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

|  |
| --- |
| **Key concept (age 11-14)** |
| **BVE1.2: Changes in species over time – fossil evidence** |

**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 building understanding that the fossil record provides evidence that the characteristics of species change over time.

The conceptual progression starts by checking understanding of what can be learnt about organisms that lived long ago from fossil evidence. It then supports the development of understanding of how the fossil record provides evidence that species change over time, and why there are limitations to the conclusions and explanations that can be made from fossil evidence.

**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: Changes in species over time – fossil evidence**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Learning focus** | The fossil record provides evidence that species change over time, but it is incomplete and there are limitations to the conclusions that can be drawn from it. | | | | |
|  |  |  |  |  |  |
| **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** | | | | |
| Recall that fossils provide evidence about organisms from long ago and their habitats.  **P** | Recall that fossils are between ten thousand and billions of years old. | Recognise that all fossils are the mineralised remains of once-living organisms or of traces left behind by once-living organisms. | Explain how the fossil record provides evidence that species change over time. | Explain why there are limitations to the conclusions and explanations that can be made from fossil evidence. |
|  |  |  |  |  |  |
| **Diagnostic questions** | How do we know? | How old are fossils? | Could it become a fossil? | The fossil record | *Archaeopteryx* |
| What can we learn from fossils? | Billions of years |
|  |  |  |  |  |  |
| **Response**  **activities** | The year of life | | Fossilisation |  | *Stegosaurus* |

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **How do we know?** | **What can we learn from fossils?** | **How old are fossils?** | **Billions of years** | **Could it become a fossil?** |
|  |  |  |  |  |
| Simple multiple choice | Confidence grid | Simple multiple choice | Simple multiple choice | Two-tier multiple choice |
| **The fossil record** | ***Archaeopteryx*** | **The year of life** | **Fossilisation** | ***Stegosaurus*** |
|  |  |  |  |  |
| Linking ideas | Confidence grid | Challenge to thinking, discussion | Ordering/Sequencing, discussion | Discussion |

**What’s the science story?**

There is variation between individual organisms of the same species, caused by differences in the genome, lifestyle and interactions with the environment.

Fossils provide evidence about organisms that lived and died tens of thousands to billions of years ago. The fossil record provides evidence that the characteristics of species change over time, and that many species that once existed are now extinct. The fossil record is incomplete, and there are limitations to the conclusions that can be drawn from it.

**What does the research say?**

*Learning about fossils*

Numerous authors have recognised that young children find fossils interesting and thus that fossils can be used to increase student engagement in learning about evolution (e.g. Earland, 2004; Borgerding and Raven, 2018; Hunter et al., 2018). It has also been reported that experience of examining real fossils in the classroom and in the field can increase engagement and learning of concepts (e.g. Clary and Wandersee, 2009; Anderson et al., 2016; Teske and Pittman, 2016). Some authors have noted that fossils provide a useful context for leaning about the nature of science, e.g. collecting evidence, making observations, and making inferences from evidence (e.g. Gift and Krasny, 2003; Balmer, 2015).

There is limited research into children’s understanding (and misunderstandings) of fossils, but Borgerding and Raven (2018) report findings from work with younger children (up to 6 years old), including:

|  |  |
| --- | --- |
| **Commonly understood:** | **Less commonly understood:** |
| * Fossils are not alive. * Fossils are found underground. * Inferences about body shape and size can be made from fossils. * Inferences about the habitats of fossilised organisms can be made from the locations in which fossils are found. | * All fossils are the mineralised remains (or traces) of organisms that were once alive. (This was especially problematic in the case of fossilised plants, perhaps because the children were not sure that plants are living organisms). * Things other than bones and shells can become fossilised. * Non-mineralised remains such as skeletons are not fossils. * The relative and absolute ages of fossils. |

*Understanding timescales*

Learning about fossils and evolution requires students to appreciate the timescales involved. Studies have found that children understand relative time (including the concepts of ‘before’ and ‘after’) long before they understand absolute time (e.g. historical dates) (Ault, 1982; Barton and Levstik, 1996). Research has suggested that children at age 10-11 find it difficult to appreciate the absolute ages of fossils and the species they relate to; for example, one study found that when children of this age were asked to estimate when dinosaurs lived, answers ranged from “1000 years ago” to “millions of years ago”, and this could be down to guessing due to the children’s limited understanding of large numbers (Trend, 1998). Another study found significant differences between the abilities of 14-18 year-olds and 12-14 year-olds to use diachronic thinking (i.e. to place an object or event in time and then to think about how it changes over time) within geological timescales (Dodick and Orion, 2003).

*Fossils and species*

Teaching about fossils will inevitably include references to various species. There is considerable debate amongst biologists about how to define the concept of ‘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.

The third bullet point, above, builds on the idea that the characteristics of the organisms in a species change (evolve) over many generations. This idea can be introduced and developed with students at age 11-14 using evidence from fossils, including through the comparison of fossilised and extant organisms (Ingram, 2011; Teske and Pittman, 2016).

**References**

Anderson, A. E., et al. (2016). Students explore fossil creatures of the Cambrian Period Burgess Shale through model-making. *Journal of STEM Arts, Crafts, and Constructions,* 2(1)**,** 32-57.

Ault, C. J. (1982). Time in geological explanations as perceived by elementary-school students. *Journal of Geological Education,* 30**,** 304-309.

Balmer, D. (2015). A fossil-based enquiry day stimulates children to think scientifically. *Primary Science,* (136)**,** 23-25.

Barton, K. C. and Levstik, L. S. (1996). “Back when God was around and everything”: Elementary children's understanding of historical time. *American Educational Research Journal,* 33**,** 419-454.

Borgerding, L. A. and Raven, S. (2018). Children's ideas about fossils and foundational concepts related to fossils. *Science Education,* 102(2)**,** 414-439.

Clary, R. M. and Wandersee, J. H. (2009). Incorporating informal learning environments and local fossil specimens in earth science classrooms: a recipe for success. *Science Education Review,* 8(2)**,** 47-57.

Dodick, J. and Orion, N. (2003). Cognitive factors affecting student understanding of geologic time. *Journal of Research in Science Teaching,* 40**,** 415–442.

Earland, S. (2004). Researchers in Residence put the fun back into science: learning from the fossil record. *School Science Review,* 85**,** 63-70.

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

Gift, N. and Krasny, M. (2003). The great fossil fiasco: teaching about peer review. *American Biology Teacher,* 65**,** 270-78.

Hunter, J. C., et al. (2018). Capitalizing on pre-existing student engagement with fossils: a gateway to generate student interest, participation, and learning. *Education,* 139(1)**,** 19-37.

Ingram, N. (2011). Classification, variation, adaptation and evolution. In Reiss, M. (ed.) *Teaching Secondary Biology.* 2nd ed. London, UK: Hodder Education.

Teske, J. K. and Pittman, P. J. Z. (2016). Eighth graders explore form and function of modern and fossil organisms. *Journal of STEM Arts, Crafts, and Constructions,* 2(1)**,** 79-94.

Trend, R. (1998). An investigation into understanding of geological time among 10- and 11-year-old children. *International Journal of Science Education,* 20**,** 973–988.