some of the notes are **right** and some are **wrong**.

Tick **one** box for each note.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Note** | | I am **sure** this is right | I **think** this is right | I **think** this is wrong | I am **sure** this is wrong |
| **1** | Genes are particles that carry your characteristics. |  |  |  |  |
| **2** | Genes are turned into proteins, carbohydrates and fats. |  |  |  |  |
| **3** | The information coded in genes is used by cells as instructions. |  |  |  |  |
| **4** | The sequence of chemicals in genes tells a cell how to make proteins. |  |  |  |  |

*Biology> Big idea BHL: Heredity and life cycles > Topic BHL1: Inheritance and the genome > Key concept BHL1.2: The structure and function of the genome*

|  |
| --- |
| **Diagnostic question** |
| **Genes** |

**Overview**

|  |  |
| --- | --- |
| Learning focus: | The structure and function of organisms depends on proteins made by cells using instructions stored in the DNA of the genome. |
| Observable learning outcome: | Apply the idea that cells use the information coded in regions of the genome called genes as instructions to make structural and functional proteins. |
| Question type: | Confidence grid |
| Key words: | gene, genome, DNA |

**What does the research say?**

Lewis and colleagues (Lewis, Leach and Wood-Robinson, 2000; Wood-Robinson, Lewis and Leach, 2000; Lewis and Kattmann, 2004) have reported common misunderstandings about genes in school children, including that genes and characteristics/traits are the same thing (e.g. ‘blue eyes’ is a gene) and that genes are ‘particles’ that carry a characteristics/trait.

Discussions of the problems with the “gene concept” and their implications for biology education have appeared in the science education research literature (e.g. Meyer, Bomfim and El-Hani, 2013). In brief, the classical molecular gene concept defines a gene as a stretch of DNA that encodes a functional product, specifically a single protein (polypeptide chain) or RNA molecule. This concept of the gene as a structural, functional and informational unit sits well with the Mendelian idea of heritable ‘factors’ or ‘units’ that determine traits, and is still widely taken as fact in school classrooms, textbooks, and public consciousness. However, it has been questioned in light of discoveries such as overlapping and nested genes, the important roles of regions of non-coding DNA in regulating gene expression, and mechanisms such as alternative splicing and mRNA editing that enable one-to-many relationships between a ‘gene’ and several different products.

It may be appropriate to discuss these discoveries – and the “gene concept” debate itself – with older students, for example from age 16 (Department for Education, 2014). However, care should also be taken when exploring ideas about genes with students at age 11-14, to avoid introducing or reinforcing misunderstandings that will be difficult to overcome later. For example, genes could be described in a way that does not imply that they are discrete segments, units or particles of DNA; the notion of the one-gene-one-protein relationship could be avoided; and a pro-genomic view promoted by exploring the idea that multiple coding and non-coding regions of the genome are important in making proteins that affect the structure and function of organisms.

**Ways to use this question**

Students should complete the confidence grid individually. This could be a pencil and paper exercise, or you could use the presentation with an electronic voting system or mini white boards.

*Differentiation*

You may choose to read the statements to the class, so that everyone can focus on the science. In some situations it may be more appropriate for a teaching assistant to read for one or two students.

**Expected answers**

*Part 1*

1. Genes and characteristics are the same thing – **wrong** (genes are regions of DNA that can affect our characteristics)
2. Genes are made of genetic information – **wrong** (genetic information is encoded in genes, they are not made of it)
3. Genes are regions of the DNA in your genome – **right**

*Part 2*

1. Genes are particles that carry your characteristics – **wrong** (genes are regions of DNA that can affect our characteristics)
2. Genes are turned into proteins, carbohydrates and fat – **wrong** (cells use the information coded in genes as instructions to make proteins)
3. The information coded in genes is used by cells as instructions – **right**
4. The sequence of chemicals in genes tells a cell how to make proteins – **right**

**How to respond - what next?**

If there is a range of answers, you may choose to respond through structured class discussion. Ask one student to explain why they gave the answer they did; ask another student to explain why they agree with them; ask another to explain why they disagree, and so on. This sort of discussion gives students the opportunity to explore their thinking and for you to really understand their learning needs. Responses often work best when the activities involve paired or small group discussions, which encourage social construction of new ideas through dialogue.

Researchers have used constructivist approaches that enable students to build their own explanations of the structure and function of the genome, which may help to develop students’ understanding and overcome misconceptions, including the use of group discussions and concept mapping (Okebukola, 1990). If students have misunderstandings about the relationship between genes, proteins and characteristics, the following BEST ‘response activity’ describes a small group discussion activity that could be used in follow-up to this diagnostic question:

* Response activity: From genes to characteristics

**Acknowledgments**

Developed by Alistair Moore (UYSEG).

Images: pixabay.com/b0red (2497249) (modified by UYSEG)

**References**

Department for Education (2014). *GCE AS and A level subject content for biology, chemistry, physics and psychology (DFE-00356-2014),* London, UK.

Lewis, J. and Kattmann, U. (2004). Traits, genes, particles and information: re-visiting students' understandings of genetics. *International Journal of Science Education,* 26(2)**,** 195-206.

Lewis, J., Leach, J. and Wood-Robinson, C. (2000). All in the genes? Young people's understanding of the nature of genes. *Journal of Biological Education,* 34(2)**,** 74-79.

Meyer, L., Bomfim, G. and El-Hani, C. (2013). How to understand the gene in the twenty-first century? *Science & Education,* 22(2)**,** 345-374.

Okebukola, P. A. (1990). Attaining meaningful learning of concepts in genetics and ecology: an examination of the potency of the concept-mapping technique. *Journal of Research in Science Teaching,* 27(5)**,** 493-504.

Wood-Robinson, C., Lewis, J. and Leach, J. (2000). Young people's understanding of the nature of genetic information in the cells of an organism. *Journal of Biological Education,* 35(1)**,** 29-36.