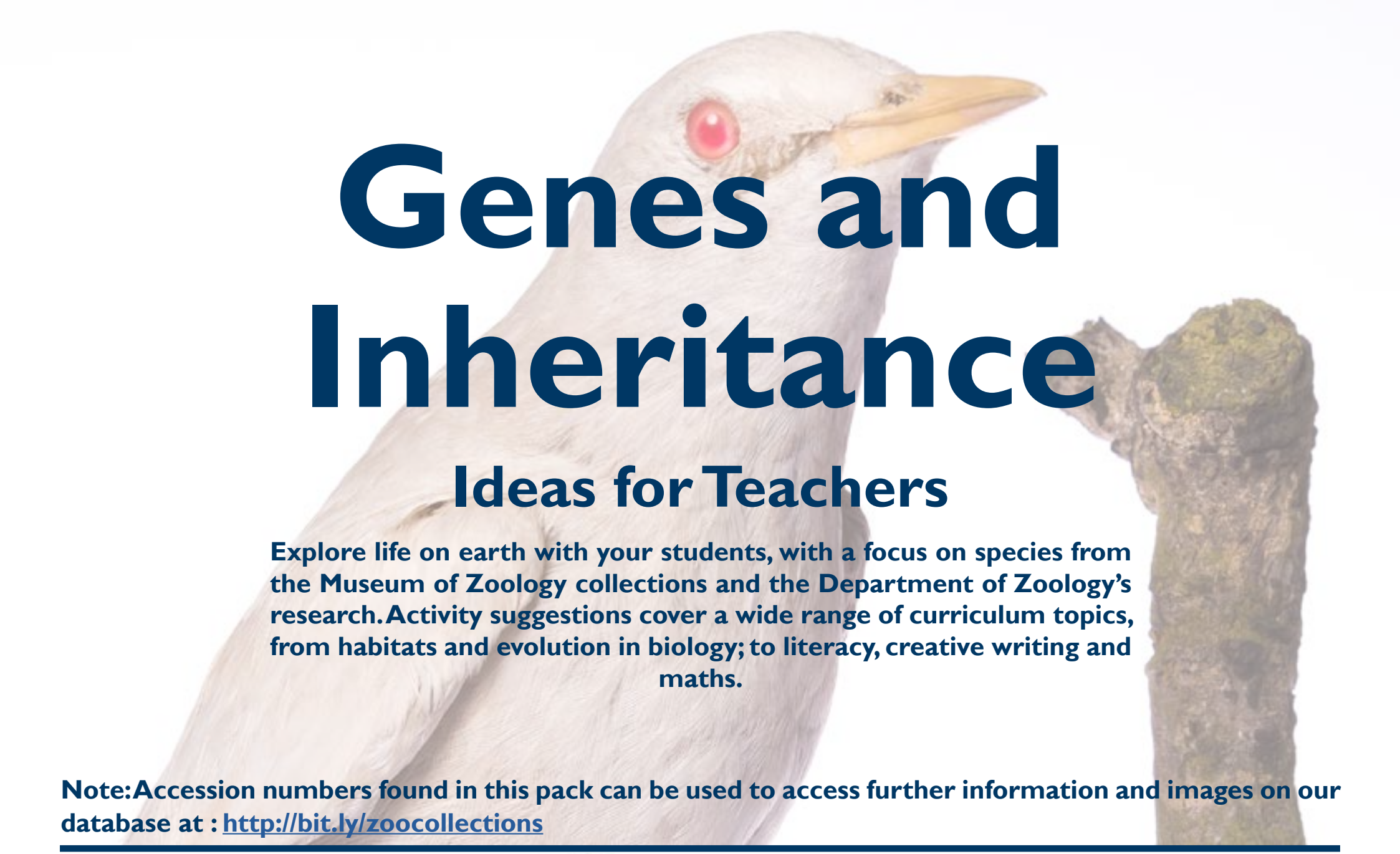

Genes and Inheritance

Ideas for Teachers

Explore life on earth with your students, with a focus on species from the Museum of Zoology collections and the Department of Zoology's research. Activity suggestions cover a wide range of curriculum topics, from habitats and evolution in biology; to literacy, creative writing and maths.

Note: Accession numbers found in this pack can be used to access further information and images on our database at : http://bit.ly/zoocollections

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund
LOTTERY FUNDED

Newly acquired specimen - image coming soon!

Grey Squirrel

Scientific Name: *Sciurus carolinensis*

Location: UK (invasive species), native to North America.

The Grey Squirrel is a very adaptable species and has spread rapidly areas where it has been introduced without trouble. While they prefer mature broadleaved woodlands, they can be found in conifer woodlands, and in urban areas, gardens and parks where mature trees exist. The spread of this species is largely to blame for the decline in the UKs native Red Squirrel.

