Webinar 2. Teach science ideas

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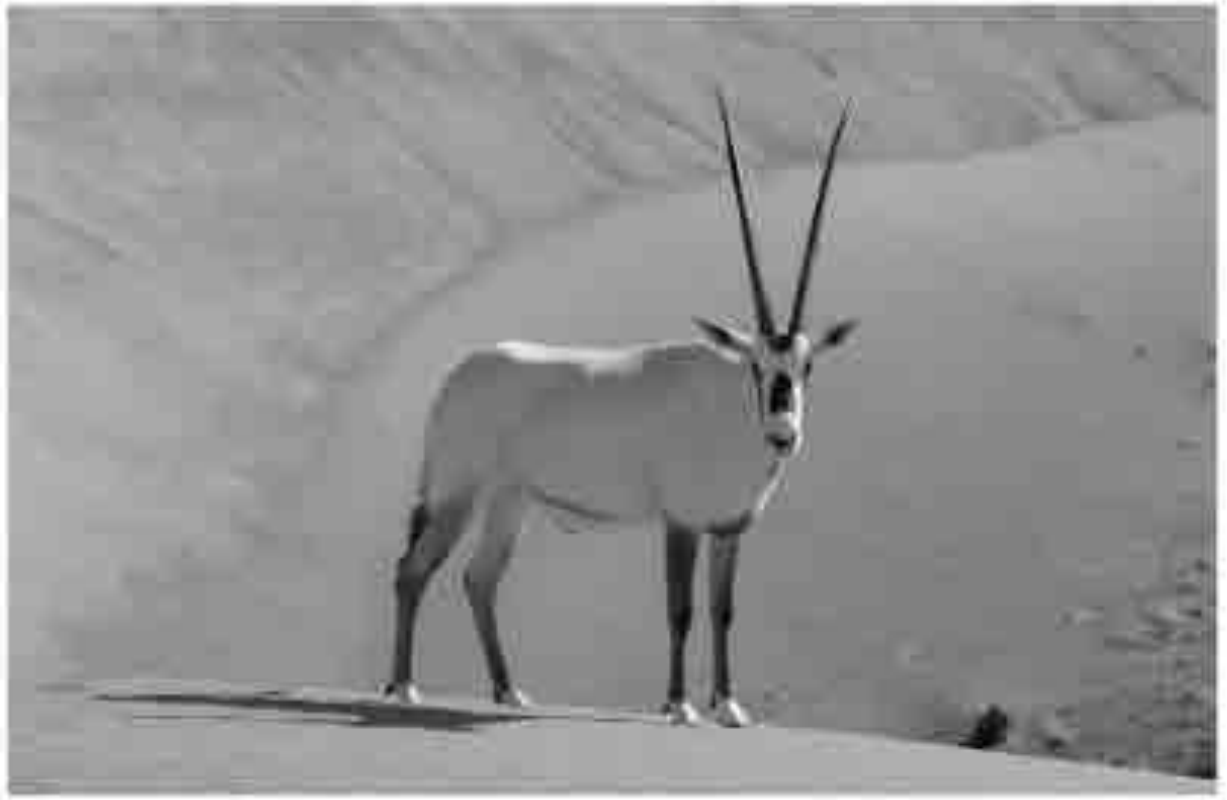
mastery science

Design for understanding

Design for understanding

The Arabian oryx (*Oryx leucoryx*) is a mammal that was once extinct in the wild.

The image shows an Arabian oryx.



(c) The Arabian oryx uses its long horns to fight for territory and mates.

Describe how the long horns could have evolved.

Design for understanding

A rare orchid plant has been found in the mountains in China.

The orchid has pale yellow flowers.

DNA analysis of the genome shows that it is an ancestral species.

All other present-day orchids evolved from this ancestral species millions of years ago.

One present day species has bright purple flowers.

Describe how an orchid with bright purple flowers may have evolved from the ancestral species which has pale yellow flowers.

Design for understanding

Low AO2 performer

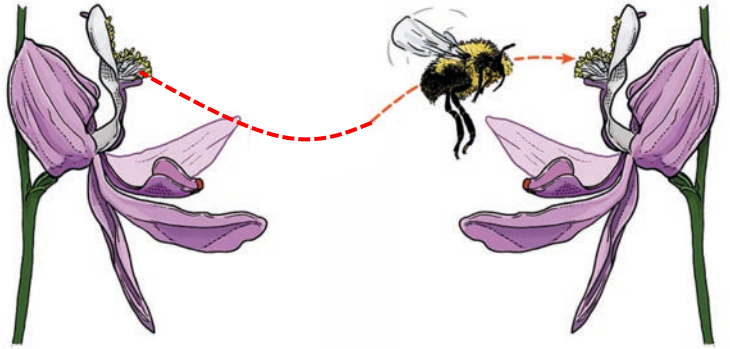
“What caused this?”

