*Biology> Big idea BOE: Organisms and their environments > Topic BOE1: Interdependence of organisms*

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| **Key concept (age 11-14)** |
| **BOE1.1: Food chains and food webs** |

**What’s the big idea?**

A big idea in biology is that all organisms, including humans, depend on, interact with and affect the environments in which they live and other organisms that live there.

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

This key concept helps to develop the big idea by exploring how feeding relationships within a community of organisms can be modelled using food chain and food web diagrams.

The conceptual progression starts by checking understanding of depictions of food chains, including the significance of the order of organisms and the meaning of the arrows. It then supports the development and use of food webs depicting multiple interconnected food chains, to enable understanding of how changes in populations can through food webs to affect populations in the whole community.

**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: Food chains and food webs**

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| **Learning focus** | Feeding relationships within a community of organisms can be modelled using food chain and food web diagrams. | | | | |
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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** | | | | |
| Explain the order of organisms in a given food chain, using ideas about producers, consumers, predators and prey.  **P** | Explain that the arrows in a food chain diagram represent transfers of biomass from producer to consumer, or from prey to predator. | Recognise that the words and pictures in a food chain diagram represent populations of organisms in a community. | Recognise that food web diagrams represent several interconnected food chains within a community of organisms. | Use a food web diagram to predict and explain effects that a change in the size of a population could have on other populations in the same community. |
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| **Diagnostic questions** | Food chain (1) | Links in the chain | How many organisms? | Food web | Through the food web |
| Food chain (2) |
| What do the arrows mean? | Populations and communities |
| Bottom of the food chain |
|  |  |  |  |  |  |
| **Response**  **activities** | Build a food chain | |  | Food web discussion | Food web role play |
| Breakfast food chains | | Food web art! |

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

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| **Food chain (1)** | **Food chain (2)** | **Bottom of the food chain** | **Links in the chain** | **What do the arrows mean?** |
|  |  |  |  |  |
| Confidence grid | Confidence grid | Simple multiple choice | Simple multiple choice | Simple multiple choice |
| **How many organisms?** | **Populations and communities** | **Food web** | **Through the food web** |  |
|  |  |  |  |  |
| Two-tier multiple choice | Two-tier multiple choice | Simple multiple choice | Confidence grid |  |

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| **Build a food chain** | **Breakfast food chains** | **Food web discussion** | **Food web art!** | **Food web role play** |
|  |  |  |  |  |
| Modelling, discussion | Independent research | Discussion | Drawing | Role play |

**What’s the science story?**

Organisms of the same type living in the same place make up a population. Populations of organisms living in the same place interact to make up a community. The biological material that makes up the organisms in a population can be referred to as biomass. Some of the biomass is transferred between populations when organisms are eaten. The feeding relationships within a community of organisms can be depicted using food chains to represent transfers of biomass between populations. Two or more interconnected food chains can be depicted using a food web.

All food chains start with producers and include one or more consumers. Producers make their own food and are the source of biomass for food chains. All consumers depend upon producers for food. Consumers cannot make their own food so have to get it by eating producers or other consumers. Consumers can be predators and prey.

**What does the research say?**

Food chains and food webs are key concepts in ecology, and understanding these concepts enables the exploration of more complex ecological principles and environmental issues later, including population management and food security (Alexander, 1982). Food chains and food webs are models – they are simplified representations of feeding relationships in a community of organisms, and can be used to make predictions about the effects that a change to one population could have on interdependent populations in the community (Griffiths and Grant, 1985).

In a multinational study of students aged 16-18 (Barman, Griffiths and Okebukola, 1995), the majority of students described a food chain as showing ‘what eats what’ (i.e. feeding relationships); however, only approximately 10% of students used the terms ‘producer’ and ‘consumer’ when asked to explain what is shown by a food chain. Leach et al. (1992) found that many students aged 5-16 used teleological reasoning to explain feeding relationships, i.e. that producers of prey existed in order to feed consumers or predators. Research has suggested that students’ ability to apply the terms ‘producer’ and ‘consumer’ correctly may depend upon their prior understanding of the concepts of ‘plant’ and ‘animal’ (Bell and Barker, 1982).