Accession number: Newly aquired specimen - coming soon!

This melanic Grey Squirrel is jet black in colour due to a mutation in the gene that coordinates the production of the pigment, melanin. In this case, the wildtype ('normal') gene, and the mutant (melanistic) gene are both dominant. If a squirrel inherits two of the wildtype genes (homozygote E+/+) it would be grey. If it inherits two of the mutant gene (EB/B) it would be black. However if the squirrel inherits one of each (heterozygote E+/B) it will be brown-black.
The melanic squirrels interbreed freely with the wildtype, and so pass the mutant gene on to the next generation.

RED LIST Least Concern

Other resources:

Melanstic Grey Wolf and advantageous behavioural traits: http://newsroom.ucla.edu/releases/biologists-solve-mystery-about-80301

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund LOTTERY FUNDED

Brown-lipped Snail

Scientific Name: *Cepaea nemoralis*

Location: United Kingdom and Europe

The Brown-lipped Snail can be found in a wide range of habitats, including waste ground, woodland, hedgerows and grassland. They need plenty of moisture around, and will retract into their shell and remain inactive during dry periods. Airbreathing land snails breathe through an opening near the shell called a pneumostome.
The colour and pattern of a snail's shell can assist with camouflage and survival, as their bird and mammal predators rely heavily on sight to find their prey.

Accession number: I.70486

Did you know... most snails are hermaphrodites, meaning that an individual possesses both male and female reproductive organs. They are able to reproduce without a mate when necessary, ensuring the survival of the species.

Brown-lipped snail shells vary greatly in colour and banding within the species. A snail's colouration (phenotype) is determined by a number of inherited dominant and recessive genes (genotype), with many possible outcomes.

RED LIST Least Concern

Other resources:
Mendel's Peas: http://www.saps.org.uk/secondary/teaching-resources/821-work-of-mendel

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund
LOTTERY FUNDED

European Starling

Scientific Name: *Sturnus vulgaris*

Location: Native to UK, Europe to southern Asia.

The European Starling can be found living in urban and rural areas, and has a beak that is well adapted to eating insects and grains. Starlings make a wide range of sounds including chuckles, whistles, knocking and good imitations of other bird songs. They are gregarious birds and well known for their dramatic displays of coordianted movements in large numbers, known as murmurations.

Accession number: 27/Stu/26/p.35

Starlings usually display a myriad of irridescent purple and green feather colours, however this specimen inherited a combination of genes that have resulted in albinism. Albinism is the inability of cells to produce melanin; a pigment that helps to protect skin and eyes from overexposure to sunlight. The consequences of which include a higher risk of developing melanomas, and poor vision. Birds also use their colours to attract mates.

The gene which causes albinism is recessive, meaning that two of the same mutant gene are needed to produce the phenotype. There is a higher chance of this occuring in an isolated population, confirming the importance of variation in inheritance.

RED LIST Least Concern

Other resources:

Identifying genes: http://www.hhmi.org/biointeractive/exclusion-mapping

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund LOTTERY FUNDED

Medium Ground Finch

Scientific Name: *Geospiza fortis*

Location: Santiago Island, Galápagos Islands (Beagle Voyage)

A first, Darwin believed that the many species of Galápagos Island finches were a mix of blackbirds, wrens and finches, due to their dramatic differences in appearance. Ornithologist John Gauld identified them all as finches in 1837, but it was much later that scientists began to consider them an example of evolution by natural selection. All Galápagos finches are decended from one common ancestor. Later generations evolved particular traits, giving them an advantage on the island in which they settled.

Accession number: 27/Fri(E)/26/b/4, 27/Fri(E)/26/b/3, 27/Fri(E)/26/b/2

The Medium Ground Finch is a 'generalist' and has a beak that is suited to feeding on a wide range of seed sizes. Rosemary and Peter Grant have studied this species for 40 years, observing two instances of physical adaptation within the species.

A drought in 1977 saw food become scarce, with the larger beaked birds being able to eat the leftover large, tough seeds. The next generation of finches had a larger average beak size. The 1983 El Niño event encouraged vines to grow, causing small seeds to be more numerous in the 1985 drought. The finches with smaller beaks had the advantage and passed this trait onto the next generation. This is a good example of the role that genetics and inheritance plays in evolution.