yellow

purple

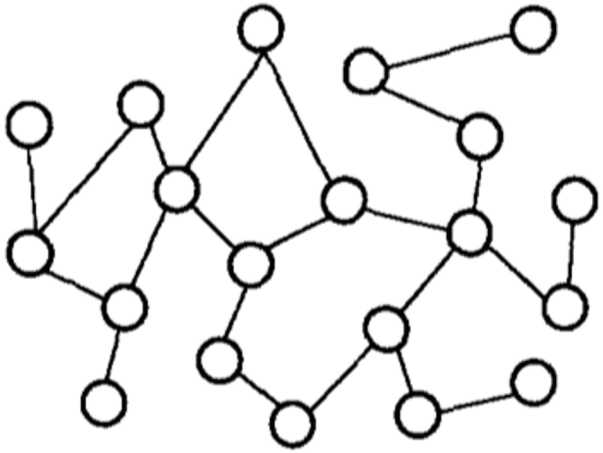
“They became purple because bees prefer brighter colours.”

Design for understanding



“Bees prefer purple flowers so they visited the purple flowers more often, so more purple flowers were produced.”

Novice knowledge



Disorganised ideas and facts are hard to use

Disorganised ideas

Situations → **Natural selection**

Insects and camouflage

Birds and beaks

Variation

↓

Survival of fittest

↓

Increase in characteristics

↓

New species over time

↓

Design for understanding

High AO2 performer

“What caused this?”

yellow

purple

“The plant evolved so having purple flowers must give the plants an **advantage**.”

Design for understanding

1.Variation → 2. Competition → 3. Survival → 4. Reproduction

"Evolution happens because of natural selection.
There are four stages.
This is a template - I remember it from a lesson -
I have to fill in the gaps."

Design for understanding

1.Variation

2. Competition

3. Survival

4. Reproduction

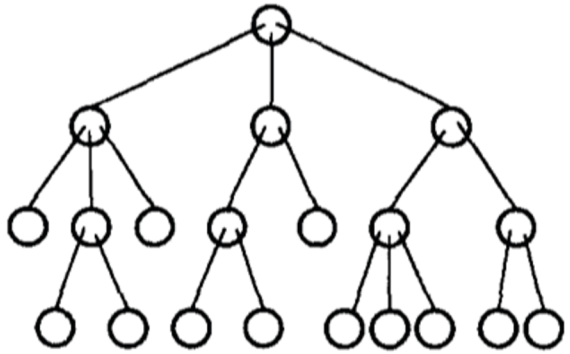
"In the past most orchids had yellow flowers. But there was variation because of differences in genes - some orchids were produced that had different coloured flowers such as purple.

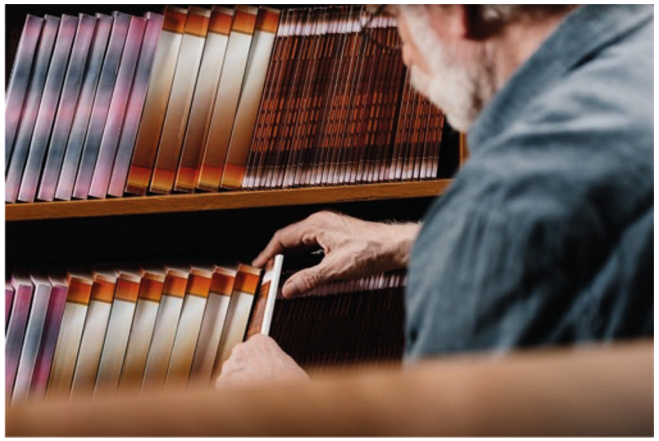
Plants compete for pollinating insects. More insects were attracted to the orchids with purple flowers and pollinated them.

(Nothing needed for this stage)

These orchids would then reproduce, and pass on the genes for purple flowers to their offspring. So the number of purple-flowered orchids in the population would slowly increase in each generation."

Expert knowledge





Knowledge organised around fundamental principles – **a schema** - is easy to use

Design for understanding

Schema

1. Situations

Evolutionary changes

Limited resources

Adaptations

Natural selection

2. Slots

Variation	Competition	Survival	Reproduction
Characteristic	**Limited resource**	**Adaptation**	**Adaptation**

Design for understanding

Solving problems with schema

1. Recognise situation

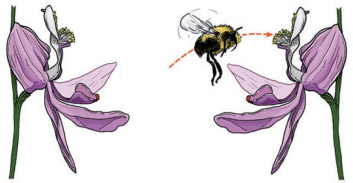
Evolutionary changes

Limited resources

Adaptations

Natural selection

2. Fill slots

Variation	Competition	Survival	Reproduction
Characteristic	**Limited resource**	**Adaptation**	**Adaptation**
			
