Science - Spiders: genetics and natural selection

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Number of lessons: **2**

Year Level(s): **Year 10**

Australian Curriculum content descriptions:

Transmission of heritable characteristics from one generation to the next involves DNA and genes (ACSSU184)

The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (ACSSU185)

Achievement standard:

By the end of Year 8, students compare processes of rock formation, including the timescales involved.

Lesson 1 - Tarantulas

Context

The lands of the Ewamian People provide homes to many different species of spider. Studying these gives us insight into evolution by natural selection and hereditary.

Materials and equipment

- YouTube – Australian Tarantula, central Australia (https://www.youtube.com/watch?v=c3fwFvpIzm0)
- Blank A4 paper

Safety Advice

Please be advised that these lessons may be distressing to individuals who experience arachnophobia, students should be forewarned.

Objectives

Students can explain different ways in which natural selection affects tarantula survival from birth.

Introduction

During the BushBlitz 2022 expedition to Rungulla National Park, Dr Robert Raven, an arachnologist from the Queensland Museum, collected an undescribed specimen of Australian tarantula. He informed the other team members of some very interesting (and creepy!) details about how tarantulas raise their young.

Core

Engagement

Show the YouTube clip "Australian Tarantula, central Australia" to students. Ask students to imagine what the inside of the tarantula's tunnel might look like and share their thoughts with the class.

Focused Instruction

Provide the following information to students:

- Australian tarantulas live in tunnel nests that extend under the ground for over a meter. The opening of the tunnel is surrounded by fine silk threads. If prey animals come near the opening, they shake the threads, alerting the tarantula to their presence. The tarantula then pounces! Envenomating the animal with its sharp fangs and dragging it into their lair.
- Females are larger than males. Males will move between nests looking for females to mate with. This is very dangerous as females will often kill and eat males before, during or after mating.

- Females will then lay around 100 eggs, however scientists have only ever found nests containing one spiderling living with the mother. It is believed that when the baby spiders hatch, they eat each other until only one remains (cannibalism).
- Mother spiders care for the single surviving spiderling for 6 months to a year before it leaves to dig its own nest tunnel.

Guided Instruction

The teacher considers the following questions with students in an open discussion:

- Natural selection is the process where different individuals in the same species have different levels of "fitness" – some are better adapted to survive than others. Where is natural selection acting in the tarantula's life cycle?
  - Example answers; one spiderling is stronger than all the others (why?), some males are better at successfully mating than others (why?), some adult spiders are better at finding food than others (why?)
- ·Thinking about the spiderling that manages to survive when all the others are cannibalized, why do you think they mother spider would let this happen? Why wouldn't she try to protect all her babies?
  - Example answer; with only one offspring to care for, she needs to find less extra food, and the surviving spiderling should be stronger and "more fit" than all the others. It will also be bigger earlier in its life as it has eaten all its siblings, meaning it is stronger and more able to protect itself

Collaboration

Students form groups of 2 or 3 and discuss what physical features would confer a fitness advantage on a baby tarantula. They can be creative with their features, within the realms of nature (extra big fangs and venom spraying would be reasonable, flamethrowers and magic powers not so much…). Within each group or pair, students should designate an illustrator to draw a picture of their spiderling, and a scribe to write annotations on the diagram explaining what the features are and how they would confer an advantage. The third student, (or one of the pair) can present their diagram to their neighboring group and explain the adaptations.

Independent

Students consider the following photograph taken two days before the two above, 2 km downstream:

"My spiderling has ___ which gives it an advantage over other spiderlings. What kind of environmental conditions would turn this advantage into a disadvantage?"

For instance, if the spiderling could spray its venom, this would become a disadvantage if it was trying to catch fast moving prey which would be very hard to hit, or if it was raining and the sprayed venom was washed away mid-air. Encourage students to present their response as a PEEL paragraph (or whichever paragraph writing convention is used by your school).

Conclusion

Tarantula spiderlings must fight to stay alive as soon as they are born. They must prove they are stronger than their siblings by eating them if they want to survive to adulthood. It is difficult to determine which traits make a tarantula spiderling more "fit" than others, however fitness is situational – an advantage in one environment can become a disadvantage in another environment.

Resources

Digital:
Australian Tarantula, central Australia (https://www.youtube.com/watch?v=c3fwFvpIzm0)
Worksheet:
nil
Useful links::
nil

Lesson 2 – Redback Spiders

Context

The lands of the Ewamian People provide homes to many different species of spider. Studying these gives us insight into evolution by natural selection and hereditary.