RED LIST Least Concern

Other resources:

Explanatory Video: http://www.hhmi.org/biointeractive/origin-species-beak-finch

Work of Rosemary and Peter Grant: https://www.nature.com/news/2006/060710/full/news060710-11.html

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund LOTTERY FUNDED

Sky Terrier

Bulldog

Greyhound

Wolf

Domestic Dog

Scientific Name: *Canis familiaris*

Location: Worldwide, except Antarctica

All dogs are decendants of a species of wild wolf. Domesticated at least 15,000 years ago; they became valuable hunting partners, guards and herders. Modern breeds display a diverse range of morphologies and phenotypes, due in part to the consequences of domestication and human influence through artificial selection.

Accession number: Skye terrier K.3003, Bulldog K.3040, Greyhound K.3012, Wolf K.3148

The skulls here show how very diverse the one species has become. While many of the differences have aesthetic or functional implications only, some mutations have allowed for side effects, such as a higher likelihood of disease. One explanation for this is the dramatic change in lifestyle from wild wolf to domestic dog. 'Natural Selection' has less of an influence, so individuals with disadvantageous traits are more likely to survive and reproduce. While they can physically look very different, all dogs remain within the one species and can produce fertile offspring.

RED LIST Not assessed

Other resources:
Inherited diseases in dogs database: https://www.vet.cam.ac.uk/idid/Search

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund LOTTERY FUNDED

Cold-Temperature Size Typical Size

Cold-Temperature Size Typical Size

Butterflies

Scientific Name: Lepidoptera

Location: Worldwide

Butterflies go through four life stages; egg, larva, pupa and adult. Their larvae, called caterpillars, spend their time eating as much as possible before a change in specific hormone levels causes them to pupate. Insects are unable to regulate their own temperature and rely on warmth in their environment to get their muscles moving. Caterpillars in cold climates will make slower movements and eat less. During metamorphosis, the genetic code (genotype) is still controlling how the insect looks, but only has the energy consumed by the caterpillar to work with; resulting in smaller butterflies.
The resulting smaller size (phenotype) is not a genetic trait, and will not be passed onto offspring. It is a consequence of the environmental factors in which the animal lived.

Accession number: due to the small size and large quantity of our insect specimens, they are not yet catalogued. To keep track of our mini-beasts we arrange them systematically by species.

Did you know...Butterflies and moths belong to the group Lepidoptera, which means 'scaly wings'.

RED LIST Least Concern

Other resources:
Butterfly wings and genetics: http://www.hhmi.org/biointeractive/how-did-we-get-here

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund LOTTERY FUNDED

Activity Ideas for the Classroom

BACKGROUND	ACTIVITY IDEAS	RESOURCES	KEYSTAGE	CURRICULUM LINKS
Environment and Phenotypes Caterpillars are easy to keep and a good animal for observing growth, life cycles, the need for warmth for muscles, and cause and effect.	Take two groups of caterpillars and keep them in separate butterfly 'gardens'. House one garden in a room temperature environment, and the other in a warmer space (near a radiator for example). Feed them the same food; type and quantity. Have students fill in a table detailing how much food they have given to each group, and how much seem to have been eaten at regular points in the week. Watch them grow, pupate and emerge. Record which butterflies are bigger! Explore why this is then release your butterflies into a garden or woodland habitat.	Butterfly Garden (or similar) e.g. Baker Ross N120 Table to record observations and findings Time: Short intervals over 2 weeks	KS2 KS3	Biology: Growth, Exoskeletons, Nutrition, Hormones, Phenotype and Genotype, Inheritance Working Scientifically: Cause and Effect, Charts and Tables, Drawing Conclusions
Discussing Consequences Since the first dogs were domesticated, humans have been selectively breeding dogs, choosing individuals with desirable physical and behavioural traits. We now understand that repetitive elements in genes can cause disease in both dogs and humans.	Take a look at the dog skulls and think about the advantages and disadvantages of each breed's characteristics. Would these traits/ phenotypes help or hinder the animal in a wolf's natural habitat? Do they come with undesirable side effects, such as susceptibility to disease? Compare the dog skulls to the wolf skull. Why have humans chosen to emphasise some physical or behavioural characteristics over others? Extension: Explore the ethical considerations surrounding human involvement in the selectivity and creation of dog breeds. Much of this was done long before we gained an understanding of genetics and inheritance. Would we make the same decisions today?	Dog Skull Resource Images of the dog breeds in life Access to the internet or books to research associated diseases. Time: 20-30 minutes	KS3 KS4	Biology: Genes and Genetics, Inheritance, Selective Breeding, Importance of Biodiversity, Mutations, Disease Working Scientifically: Ethics of Human Involvement, Predictability of Phenotypes