Bright colour	Bees		More pollination

Knowledge framework

Knowledge framework

Levels

8KC-Natural selection

Mastery planner 8U-Life diversity unit

Time

more

less

Acquire

Natural selection

Level 3	Natural selection: In a population of a species, some organisms have characteristics that help them survive and reproduce better in their environment. Their offspring inherit these characteristics, which become more common over time.
Level 2	Evolution, Adaptations
Level 1	Species, Extinct

Knowledge framework

Level 3 idea

8KC-Natural selection

Mastery planner 8U-Life diversity unit

Acquire

Natural selection

Level 3 Natural selection: In a population of a species, some organisms have characteristics that help them survive and reproduce better in their environment. Their offspring inherit these characteristics, which become more common over time.

4-stage process

1.Variation → 2. Competition → 3. Survival → 4. Reproduction

Natural selection is the cause of evolution.

Knowledge framework

Level 2 ideas

8KC-Natural selection

Mastery planner 8U-Life diversity unit

Acquire

Natural selection

Level 2 Evolution, Adaptations

Knowledge framework

Level 1 ideas

8KC-Natural selection

Mastery planner 8U-Life diversity unit

Acquire

Natural selection

Level 1 Species, Extinct

Knowledge framework

AO2 is science in disguise

New phenomenon →

A rare orchid has been found in the mountains in China. The orchid has pale yellow flowers. DNA analysis of the genome shows that it is an ancestral species. All other present-day orchids evolved from this ancestral species millions of years ago. One present day species has bright purpose flowers.

Develop an explanation →

Describe how an orchid with bright purple flowers may have evolved from the ancestral species which has pale yellow flowers.

How scientists develop an explanation

Engage	Find a problem or a big question you want to research
Enable	Research existing knowledge
Explore	Do experiments to understand phenomenon
Explain	Develop a theory to account for results
Epilogue	Theoretical framework to make sense of experience
Extend	Provide extra knowledge and new situations
Evaluate	Check for understanding and decide next steps

Acquire follows the same stages

Engage

Enable

Explore

Explain

Epilogue

Extend

Evaluate

Rich, concrete representations

Abstract theoretical representations

Theory of progression towards understanding (Forbus & Gentner)

Activate stage

activate stage

Activate purpose

To find out what a student's ideas are on the prerequisites BEFORE teaching.

Natural selection

Activate ...prior ideas & address gaps/misconceptions

Prior	7KC-Competition, PS-Evolution: Animals and plants are adapted to suit their environment in different ways, 8KC-Variation
Goal	To show understanding of prior ideas that are prerequisite for new learning.

activate stage

Pre-assessment

Assess
Prior understanding to knowledge gaps and misconceptions.

Teach new concept

What activity would you choose for natural selection?

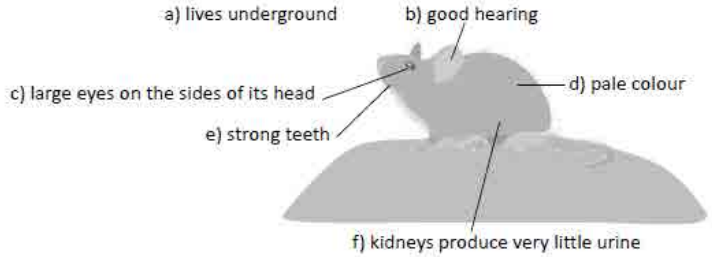
activate stage

Example: Preassess natural selection

Check your understanding: Adaptation

1. The rock pocket mouse lives in deserts in the United States and Mexico. Its home is a burrow where it stores seeds for eating.

   Here are some of its characteristics.



How does each characteristic a) - f) help the mouse survive in its environment?

2. The sand where the mice lives used to be pale. Then a thousand years ago, a lava flow turned the ground black. The population of mice in black areas changed. Gradually more and more mice had dark fur.

Look at these facts about **rock pocket mice:**

- Fur colour is inherited.
- Occasionally, a mouse is born with dark fur.
- The predators of rock pocket mice are owls, snakes and coyotes.
- Predators are more likely to spot mice whose colour doesn't match their habitat

Can you use put these facts together to explain why their fur changed colour?