Materials and equipment

- YouTube – Red Back Spider | Attenborough: Life in the Undergrowth | BBC Earth (https://www.youtube.com/watch?v=bQABY9H1h1Y)
- Graph paper or computers with Excel

Safety Advice

Please be advised that these lessons may be distressing to individuals who experience arachnophobia, students should be forewarned.

Objectives

Students can explain how adverse environmental conditions can reduce the genetic fitness in redback spiders through the use of Punnett squares.
Assumed knowledge: use of Punnett squares, alleles and allele frequency, dominant and recessive genes

Introduction

During the BushBlitz 2022 expedition to Rungulla National Park, after a long day collecting invertebrates in the field, Queensland Museum Arachnologist Dr Robert Raven told the horrifying tale of pregnant redback spider females and how they survive when trapped in a container for long periods of time.

Core

Engagement

Show the YouTube clip "Red Back Spider | Attenborough: Life in the Undergrowth | BBC Earth" (0:01 to 3:05) to students. Ask students if they have noticed redback spiders around their own homes.

Focused Instruction

Provide the following information to students:

- ·Just like the Australian tarantula, female redback spiders are larger and more dangerous that the males. Females need to be larger as they need to produce the eggs, which requires a lot of energy.
- ·In laboratory experiments, some pregnant females were isolated in containers with air and moisture but no food. The following series of events was observed:
  - The female laid her eggs and guarded them until they hatched.
  - When the young were unable to disperse, they began to kill and eat each other. The mother did not each the offspring and did not attempt to care for them.
  - Eventually all the offspring would eat each other until only one was left – this was always a male
  - The female would then mate with the male offspring, before killing and eating him.
  - The fertilized female would then lay another clutch of eggs and the process would repeat until the original female died or was released.
- It is believed that this is a survival strategy for harsh conditions in the wild, like drought or bush fire. It is not ideal for the female to mate with her own offspring, but it meant that she had a food supply and could survive to mate again once conditions became more favourable.

- However, this cycle of in-breeding does cause a reduction in genetic fitness of the successive generations of offspring.
- Remind students that homozygous traits are less genetically fit that heterozygous traits.

Guided Instruction

The teacher co-constructs a Punnett square with the class to refresh/review skills:

First cross – trapped female (XX, females have two X chromosomes) and external male (X, males only have 1 chromosome)

Original female (trapped)		Male (external) X	Male (external) X
	X	XX	X
	X	XX	X

As the female can only reproduce with a male offspring, and the males have identical sex chromosomes to their father, then all future generations will produce the same ratio of male and female offspring.

The teacher should then try the first cross again with two traits, sex and leg length:

First cross – trapped female (XX) with short legs (ll) and external male (X) with long legs (Ll)

Original female (trapped)		Male (external) XL	Male (external) Xl	Male (external) L	Male (external) l
	X	XXLl	XXll	XLl	Xll
	X	XXLl	XXll	XLl	Xll
	Kl	XXLl	XXll	XLl	Xll
	Xl	XXLl	XXll	XLl	Xll

Collaboration
Students should then work in pairs to attempt a cross with the original female and a randomly selected male offspring (XLL, XLl or Xll). Students should record for each cross:

- Percentage of each genotype in offspring
- Percentage of each phenotype in offspring

Students should continue crossing male offspring with the original female until homozygosity is reached.

Independent
Once all groups have reached homozygosity, they should report their results by recording them on the board. Students can then independently graph the classes results using graph paper or Excel.

Once the graphs are completed, students should attempt to answer the following question:.

"Why are homozygous individuals less genetically fit than heterozygous individuals?"

Possible response – homozygous individuals cannot produce diverse offspring. Once a version of a gene is lost from the breeding pool, it cannot spontaneously reappear. Breeding populations rely on having genetic diversity so that they can be more able to adapt to changing environmental conditions. A population of short legged spiders may be wiped out if the environment favours long legs, whereas a population with a mix of long and short legged spiders will have at least some long legged survivors.

Conclusion

Redback spider females can adapt to being trapped by allowing their young to cannibalise each other and then engaging in inbreeding and cannibalizing the surviving male. While this strategy may allow the female to survive adverse conditions and mate another day, it reduces heterozygosity in her offspring and lowers their genetic fitness.