Confusion about the direction and meaning of the arrows in a food chain is a commonly reported misunderstanding (Gallegos, Jerezano and Flores, 1994; Gotwals and Songer, 2010), and suggests that students interpret the arrow to mean “eats” (Allen, 2014). Most of the students in the study by Barman et al. (1995) placed the arrows the wrong way around (e.g. from predator to prey) when asked to assemble a food chain using pre-printed cards, yet when presented with a correct depiction of a food web they did not question the direction of the arrows even though in most cases they contradicted the students’ own constructions. It has been suggested that children find it easier to correctly identify predator and prey arrangements within food chains when the species are familiar, and particularly when the names are accompanied by pictures (Schollum, 1983).

A number of authors (Griffiths and Grant, 1985; Webb and Boltt, 1990; Gallegos et al., 1994; Barman et al., 1995; Gotwals and Songer, 2010) have identified misunderstandings about food chains and food webs that are commonly held by school children, including that:

* classification of organisms as herbivores or carnivores, and as predator or prey, is only done on the basis of their relative size and ferocity;
* the words and pictures in a food chain represent individual organisms, rather than populations of organisms;
* a population located higher in a given food chain is a predator of all populations below it in the chain;
* a change in the size of a population will only affect another population if they are related as predator-prey;
* a change in the size of a population will only affect other populations in the same food chain within a food web (and will not affect populations in other food chains within the food web);
* if the size of one population changes, all other populations in the food web will change in the same way (e.g. a decrease in one population means all other populations will also decrease).

Griffiths and Grant (1985) drew a distinction between students’ ability to recall that populations in a food web interact, and their ability to apply that principle to predict possible effects of a change in one population on others in the same food web. Research has shown that when students are asked to predict possible effects of a change in a population within a food web, they tend to focus only on single food chains within the web, struggle to trace changes through more than one chain, struggle to think about the impact of a change in a population more than one trophic level away, and are more able to trace changes upwards through a chain than downwards (Webb and Boltt, 1990; Leach et al., 1992; Gotwals and Songer, 2010). As Allen (2014) has pointed out, “Anyone who is not able to fully appreciate the far-reaching impacts of changes to a single population may trivialize a media report about an endangered species, only believing that species alone is under threat, when the likelihood is that many members of an ecosystem will be adversely affected”.

Learning about food chains and food webs can help to increase students’ emotional involvement and engagement with biology (Alsop, 2001). Barker and Slingsby (2011) emphasise that developing understanding of the key ecological concepts of food chains and food webs is best achieved in the context of real ecosystems that students can visit, observe and explore; as they put it, “What we are trying to do is make them leap out of the textbooks”. Additionally, a number of authors have suggested using model-making (e.g. Grumbine, 2012), role play (e.g. Ford and Smith, 1994), games (e.g. Biffi et al., 2016; Hartweg et al., 2017) and art (e.g. Conkey and Green, 2018) to increase engagement and help develop students’ understanding of food chains and food webs.

*Everyday and scientific usage of ecological terms*

Learning about food chains and food webs inevitably involves discussions about food, but as noted by Driver and colleagues “any discussion of ‘food’ is fraught with the semantic problem of the word ‘food’ having different meanings in everyday and scientific contexts” (Driver et al., 1994). Everyday conceptions of food may make it difficult for students to understand what is meant by phrases such as “producers make their own food”. In this context, ‘food’ refers specifically to organic molecules that living organisms can use as a source of energy (i.e. as a substrate for cellular respiration), and to build biomass. Research has found that students up to age 14 do not link food to cellular respiration, instead giving simplistic explanations such as that it is needed to ‘keep organisms alive’ or to promote growth and health (Stavy, Eisen and Yaakobi, 1987).

Students at age 11 are likely to be more familiar with the everyday, rather than the ecological, use of terms such as ‘population’ and ‘community’. In one study, a quarter of children in a sample of secondary school students thought that a ‘community’ could only be formed by people living together, and another quarter could not distinguish between ‘population’ and ‘community’ (Adeniyi, 1985).

*Biomass and energy*

The biological material that makes up the organisms in a population is referred to in ecological parlance as ‘biomass’. Some of the biomass is transferred between populations when organisms are eaten, and energy is made available for life processes when food from digested biomass is respired inside the cells of organisms (Needham, 2014). In keeping with the ‘energy stores and pathways’ approach to teaching about energy (see: Fairhurst, 2018), we could explain that food or biomass has a chemical store of energy; food or biomass (i.e. matter, rather than energy) is transferred through food chains; chemical reactions in cells (e.g. cellular respiration) are the pathways through which energy is transferred from chemical stores associated with food to other stores in organisms and their surroundings during life processes.

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