*Biology> Big idea BVE: Variation, adaptation and evolution > Topic BVE1: Variation*

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| **Key concept (age 11-14)** |
| **BVE1.1: Differences within species** |

**What’s the big idea?**

A big idea in biology is that there is a great diversity of organisms, living and extinct, with many similarities and differences between them. The diversity of organisms is the result of evolution by natural selection.

**How does this key concept develop understanding of the big idea?**

This key concept helps to develop the big idea by developing understanding that there is variation within populations of a species – a fundamental concept underpinning the idea of natural selection.

The conceptual progression starts by checking understanding of what is meant by a species. It then supports the development of ideas about variation within a species, and progresses on to understanding of heritable variation (a necessary foundation for moving on to explore natural selection as an explanation for the evolution of species).

**Using the progression toolkit to support student learning**

Use diagnostic questions to identify quickly where your students are in their conceptual progression. Then decide how to best focus and sequence your teaching. Use further diagnostic questions and response activities to move student understanding forwards.

**Progression toolkit: Differences within species**

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| **Learning focus** | There is variation between individuals of the same species, caused by differences in the genomes, lifestyles and environments of the individuals. | | | | |
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| **As students’ conceptual understanding progresses they can:** | **C o n c e p t u a l p r o g r e s s I o n** | | | | |
| Recognise what is meant by a ‘species’. | Recognise that there are differences between individuals within a species, and this is called variation. | Identify sources of variation, including differences in the genomes, lifestyles and environments of individuals. | Distinguish between continuous and discontinuous variation. | Apply the idea that only genetic variation can be inherited. |
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| **Diagnostic questions** | What is a species? | Variation | What causes variation? | Continuous and discontinuous variation | Heritable variation? |
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| **Response**  **activities** | Ideas about species | Observing and explaining variation | | Measuring variation |  |

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| Key: | | | |
| **P** | Prior understanding from earlier stages of learning | **B** | Bridge to later stages of learning |

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| **What is a species?** | **Variation** | **What causes variation?** | **Continuous and discontinuous variation** | **Heritable variation?** |
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| Confidence grid | Two-tier multiple choice | Focussed cloze | Focussed cloze | Two-tier multiple choice |
| **Ideas about species** | **Observing and explaining variation** | **Measuring variation** |  |  |
|  |  |  |  |  |
| Talking heads, discussion | Challenge to thinking, discussion | Practical investigation, numeracy |  |  |

**What’s the science story?**

There is variation between individual organisms of the same species, which can be described as continuous or discontinuous. Variation can be caused by differences in the genome, lifestyle and interactions with the environment. Only variation caused by differences in the genome can be inherited.

**What does the research say?**

*The species concept*

Developing scientific understanding of variation, classification and evolution requires students to understand the concept of a species. Students at age 11 are likely to be familiar with the term ‘species’ from earlier stages of education (AAAS Project 2061, 2009) and from their everyday experiences, for example from reports about endangered species and conservation. They will have formed their own conceptions of what is meant by a ‘species’, which may or may not align with scientific explanations or usage of the term. Researchers have reported that the term ‘species’ is often used in school science lessons without any explanation of what it means (Ellis and Wolf, 2010).

Many students distinguish between species based solely on visible differences (Jiménez-Tejada, Sánchez-Monsalve and González-García, 2013). There is considerable debate amongst biologists about how to define ‘species’. This debate is rarely acknowledged in school classrooms and textbooks, and ‘species’ is usually defined unproblematically in these settings using what is known as the ‘biological species concept’ – i.e. “a group of organisms that can breed to produce fertile offspring” (Ellis and Wolf, 2010). Biologists have offered many definitions of ‘species’ over many decades, but there are some overarching concepts, including (adapted from Ellis and Wolf, 2010):

* a species is a set of morphologically and genetically similar organisms, living in one or more populations;
* the individuals within the population(s) of a species do or can reproduce to make fertile offspring;
* a species has a separate line of descent from a common ancestor, and its own evolutionary trajectory [or, put more simply, the characteristics of the organisms in a species change (evolve) over many generations, separately to those of other species].

Researchers have recognised that the underlying reasons for the species debate, and many of the alternative species definitions offered, may be too complex to grapple with in school settings, but that it may be useful to widen the traditional definition to encompass the ideas presented in the bullet points above. It has been suggested (e.g. by Chung, 2004) that it may be helpful to acknowledge, even in introductory courses, that the above ideas are *one* useful way of defining a species, but other useful definitions are also sometimes used; this will better prepare students to engage with the species concept debate later. It has also been suggested that acknowledging how biologists have debated and changed their definition of species over time based on evidence may be a useful context for leaning about the nature of science (Nyléhn and Ødegaard, 2018).

