Interdisciplinary Science

PA3016

Evolution

University of Leicester

Contents

Welcome

Evolution by Natural Selection is the fundamental theorem of the biosciences, and it is a concept which is increasingly applied to other areas including computing, economics and statistics. This module aims to introduce the fundamental concept of evolution by selective adaptation and then to analyse an in-depth example of evolutionary change.

Module Authors

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Cover Image: Sea Lion Pup (Galapagos Islands) by Dag Peak CC-BY

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Problem Statement

Problem 01: Research Assignment

Select a topic in evolution suitable for a short podcast. The topic should be chosen to illustrate your ability to critically analyse an issue succinctly. It may be, for example, a scripted “essay” or an “interview”. It is important that the topic you chose should relate to the material of the module. Check your topic with your facilitator.

Produce the podcast. This is scheduled for week 4 of the module to give time to develop *material based on what you have learnt in the module.*

Problem 02: The Fossil Record and Evolution

Adapted from an article published in the Pittsburgh Post-Gazette, Sunday, September 26, 1999. http://carnegiemuseums.org/cmag/bk_issue/2000/marapr/feat7.html

The Fossil Record and Evolution
By Tina Calabro

Carnegie scientists prove that Darwin got it right

Evolution is based on authentic evidence of how life on the Earth works, say Jay Apt, Mary Dawson, and John Wible of the Carnegie Museum of Natural History. They point to recent discoveries that support Darwin's theories, and note that visitors were entranced with the recent museum display of feathered dinosaurs, which clearly bridged the gap between modern birds and dinosaurs of long ago.

In the 150 years since the publication of Charles Darwin’s Origin of the Species, scientists have used new data to become even more convinced of Darwin’s observations. New information appears constantly: a few years ago paleontologists revealed the latest example of a fossil animal intermediate in the progression from dinosaurs to birds in Nature (September 16, 1999), and also in National Geographic (October 1999). But revivals of hundred-year-old debates also appear constantly, generally without consideration of the scientific discoveries of Darwin’s time or of ours. In 1999, the Kansas Board of Education decided to delete the teaching of evolution from the state's science curriculum. Locally, journalist Jack Kelly of the Pittsburgh Post-Gazette (September 19, 1999) wrote that the fossil record does not support evolution. Nothing could be further removed from the facts.

Millions of fossils, found in well-dated sequences of rocks, show evolution of forms through time and show many transitions among species. Charles Darwin began in 1831 to assemble a huge body of evidence that he analyzed and evaluated for more than 25 years before he carefully deduced a new rule of descent of organisms with modification. The rules of evolution and natural selection have been observed to apply to viruses within a few hours, to reptiles on islands changed by a hurricane over a few months, to fish in isolated ponds over a few years, and to horses over millions of years.

The fossil record is unequivocal on the progression of life from simple beginnings to complex organisms. Animals without backbones predate vertebrates. Amphibians appear after fish, mammals appear after reptiles, and no complex life occurs in rocks nearly as old as those containing the oldest fossil bacteria. There is a vast body of fossil confirmation of evolution and of

natural selection preserved in the world's great collections, including those of Carnegie Museum of Natural History.

A list of fossils from the local museum

Graptolites:

A)
1. Orthograptus
2. Petalolithus (Petalograptus)
3. Cephalograptus

B)
1. Monograptus triangulates
2. Rastrites

Echinoderms:

1. Micraster

Problem 03: Human Evolution

During refurbishment of certain areas of the Natural History Museum, some displays had to be removed and stored away. There is a huge box of human-like fossils that needs to be sorted and ready for display. However, all the names of the different skulls and information about them have gone missing.

Your task is to sort through this box of skulls and come up with a human evolution tree. You would also be required to provide evidence on why you think it should be set out in that particular way.