activate stage

Pre-assessment task

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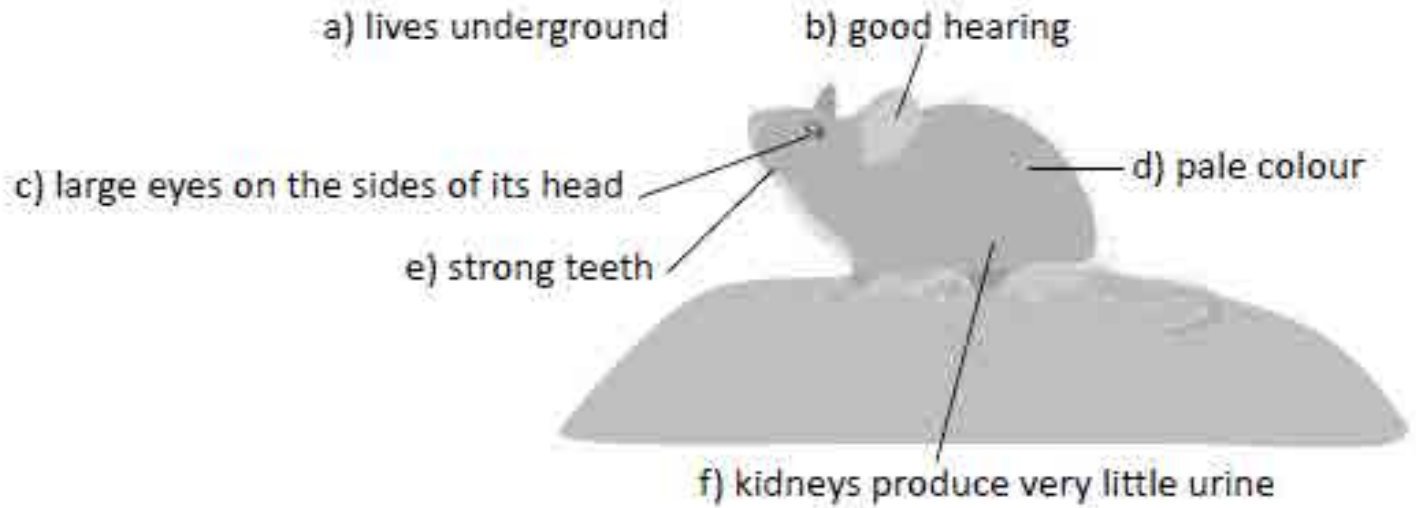
   Here are some of its characteristics.



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activate stage

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activate stage

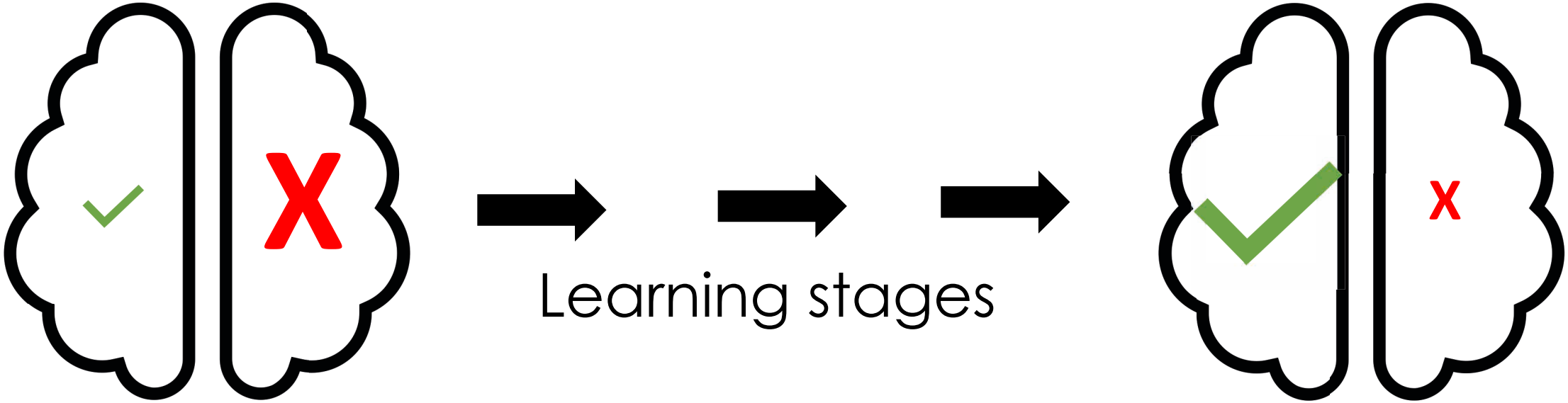
Re-think purpose

To teach any gaps in knowledge or correct misconceptions that might be barriers to acquiring new knowledge.

activate stage

Re-think purpose

Memory activation



activate stage

Misconceptions to address

- if there is a change in the environment then an individual organism can change its features to be more successful.
- changes to individuals only occur if there is an environmental change.
- change happens to all organisms in a population.