Resources

Digital:
YouTube – Red Back Spider | Attenborough: Life in the Undergrowth | BBC Earth (https://www.youtube.com/watch?v=bQABY9H1h1Y)

Useful links::
Punnett square templates (free but require you to create an account) - https://www.teacherspayteachers.com/Product/Punnett-Squares-Blank-Templates-515532

Lesson 3 – Analysing and interpreting data

Context

Once all the raw data has been transferred to a central and open access point each student should save a personal copy for their manipulation.

Teaching the skills of creating data tables and graphs that can be analyzed and interpreted as evidence to address a question/s.

Materials and equipment

- Laptop (Excel)

Safety Advice

- See Worksafe Queensland https://www.worksafe.qld.gov.au/ for advice on safe use of laptops.

Objectives

Learning Intention:
Students will be able to create visual representations of the collected data.

Success Criteria:
You will be successful when:

- create multiple graphs as evidence of data
- write an analysis under each graph, identifying trends and patterns in the data

Introduction

Prior to this unit please ensure you have a good understanding of the students' prior skill levels using excel.

Strategy - I do: we do: you do
I do – role model choosing raw data; applying any statistical/mathematical calculations to create a new table that will be used in the final report; how to turn table data into a graph in

excel. All the time talking about the trends and patterns in the data (and how to write the description under the graph).
https://www.biointeractive.org/sites/default/files/media/file/2019-05/Statistics-Teacher-Guide.pdf

- teacher reference book on Maths and Statistics in Biology

Core

We do – together choose another raw data set and create an excel graph. Once created have students identify and share the trends and patterns in the data and as a class write the description under the graph together.

You do – data collection groups to work together on the remaining data they collected. Once the group is happy with the graph and written analysis they will share on the collaboration space.

Conclusion

To receive feedback on student understanding collect the student reflection journals.

Resources

Digital:
Youtube channel – Technology for Teachers and students (excel)

Worksheet:

Useful links:
https://www.biointeractive.org/sites/default/files/media/file/2019-05/Statistics-Teacher-Guide.pdf

Lesson 4 - Restoring biodiversity

Context

Real life scientists give presentations on their investigation findings and make recommendations. Students will work in their groups to develop a plan to increase biodiversity levels within the school grounds. Students will present ideas.

To present the ideas the strategy of a 'gallery walk' can be used.Special guests could be invited, for example, the Principal, P&C members, grounds staff. They could then provide immediate feedback to the students.

Materials and equipment

- Laptop
- Butchers paper
- Pens

Safety Advice

- See your school's IT permissions for any app or software the students wish to use as parental permission is required for any new service.

Objectives

Learning Intention:
Students will be able to create a presentation on how to increase biodiversity locally

Success Criteria:
You will be successful when:

- decide format of presentation
- create visually engaging presentation
- create informative presentation
- write speech

Introduction

Prior to lesson: Teacher - Explore apps and software programs and choose a few options as a selection for your students to choose from, this list will be site specific due to permission levels.

Beginning of lesson – engage students by showing a range of science conferences in Australia. Explain how and why scientists need to be good communicators.
https://allconferencealert.net/australia.php

Core

Students to brainstorm in their groups using butcher's paper and pens to record all ideas.

Write on board each stage required and time allocated. Turn on timer, after each section have a 'check in' process to gain a quick understanding how all groups are progressing with the check list.

Checklist:

1. brainstorm ideas for increasing biodiversity on school grounds/local area (5 minutes)
2. choose agreed ideas (2 minutes)
3. review list of presentation options (5 minutes)
4. choose agreed presentation format (2 minutes)
5. create a list of tasks and student responsible for each task (2 minutes)
6. create presentation (20 minutes)
7. run through speech/es or words students will share as people walk around the gallery (5 minutes)

Gallery walk (25 minutes): - special guests (the Principal, grounds staff, P&C members), other Year 9 students walk around the classroom listening to presentations and providing feedback on ideas (using a criteria sheet).

Conclusion

Send all participants a survey to receive feedback on all aspects of the presentations including voting on the best ideas for improving biodiversity levels within the school grounds/local area.

Organise a meeting with the Principal for support to implement the student plans. Create an action committee to develop timeline of project implementation. There are grants available if funds are limited.

Resources

Useful links:
https://visme.co/blog/best-presentation-software/
https://www.grants.gov.au/