To help you further with your research some further samples of skulls which were recently discovered are thought to be more modern will be provided. ***(These skulls will be separately marked during your practical session).***

Staff

Dr Chris Cane	(Genetics Department)
Dr Jan Zalasiewicz	(Department of Geology)
Dr Paul Howes	(Department of Physics & Astronomy)

Learning Objectives

After completing this module students should be able to

- Present an overview of evolutionary studies in modern science and be able to carry out an evolution related research project
- Critically evaluate the different theories of evolution and the ideas behind each theory
- Discuss the influence and impact of environment, social and cultural factors on evolution
- Use evolutionary algorithms to demonstrate that evolution is a generic process and applicable to a wide variety of disciplines
- Investigate examples of micro and macro evolution by gaining an in depth knowledge in two different areas of evolution:
    - Evolution of graptolites
    - Evolution of echinoderms
    - Evolution of humans
- Discuss the importance of accurate dating techniques and their role in evolutionary studies
- Demonstrate an understanding of the basic genetic principles which give rise to evolution
- Explain the role and impact of fossil record and genetics in evolution studies and how they complement each other
- Demonstrate competence in the analysis of human fossils using morphological techniques
- Be able to review recent discoveries on the origins of modern humans
- Show proficiency in using online biology tools to perform cladistic analysis

Reading List

Below is a list of reading materials that are recommended for this module. The first section contains materials that you would definitely require in order to complete the module. A supplementary list is also provided should you want to read & research further into any of the topics covered in this module.

Main Reading List

- Campbell N.A. Reece J.B. (2005) ***Biology*** 7ed, Pearson Education Inc, USA
- Jobling M.A. Hurles M.E. Tyler-Smith C (2004) *Human Evolutionary Genetics: Origins, Peoples & Disease,* Garland Publishing, New York
- Lewin R. (1999) *Human Evolution: An Illustrated Introduction*. 4th ed, Blackwell Science, USA
- Wood B. Richmond B.J. (2000) *Human Evolution: Taxonomy & Paleobiology.* Journal of Anatomy, 196(19-60)
- http://www3.interscience.wiley.com/cgi-bin/fulltext/119004217/PDFSTART
- Cavalli-Sforza L.L. Feldman M.W. (2003) *The application of molecular genetic approaches to the study of human evolution.* Nature Genetics, 33(suppl), Mar
- http://ai.stanford.edu/~serafim/CS374_2005/Papers/PopulationMigration_Review.pdf
- http://sci.waikato.ac.nz/evolution/HumanEvolution.shtml - *Evolution for Teaching, School of Science and Engineering***,** University of Waikato. This is a good website to gain an overview of human evolution
- http://anthropology.si.edu/HumanOrigins/faq/Encarta/encarta.htm - *Smithsonian Natural Museum of Natural History***.** This is a good website to gain an overview of human evolution
- Kornfield, I. & Smith, P.F. (2000) *African Cichlid Fishes: Model Systems for Evolutionary Biology*, Annual Review Ecological Systems, **31**, pp 163-196.
- http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.ecolsys.31.1.163
- Black, R.M (1989) *The Elements of Palaeontology, 2nd Edition*, Cambridge University Press, England, 416 pp.
- Clarkson, E.N.K (1998) *Invertebrate Palaeontology and Evolution, 4th Edition*, Blackwell Publishing, Oxford, 452pp.
- Skelton, P (1993) *Evolution: A Biological and Palaeontological Approach*, The Addison-Wesley Publishing Company, England, 1064 pp. (pp 390-417)

Supplementary Reading List

- This is a good website of skull animation. For the majority of the skulls they provide a 360° view. http://www.glendale.edu/skull/index.htm
- Klug and Cummings *Concepts of Genetics* (Prentice Hall) – Library code 575.1 KLU This is a good book if you need to learn any genetics concepts. It is simply written and easy to understand.
- Stearns, S.C. & Hoekstra, R.F. (2005) *Evolution: An Introduction, 2nd Edition*, Oxford University Press, Oxford, 557 pp.

Facilitation Sessions

Facilitation Session 01

Pre-Session Preparation

- Read about general evolution in Campbell & Reece (Biology): pages 438-446 (Descent with modification), 491-497 (Phylogeny and Systematics).