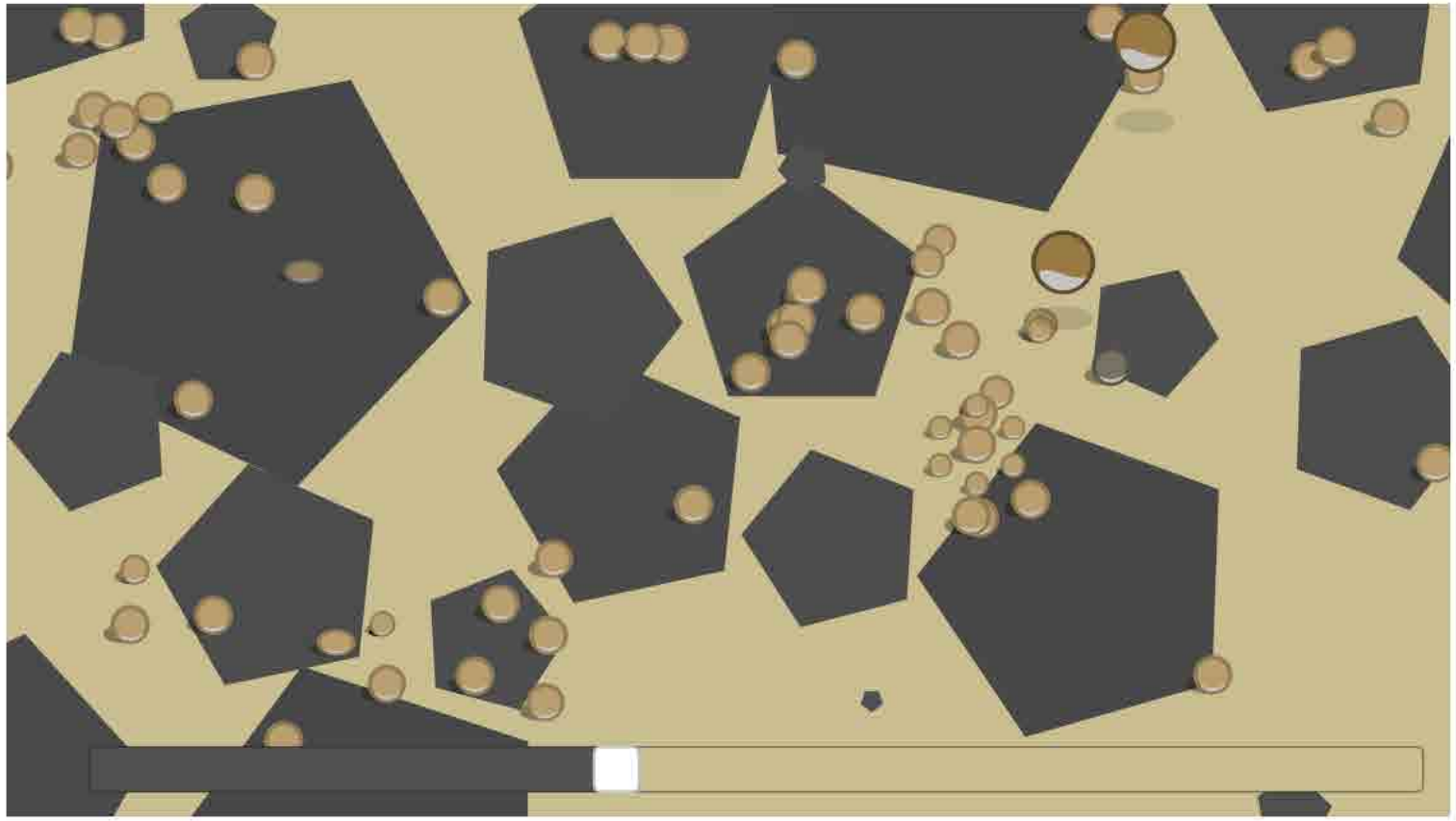
What activity would you choose for natural selection?

activate stage

Example: Rethink natural selection

Natural selection

- Activate misconceptions.
- Immediately present the proper concept.
- Explain WHY the proper conception is right.



Acquire stage

acquire stage

Acquire stage: purpose

To build a connected framework of knowledge fit for problem solving.

Acquire

Natural selection

Level 3	Natural selection: In a population of a species, some organisms have characteristics that help them survive and reproduce better in their environment. Their offspring inherit these characteristics, which become more common over time.
Level 2	Evolution, Adaptations
Level 1	Species, Extinct
Skill	Suggest an explanation for a new observation based on a scientific idea.
Technique	N/A
Goal	To explore an evolutionary change, and test a cause-effect hypothesis by simulating the steps in the process of natural selection.