*Variation*

Like ‘species’, the term ‘variation’ has different meanings and usage in everyday language and in biology. In the everyday sense, the term ‘variation’ refers to differences between things; it is common for students up to age 11 to use the term ‘variation’ in its everyday sense to refer to differences *between species* (Allen, 2014). However, strictly speaking, in biology the term ‘variation’ refers specifically to differences between individuals *within* a species.

Various researchers have described common misunderstandings about variation and its causes, which can persist in students up to undergraduate level, including that:

* while there are differences between species, there is no variation between individuals of the *same* species; or that a species has a uniform ‘type’ or an essential ‘essence’, and variation among individual members of the species is an anomalous or unimportant deviation from this norm (Shtulman, 2006; Gregory, 2009; Emmons and Kelemen, 2015);
* variation is only caused by environmental factors (students are much less likely to suggest sexual reproduction, inheritance or differences in the genome as causes of variation, even when given a scenario in which environmental conditions are said to remain constant) (Deadman and Kelly, 1978; Hackling and Treagust, 1982; Gott et al., 1985);
* teleological arguments such as that variation occurs to satisfy a need, or in order to improve (Deadman and Kelly, 1978);
* acquired characteristics (variation resulting from interaction with the environment or from learning) can be passed from parents to offspring (Cisterna, Williams and Merritt, 2013).

Gregory (2009) summarises numerous studies in which it was found that when students of various ages were asked to explain evolution by natural selection, very few explicitly included ideas about variation within species (a fundamental requirement for evolution by natural selection, in which the natural variation within populations of a species can cause some individuals to have a survival and therefore reproductive advantage when environmental conditions change).

**Guidance notes**

Students should be familiar with the ideas developed in key concept BHL1.1 *Heredity and genetic information* before they attempt the diagnostic questions “What causes variation?”, “Continuous and discontinuous variation” and “Heritable variation?“.

**References**

AAAS Project 2061. (2009). *Benchmarks for Science Literacy* [Online]. Available at: <http://www.project2061.org/publications/bsl/online/index.php>.

Allen, M. (2014). *Misconceptions in Primary Science, Second* ednBerkshire, UK: Open University Press.

Chung, C. (2004). The species problem and the value of teaching the complexities of species. *American Biology Teacher,* 66(6).

Cisterna, D., Williams, M. and Merritt, J. (2013). Students' understanding of cells & heredity: patterns of understanding in the context of a curriculum implementation in fifth & seventh grades. *American Biology Teacher,* 75(3)**,** 178-184.

Deadman, J. A. and Kelly, P. J. (1978). What do secondary school boys understand about evolution and heredity before they are taught the topics? *Journal of Biological Education,* 12(1)**,** 7-15.

Ellis, M. and Wolf, P. (2010). Teaching "species". *Evolution: Education and Outreach,* 3**,** 89-98.

Emmons, N. A. and Kelemen, D. A. (2015). Young children's acceptance of within-species variation: implications for essentialism and teaching evolution. *Journal of Experimental Child Psychology,* 139**,** 148-160.

Gott, R., et al. (1985). Science in Schools: Ages 13 and 15. Report No. 3. *Assessment of Performance Unit.* Department of Education and Science, HMSO, London, UK.

Gregory, T. R. (2009). Understanding natural selection: essential concepts and common misconceptions. *Evolution: Education and Outreach,* 2**,** 156-175.

Hackling, M. W. and Treagust, D. F. (1982). What lower secondary students should understand about the mechanisms of inheritance, and what they do understand following instruction. *Research in Science Education,* 12**,** 78-88.

Jiménez-Tejada, M.-P., Sánchez-Monsalve, C. and González-García, F. (2013). How Spanish primary school students interpret the concepts of population and species. *Journal of Biological Education,* 47(4)**,** 232-239.

Nyléhn, J. and Ødegaard, M. (2018). The “species” concept as a gateway to nature of science. *Science & Education,* 27(7/8)**,** 685-714.

Shtulman, A. (2006). Qualitative differences between naïve and scientific theories of evolution. *Cognitive Psychology,* 52(2)**,** 170-194.