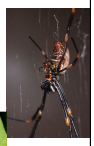
Lecture 29: Diversity

Lecture notes

- the following are copies of the slides I presented in the lecture, without the pictures. Blank slides (which only had pictures or movies) are not included
- remember, these notes are aimed to help you, not provide a substitute for attending lectures
- reading the relevant chapters in the text book will really help you to understand my lecture content (and, hopefully, vice-versa)



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my approach to first year biology

Teaching philosophy

Emphasizes an understanding of ideas, concepts and patterns

Lecture slides posted on LMS without pictures, and are an adjunct to, not a substitute for the lecture presentation

this week: evolution and diversity

Lecture 29: *Understanding Diversity* - how much diversity is there, and which evolutionary processes help bring this about?

Lecture 30: *Ecology & Evolution* - how interactions between animals, and with their environment have shaped their form and function

Lecture 31: *Evolution and the Human Animal* - evidence of evolution in our everyday lives

[Knox *et al.* 4th edn: Chapters 30 & 32
Knox et al. 5th edn: Chapters 43 & 44]

aims of this lecture

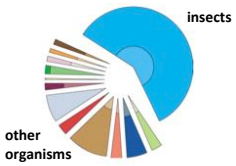
To appreciate:

i) How much diversity exists among and within species

ii) How evolutionary processes contribute to creating and maintaining this variation

how many species are there?

About 1.5 million species have been named, but many more require formal descriptions



Insects are the most diverse group

One way of estimating the total number of species is to sample one group and extrapolate. But which group?

An inordinate fondness for beetles

Almost half of all insects are **beetles**!

JBS Haldane by Klaus Patau

The Creator would appear as endowed with a passion for stars, on the one hand, and for beetles on the other, for the simple reason that there are nearly 300,000 species of beetle known, and perhaps more, as compared with somewhat less than 9,000 species of birds and a little over 10,000 species of mammals. Beetles are actually more numerous than the species of any other insect order.

JBS Haldane (1949) *What is life?*

how do we guess the real number?

Prior to 1982, most biologists thought the number of undescribed species was roughly the same as the number described

In 1982, Terry Erwin published a report in which he estimated an order of magnitude more

- he 'fogged' the upper canopy of several trees of *Luebea seemannii* in Central America
- he collected beetles that fell into the traps
- he found around 1200 species of beetles from the canopy of a single species of tree

Terry Erwin's calculation

The number of species is a function of the:

- number of species of beetles on one species of tree (1100 – 80% are new)
- proportion of beetle species that specialize on trees (14%)
- proportion of insects that are beetles (40%)
- proportion of insects that live in tree canopy (67%)
- number of species of trees in tropical rainforests (50,000)

Calculation:

- 1200 x 14% = 168 beetle species specialise on canopy of *L. seemannii*
- 168 / 0.4 = 420 insect species that specialize on canopy of *L. seemannii*
- 420 / 0.67 = 628 species specialized to *L seemannii*
- 628 x 50,000 = **31,400,000 species** in tropical rain forests

updates to Erwin's calculation

Some quibbles about his assumptions

- estimates of global species diversity now range from **2** to **80** million

Discovery of new sources of diversity:

- 1m^2 of temperate forest: **200,000 mites**
- 1m^2 of tropical grassland: **32,000,000 nematodes**
- 1g soil: **90,000,000 bacteria**

Deep-sea floor
> 1,000,000 spp

what about diversity *within* species?

Phenotypic diversity
– observed variation among individuals in morphology, development or behaviour

Genotypic diversity
– the genes an organism inherits (differences are sometimes 'invisible')

All of this diversity is the product of evolutionary processes

understanding diversity

"Nothing in biology makes sense, except in the light of evolution"

Theodosius Dobzhansky

how does diversity come about?

Four evolutionary 'forces' contribute to *generating* and *maintaining* diversity

Mutation	Migration	Selection	Drift
			

mutation

Change to the structure of an organism's DNA

- single mutations can have have large effects (e.g. if they change the way a protein works), but this is uncommon
- however, accumulation of many mutations is normally needed for evolutionary change

Normal 'wild type' American lobster

Blue 'mutant' lobster (1 in 2,000,000)

which mutations matter for evolution?