acquire stage

Engage

Purpose

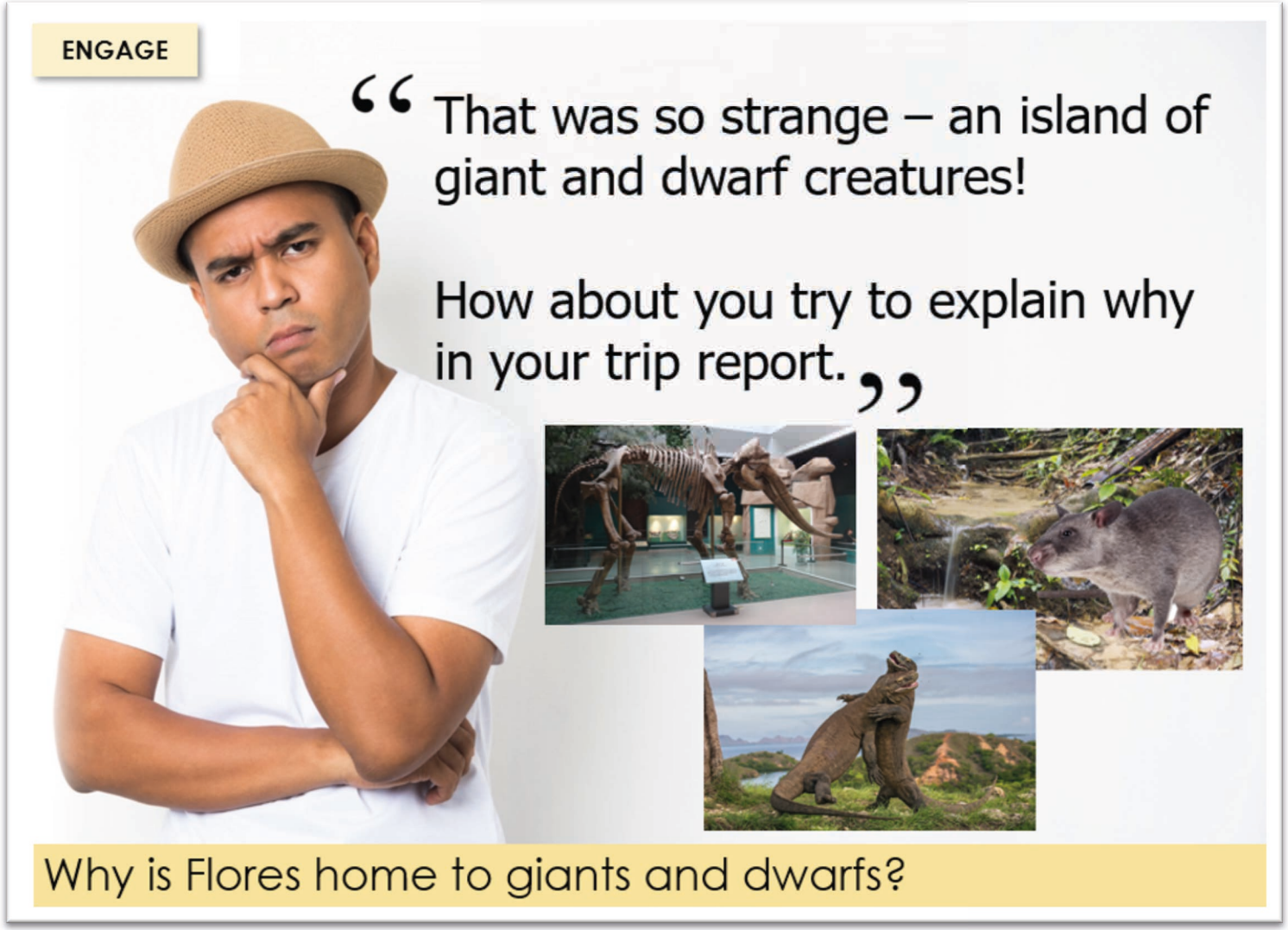
- The Engage question drives the acquire
- Show ideas as tools for explaining (for AO2)
- An intriguing phenomenon is motivation to think

What phenomenon could be used for natural selection?

acquire stage

Engage Example

- Puzzling phenomenon.
- Can only be answered by using ideas about natural selection.



acquire stage

Enable

Purpose

- Students need to understand some basic ideas before they can acquire the main understanding in ‘discovery learning’.
- In enable these are taught using direct instruction.

acquire stage

Enable Example

- Adaptation, evolution, drawing conclusions (skill).

ENABLE

All organisms have special features to help them survive and reproduce in the **environment** where they live. These are called **adaptations.**

The environment includes all abiotic and biotic factors.

There are 3 types of adaptation:

structural	behavioural	functional
features you can see	things the organism does	how cells, tissues and organs function

Which of the rock pocket mouse adaptations are structural, behavioural, functional?

acquire stage

Explore

Purpose

- Students experience key features: hands on/minds-on They start to build their own understanding of the main idea.
- This prepares students for the explanation of the main idea.

acquire stage

Explore

Example

- Question to investigate.

EXPLORE | How did elephants evolve to become dwarfs?

Was it a lack of food?
Let's test the hypothesis.

What activity do you normally use to teach natural selection?

acquire stage

- Question to investigate.

Bean-Counter Evolution

Hunt for prey and discover the meaning of evolutionary "fitness" in this physically active group game.