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund
LOTTERY FUNDED

Activity Ideas for the Classroom

BACKGROUND	ACTIVITY IDEAS	RESOURCES	KEYSTAGE	CURRICULUM LINKS
Evolution in Action Rosemary and Peter Grant have witnessed at least two instances of 'evolution in action' in the Galápagos Islands in the last 30 years. The consequences of El Niño and subsequent drought have a direct effect on finch population survival and the traits that are passed onto the next generation; with average beak size being a notably shifting variable.	The Medium Ground Finches displayed in this pack were collected in 1835 on the Beagle Voyage. Students should use their research skills to predict when El Niño and drought events most likely occurred around this date, and what the consequences of these events for the Galápagos Islands may have been. Use the images to take beak measurements and note any other variations. Do the same with the finches collected in 1891 (see additional images). How do the beak sizes compare? What may be the cause of differences or similarities in average beak sizes? Extension: Rosemary and Peter Grant give us good evidence that the change in beak size they witnessed is due to the consequences of El Niño. Why can the conclusions drawn on the data for our birds from the 1800s never be certain?	Ground Finch resource 1891 Ground Finch Image Historical El Niño Events:http://bit.ly/externalsitehistoricaln-inos El Niño explained: https://oceanservice.noaa.gov/facts/ninoni-na.html Time: 30 minutes	KS3 High ability KS4 KS5	Biology: Evolution, Adaptation, Variation within a species, Inheritance, Natural Selection Geography: Climate, Ocean Currents Working Scientifically: Analysing Data Sources, Drawing Conclusions
Tracking Gene Mutation Melanism and Albanism are genetically inherited traits, with Melanism the result of a dominant gene, and Albinism the result of a recessive gene.	Give students a population of grey squirrels with the below ratio: **6** Grey (wild type):**1** Black (melanistic):**1** White (albino) Use punnett squares to predict the phenotypes of the next 3 generations, with each pair producing four offspring. Randomise pairs and remember that the inheritance of both a wildtype and a melanistic gene results in the hetrozygous 'black-brown' phenotype. Then take a look at the resulting populations, taking into account the new ratios. Discuss why this may be.	Squirrel Resource Punnett Squares Optional: Images of squirrel phenotypes Time: 30 minutes	KS4 KS5	Biology: Genes and Genetics, Inheritance, Genetic Variants, Reproduction, Mutations, Phenotype and Genotypes Working scientifically: Punnett Squares, Ratios, Probability, Keys, Graphs and Charts

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund
LOTTERY FUNDED

Activity Ideas for the Classroom

BACKGROUND	ACTIVITY IDEAS	RESOURCES	KEYSTAGE	CURRICULUM LINKS
Visualising Genetics Gregor Mendel debunked the 'blending theory' of inheritance with his pea plant experiments, and found that the inheritance of each trait is determined by 'factors' that are passed on to descendants unchanged (genes). He also determined that genes can be dominant or recessive, and that recessive genes can still be passed onto the next generation. Alleles are passed on independently, and which allele is passed on is a matter of chance.	This activity builds on the use of Punnett Squares. The genes that determines the shell colour and band type (phenotype) of a banded snail are reliant on more than one gene instruction. This can help to show students why the same species (including humans) can have many different phenotypes. With this in mind, decide on two 'features' to focus on, then choose two snails from the specimen image. Use the table and Dihybrid Cross below to show how many more possible phenotypes exist, simply by adding an extra feature. The Dihybrid Cross gives 16 different possibilities! Discuss how complex this can become in reality! Extension: Discuss how the phenotypes would be different if the next generation were produced through asexual reproduction.	Banded Snail resource Image of Banded Snails or Banded Snail finds from school grounds Tables provided below Dihybrid Cross BBC Bitesize: http://bbc.in/2DqeVjq Time: 20-30 minutes	KS4 High ability KS5	Biology: Genes and Genetics, Inheritance, Genetic Variants, Reproduction Working scientifically: Punnett Squares, Ratios, Probability, Keys, Graphs and Charts

Feature	**Possibilities (Alleles)** Dominance ordered from top to bottom for each feature
Bands	Unbanded Banded
Band design	Dotted line Block line
Width of band colour	Wide band Thin band
Colour of Shell	Brown Pink Yellow
Colour of band and apertural lip	Dark brown (normal) Light brown White

Dihybrid Cross example:

	Brown Banded	Brown Unbanded	Yellow Banded	Yellow Unbanded
Brown Banded				
Brown Unbanded				
Yellow Banded				
Yellow Unbanded				

MUSEUM OF ZOOLOGY
UNIVERSITY OF CAMBRIDGE MUSEUMS & BOTANIC GARDEN
Designated Outstanding Collection
ARTS COUNCIL ENGLAND
Supported using public funding by ARTS COUNCIL ENGLAND
Funding raised by The National Lottery and awarded by the Heritage Lottery Fund
heritage lottery fund
LOTTERY FUNDED