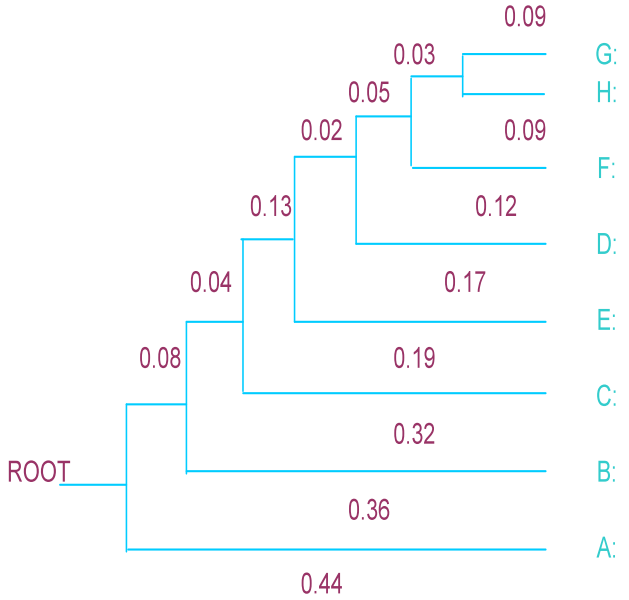
Introduction to the module

Evolution by Natural Selection is the fundamental theorem of the biosciences, and it is a concept which is increasingly applied to other areas including computing, economics and statistics. This module aims to introduce the fundamental concept of evolution by selective adaptation and then to analyse an in-depth example of evolutionary change. There are a series of three problem statements for this module; each is associated with a different deliverable, however, they are all inter-related.

Group Activity: Open Day Display

You are helping your supervisor put some information on evolution for your department open day. He gave you this tree like diagram and has told you where all the animal names should go. Half an hour later when you are actually putting the poster up, you realise you have no idea where each one fits.

a. *You now have to go and do some research on these seven animals and try to understand in which order they evolved*
b. *You also need to know what this tree like structure is all about.*



KANGAROO

CHICKEN

SHARK

NEWT

HUMAN

CARP

DOG

ECHIDNA

You also remember asking your supervisor what an Echidna was. He mentioned that it was a type of species that belonged to a primitive group of mammals known as monotremes.

Guide: each 0.01 unit is about 10.23 million years ago. This is based on the assumption that vertebrate evolution evolved about 450 million years ago.

Expectations for the next session:

You should:

- Read Campbell & Reece (Biology): Chapter 13 (Meiosis and Sexual Life Cycles) and 23 (The Evolution of Populations).
- Understand the process whereby chromosomes undergo mitosis and meiosis.
- Understand how recombination occurs and how this can lead to new genetic combination.
- Be prepared to discuss the reading material and concepts above in the next session.

Facilitation Session 02

Pre-Session Preparation

You should have:

- Read Campbell & Reece (Biology): Chapter 13 (Meiosis and Sexual Life Cycles) and 23 (The Evolution of Populations).
- Understood the process whereby chromosomes undergo mitosis and meiosis.
- Understood how recombination occurs and how this can lead to new genetic combination.
- Be prepared to discuss the reading material and concepts above in the next session.

Group Discussion: Key Concepts

Within your groups make sure that everyone understands the following key concepts/terms from the reading material:

- Genotype & phenotype
- Somatic & germ-line mutation
- Translocation
- Chiasma
- Dominant & recessive genes/traits
- Allele
- Locus
- Homozygous
- Heterozygous

Group Discussion: The Harvey-Weinberg Theorem

Within your groups discuss the Harvey-Weinberg Theorem and its impact on evolutionary theory.

Expectations for the next session:

You should:

- Read Campbell & Reece (Biology): Chapter 13 (Meiosis and Sexual Life Cycles)
- Conduct independent research (overview) on the theories of evolution: Creationism/ Intelligent Design, Natural selection/ Darwinism, Lamarckism.