In this simulation game, teams of predators equipped with genetically different "mouths" (utensils) hunt for "prey" (assorted beans). Over several "generations" of play, the fittest among the predators and prey dominate the population, modeling the evolutionary process of natural selection.

Note: This game works best with a group of 15 or more people. See Teaching Tips, below, for ways to accommodate smaller groups.

acquire stage

- Question to investigate.
- Students take part in a simulation where they are the organisms.

You can simulate how evolution works with these imaginary creatures.

hoppers jumpers walkers

Activity: Use a simulation to show evolution **SS1**

- Use a simulation to model how species evolve.
- Use what you found out to improve the hypothesis.

acquire stage

Explain

Purpose

Purpose

- Provide a theoretical framework to make sense of students' experience in Explore.
- Connect the abstract idea with the concrete experience in the Explore.

acquire stage

Explain

Example

- The simulation is broken down into stages.

EXPLAIN

In the simulation, the population of creatures evolved in 4 stages.

1. Individuals in a population vary.

In the simulation, creatures varied on how they moved. There were:

hoppers

jumpers

walkers

What did the creatures compete for?

acquire stage

EXPLAIN

CAUSES & EFFECTS

NATURAL SELECTION

The 4-stage process you have seen in the simulation is called **natural selection.**

1.Variation → 2. Competition → 3. Survival → 4. Reproduction

Natural selection is the cause of evolution.

acquire stage

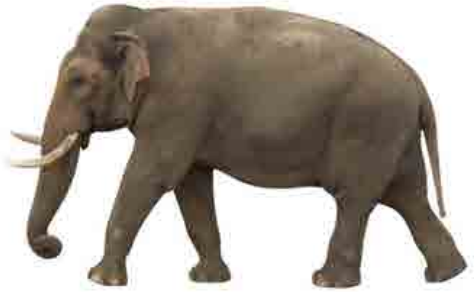
- The same stages are then used to explain how the dwarf elephants evolved.

EXPLAIN

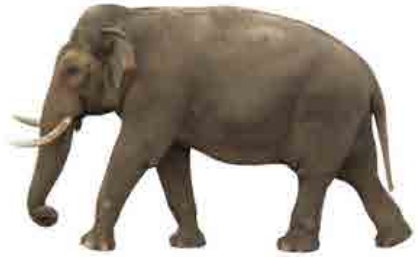
NATURAL SELECTION

1. Individuals in a population vary.

Elephants on the island show variation in size.



Most elephants are large



A few elephants are small

What causes this variation?

acquire stage

Epilogue

Purpose

- Return to the Engage question.
- Students use what they have learnt to answer it.

acquire stage

Epilogue

Example

- Explain another process using natural selection.

EPILOGUE

Why is Flores home to giants and dwarfs?

“ Hi! How is the report going?

You showed that natural selection can explain dwarf elephants.

Can it also explain why island rats become giants? ”

Activity: Complete your report **SS2**

- Complete the flow chart to explain how rats got bigger.

acquire stage

Extend

Purpose

- To put the main idea into use.
- To generalise features of the situation where this key idea can be used.

acquire stage

Extend

Example

Natural selection

- Why are fossils evidence for natural selection?

EXTEND

INTERPRET

How do we know this is what happened?

We need evidence to support the hypothesis.

Could studying fossils help?