Only **germline** mutations (in cells that produce eggs and sperm) can be passed on

Somatic mutations only affect the individual in which they occur

e.g. *Cancer*

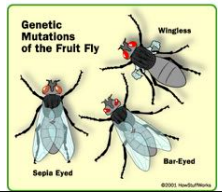
mutations have different effects

Most are **disadvantageous** (reduce fitness or cause death)

Some are **neutral** (genetic changes that don't affect function) or cause small changes

A few are **advantageous**

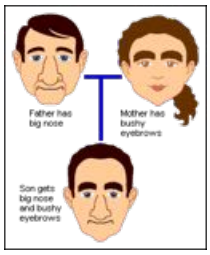
All mutations are random

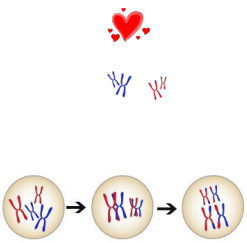


sexual reproduction

Genetic 'shuffling'

Introduces new combinations of genes into the population

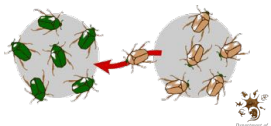




Not always advantageous; can break up 'good' gene combinations

migration (*gene flow*)

Movements of genes between populations



gene flow varies across species

Populations of sedentary organisms are more isolated from one another than very mobile ones

Maize – wind-pollinated; *low gene flow*

Vinegar fly – can fly more than 15km; *higher gene flow*

why does gene flow matter?

Within populations:

It can introduce or reintroduce genes to different parts of the population, increasing the genetic variation of that population.

Between or across populations:

It can make distant populations genetically similar to one another, reducing the chance of speciation.

The less gene flow between two populations, the more likely they will evolve into separate species.

Charles Darwin and Alfred Wallace

Charles Darwin

Alfred Russel Wallace

evolution by natural selection

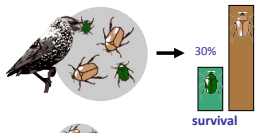
1. Individuals **vary** in a some attribute or trait (e.g. colour)

some individuals are brown; others are green …

2. The trait is **heritable** (has a genetic basis)

brown parents tend to have brown offspring …

3. The trait **affects fitness** (individuals with a particular form of the trait more likely to survive or reproduce)



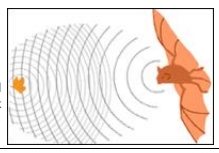
Consequence: genes for the more advantageous trait increase in frequency

examples of adaptations

Garlic mustard – is 'allelopathic', releasing a chemical into the environment that inhibits the growth of other plants

Leaf mimicry by insects to evade predators

Echolocation by bats to find food in the dark



Why is Fluffy's view of evolution wrong?

1. Selection acts only on *existing variation*
   - so it can't conjure up what an organism 'needs' or 'wants'
2. There must be an opportunity for traits to be inherited

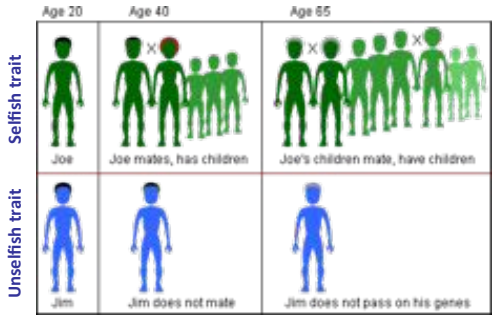
Not how evolution works!

survival of the 'fittest'

Selection acts on *individuals*, **not** *species*

In an evolutionary sense, there's no such thing as adaptations "for the good of the species"

'selfless' actions have zero fitness!



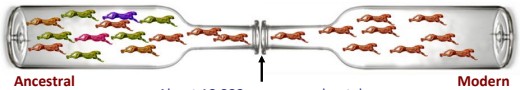
(genetic) drift

'Random' changes to the genetic make-up of a population

Drift doesn't produce adaptations

Two common forms of genetic drift are **genetic bottlenecks** and **founder effects**

Form of drift: genetic bottleneck



Ancestral population

About 10,000 years ago, cheetah populations were greatly reduced

Modern population

Only a few individuals survived - modern cheetahs descended from this limited genetic stock

another form: founder effect

Why do so many Amish people have Ellis van Creveld syndrome?

Gene mutation can be traced back to single couple who are ancestors of many Amish people

what should you have learnt from this lecture?

- how many species are there, and how do we estimate this?
- what are the four evolutionary 'forces' that contribute to generating diversity?
- what are the three requirements for natural selection?
- how does genetic drift differ from natural selection?