Facilitation Session 03

Pre-Session Preparation

You should have:

- Read Campbell & Reece (Biology): Chapter 13 (Meiosis and Sexual Life Cycles)
- Conducted independent research (overview) on the theories of evolution: Creationism/ Intelligent Design, Natural selection/ Darwinism, Lamarckism.

Group Discussion: Evolutionary Viewpoints

Below is a transcript of a meeting between 4 highly prominent people in the field of evolution. Your task as a scribe was to take note of what everyone said and to compile each person's ideas. However, after transcription, you aren't able to say exactly which person said what.

Fortunately as you were paying attention in that meeting, you realised that each had a different idea about the theory of evolution:

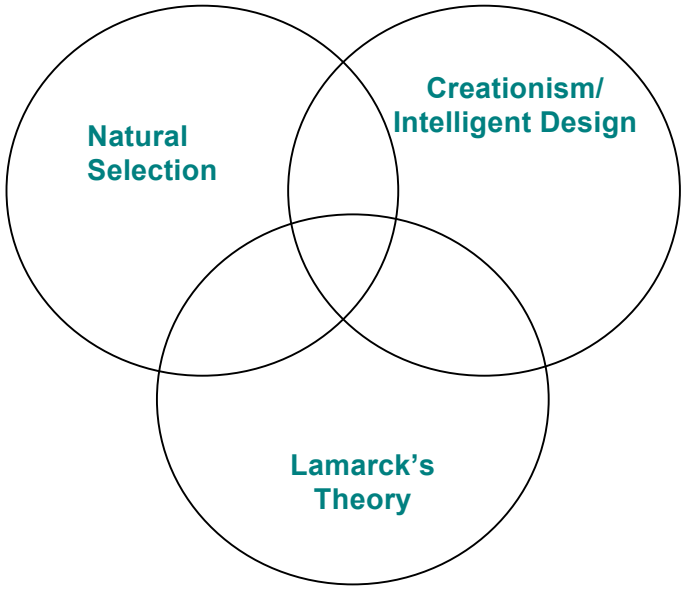
Ms Bell was a strong believer of creationism / Intelligent Design
Mr Charles was a firm supporter of natural selection / Darwinism
Mr David believed in Lamarck's theory of evolution

Below are the excerpts from the transcript (They are not in any specific order):

a. Inheritance of "selected" features: Traits involved are already inheritable, but may involve new combinations.
b. "Acquired Characteristics": Through use and/or non-use, those features needed for survival are developed in each individual.
c. trying to account for the enduring mystery of modern biology the origin of the digital information encoded in the spine of the DNA molecule
d. Change in environment: Changes in climate, topography, food supply, predators, etc.
e. New Species, better adapted to the new environment: When the collective traits of the population differ significantly from the earlier population, and can no longer reproduce with the earlier population.
f. "If we are going to teach creation science as an alternative to evolution, then we should also teach the stork theory as an alternative to biological reproduction."
g. Challenge Darwin's idea that the cause of biological change is wholly blind and undirected
h. Inheritance: Those characteristics developed ("acquired") by individuals are somehow passed on to their offspring, who can continue that development...
i. Correlation is not the same as causation unless we know what exactly the gene does
j. New Species: Eventually, over many generations, enough differences have developed that we can say we have a new species.
k. Living organisms were designed because they were really designed.
l. Overproduction: More offspring produced than will ultimately survive and reproduce
m. Variation: Inheritable features vary from individual to individual.
n. Evolution is a bankrupt speculative philosophy, not a scientific fact. Only a spiritually bankrupt society could ever believe it.… Only atheists could accept this satanic theory.
o. A changing environment creates a need for certain features to be developed in order to survive.
p. Evolution is only a theory; it hasn't been proved.
q. "Struggle for existence": Mainly competition within the species, for food, habitat, survival from being eaten.