Explain what kind of fossils would prove how island rats got bigger

acquire stage

Evaluate

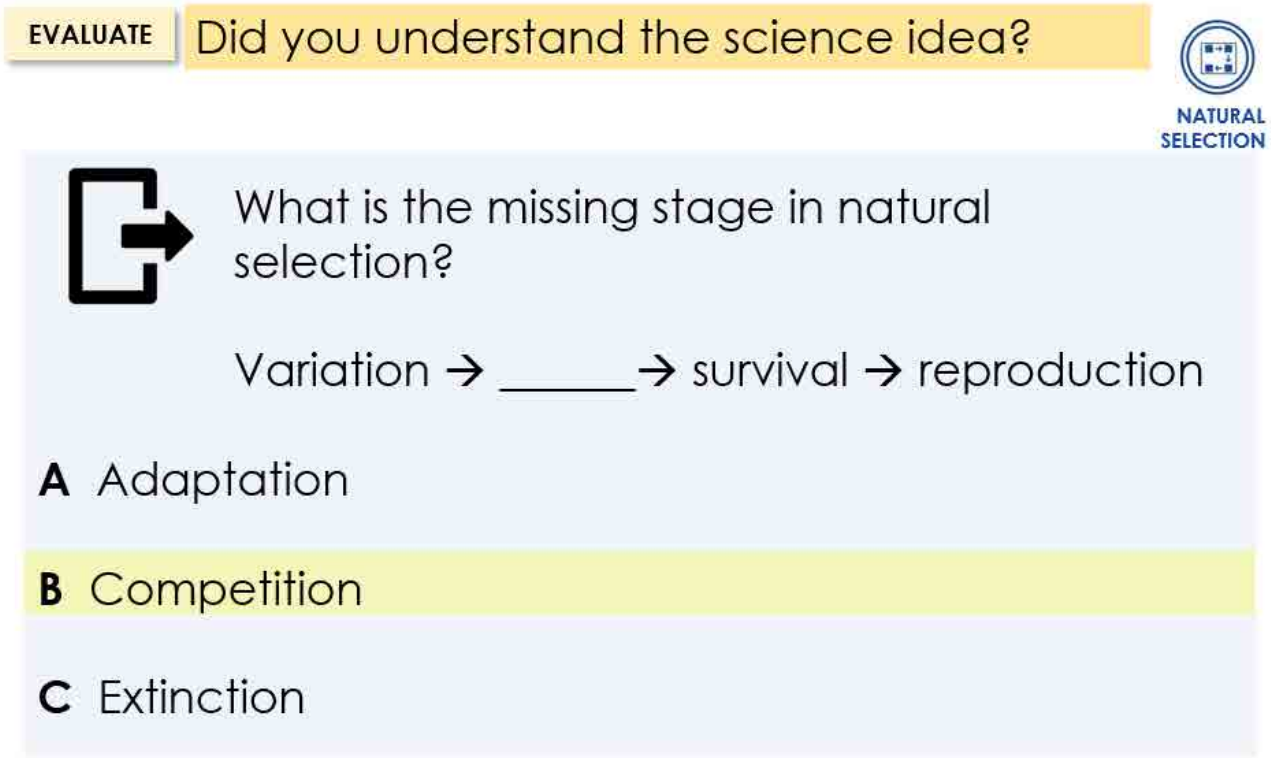
Purpose

- To assess if students understood the main idea.
- Different strategies e.g. exit ticket

acquire stage

Evaluate Example

- Do students understand the stages in natural selection?



Design for understanding

Solving problems with schema

1. Recognise situation

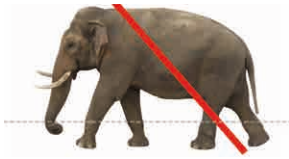
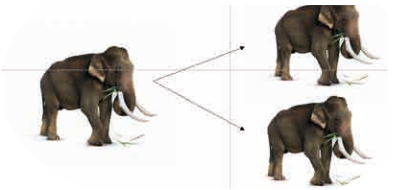
Evolutionary changes

Limited resources

Adaptations

Natural selection

2. Fill slots

Variation	Competition	Survival	Reproduction
Characteristic	**Limited resource**	**Adaptation**	**Adaptation**
			
Size	Food	Big = die, small = survive	small = reproduce

Next steps

Next steps

[Get the Y7/8 planners now]

7KC-Cell structure

blueprint

Mastery planner 7U-Cells unit

Novice

Activate

Prior: PS-Life processes: There are differences between things that are living, dead, and things that have never been alive.

Goal: To show understanding of prior ideas that are prerequisite for new learning

Acquire

Building blocks

Level 3: Building blocks: Studying living organisms with microscopes revealed that they are made of one or more cells - the smallest living units.

Level 2: N/A

Level 1: Multicellular, Microscope, Single-celled organism, Scale of cells, Calculate total magnification

Skill: Argue for a claim by explaining how each piece of evidence supports it or not.

Technique: **Use a microscope**

Goal: To check a claim that an unknown specimen is alive by using a microscope to examine plant and animal cells and identifying common structures

Life functions

Level 3: Life functions: Cells use energy to carry out life processes like growth and reproduction and have specific parts for these jobs

Level 2: **Plant cell, Bacterial cells**

Level 1: Ribosome, Cell membrane, Nucleus, Cytoplasm, Mitochondrion, Chloroplast, Cell wall, Permanent vacuole, Flagella

Skill: Represent a real world event, process or system using a model.

Technique: ...

Goal: To examine diagrams of real animal, plant and bacteria cells, identify similarities and differences, and explain how those parts keep the cells alive.

Level 3: N/A

Level 2: N/A

Level 1: N/A

Skill: N/A

Technique: N/A

Goal

Assess

Goal: To show accurate understanding of the ideas and rectify gaps and misconceptions before problem-solving.

Apply

Goal: To identify what type an unfamiliar cell is with reasons, by comparing its structures to those of plant and animals, To work out an explanation for how a given change in a cell will affect the whole organism.

Expert

Analyse

Goal: To interpret experimental results about cells and make an argument that cells carry out life processes.

U = unit, KC = Key Concept, PS=Primary Science, Level 3 = main idea, Level 2 = other ideas, Level 1 = terms/facts

blueprint secondary science