r. Darwinism is not a scientific theory but instead a materialistic myth masquerading science. Evidence is brought in only later on.
s. "Survival of the fit" (not necessarily the strongest): Those with more adaptive traits tend to survive longer and/or produce the most offspring; these are the “naturally selected”.
t. Change over time within existing species.
u. "If someone had proof that creation started the universe wouldn't more people go to church?"
v. All living things are descended from a common ancestor by unguided natural process such as random mutation and survival of the fittest.
w. A single gene cannot account for the origin of the human brain.
x. certain features of the universe and of living things are best explained by an intelligent cause, not an undirected process.
y. We do not challenge the idea of evolution defined as change over time.
z. He died in poverty and obscurity because his proposal that life took on its current form through natural processes, not through miraculous interventions was not received well especially by British naturalist who at that time believed that nature was a reflection of God's benevolent design.
aa. You evolutionists insist the dinosaurs lived millions and millions of years ago and became extinct long before man walked the planet. I don't believe that for a minute. I don't believe there is a shred of scientific evidence to suggest it. I am 100 percent certain man and dinosaurs walked the earth at the same time. In fact, I'm not at all sure dinosaurs are even extinct! – for creationism.
bb. Personally, I believe that Creationism tells what happened, while Evolution explains how it happened.

You have decided that the easiest way to sort through this transcript was to group these statements according to the ideas of the theory. That way you could identify who said what. Within your groups sort the statements above into the Venn Diagram given below:



Expectations for the next session:

- Read Clarkson (Invertebrate Paleontology and Evolution): Chapter 2 (Evolution and the Fossil Record).

Facilitation Session 04

Pre-Session Preparation

- Read Clarkson (Invertebrate Paleontology and Evolution): Chapter 2 (Evolution and the Fossil Record).

Group Discussion: Micro-, Macro- and Mega- evolution

Within your topics discuss the various different modes of evolution, i.e.: micro-, macro- and mega-evolution. Make sure that everyone within the group is able to define each of these terms and provide examples of each from the fossil record.

Expectations for the next session:

You should:

- Read over Problem Statement 02 and remind yourself of the associated deliverable.
- Watch the following videos (URLs provided in the facilitation session notes):
  - "What Darwin Saw – Wildlife of the Galapagos"
  - "Darwin's Finches"
  - "Biological Evolution – Darwin's Finches"
  - "African cichlid"
  - "Hawaiian honey creeper"

A further supporting reading list is given in the facilitation session notes.

Facilitation Session 05

Pre-Session Preparation:

- Read over Problem Statement 02 (The Fossil Record and Evolution) again and remind yourself of the associated deliverable.
- Be prepared to discuss concepts associated with Problem Statement 02 in the facilitation session.
- Watch the following videos and be prepared to discuss:
    - "**What Darwin Saw - Wildlife of the Galapagos" –** This programme prepares travellers for an expedition to Ecuador's Galapagos Islands by combining outstanding visual images of Galapagos plants and animals with a description of the islands' natural history and unique ecosystems. (http://video.google.co.uk/videosearch?hl=en&q=darwin's%20finches%20programme&um=1&ie=UTF-8&sa=N&tab=wv#hl=en&emb=0&q=darwin's%20galapagos).
    - **"Darwin's Finches"** - Video of Darwin's Finches on Isla Espanola in the Galapagos Islands. (http://video.google.co.uk/videosearch?hl=en&q=darwin's%20finches%20programme&um=1&ie=UTF-8&sa=N&tab=wv#q=darwin's%20finches&hl=en&emb=0)
    - **"Biological Evolution – Darwin's Finches"** (http://video.google.co.uk/videosearch?hl=en&q=darwin's%20finches%20programme&um=1&ie=UTF-8&sa=N&tab=wv#q=darwin's%20finches&hl=en&emb=0)
    - **African Cichlid Video** –the variation in the species. (http://video.google.co.uk/videosearch?q=cichlid&hl=en&emb=0#q=african%20cichlid&hl=en&emb=0).
    - **African Cichlid web page** –shows the huge array of Cichlids. (http://www.africancichlids.net/gallery/index.php)
    - **Hawaiian Honey Creeper Video (I'iwi)** - A naturalist talks about the history of Haleakala national park, Hawaii. Eight minutes in, he talks about the I'iwi (Hawaiian Honey Creeper). (http://video.google.co.uk/videosearch?q=cichlid&hl=en&emb=0#hl=en&emb=0&q=Hawaiian%20HoneyCreepers)

The following reading list will help to provide some background to your discussions:

- Campbell & Reece (2005) *Biology:* page 18 (Decent with modification: adaptive radiation of the finches on the Galapagos Islands); pages 447-482 (Overview of speciation and adaptive radiation).
- Kornfield & Smith (2000): African Cichlid Fishes: Model Systems for Evolutionary Biology, *Annual Review Ecological Systems*, **31**, pp 163-196. http://arjournals.annualreviews.org/doi/pdf/10.1146/annurev.ecolsys.31.1.163
- Skelton (1993) *Evolution: A Biological and Palaeontological Approach:* You are encouraged to focus on pages 402-408; a case study specifically on the Cichlid Fish of Lake Victoria.
- Stearns & Hoekstra (2005) *Evolution: An Introduction:* pages 2-3 (Hawaiian Honeycreepers); pages 289-290 (Darwin's Finches).

Group Discussion: Real life examples of microevolution

Within your groups look at microevolution in a “real life” context using examples such as Darwin’s Finches, the African Cichlids of Lake Victoria and the Hawaiian Honeycreepers, and how they relate to the terms “allopatric speciation” and “adaptive radiation”. You are strongly encouraged to use the video links and reading materials listed in the pre-session preparation to support your discussion.

Expectations for the next session:

In preparation for the next session you should research:

- Bivalves
- Brachiopods
- Graptolites
- Echinoderms

You may like to split this research amongst your group. Your research should cover the following key points:

Bivalves:

- Brief geological history

Brachiopods

- Brief geological history
-

Graptolites:

- Brief geological history
- Evolution in the shape of graptolite rhabdosomes
- Evolution of the proximal end in graptolites
- Thecal structure and its evolution

Echinoderms:

- Brief geological history
- Radiation of early echinoderms
- The evolution of tube feet
- Pentaradial symmetry

- Read:
    - Black (The Elements of Palaeontology): Chapter 2 (Mollusca), chapter 5 (Brachiopodia), chapter 8 (Echinodermata), chapter 9 (Graptoloidea).
    - Clarkson (Invertebrate Palaeontology and Evolution): Chapter 7 (Brachiopods), chapter 8 (Molluscs), chapter 9 (Echinoderms), chapter 10 (Graptolites).

Facilitation Session 06

Pre-Session Preparation

- Come to the facilitation session prepared to discuss Bivalves, Brachiopods, Graptolites and Echinoderms.
- Read:
    - Black (The Elements of Palaeontology): Chapter 2 (Mollusca), chapter 5 (Brachiopodia), chapter 8 (Echinodermata), chapter 9 (Graptoloidea).
    - Clarkson (Invertebrate Palaeontology and Evolution): Chapter 7 (Brachiopods), chapter 8 (Molluscs), chapter 9 (Echinoderms), chapter 10 (Graptolites).

Group Discussion: Graptolites and Echinoderms

In this session, within your individual groups, you will present your summary of either bivalves/brachiopods/graptolites/echinoderms, allowing for a *maximum* of 10 minutes per person. Your presentation *must* cover the following key points:

Bivalves:
- Brief geological history

Brachiopods
- Brief geological history

Graptolites:
- Brief geological history
- Evolution in the shape of graptolite rhabdosomes
- Evolution of the proximal end in graptolites
- Thecal structure and its evolution

Echinoderms:
- Brief geological history
- Radiation of early echinoderms
- The evolution of tube feet
- Pentaradial symmetry

The other members of the group who are listening will mark the presentation out of 5 for the following two criteria:

1) How well did he/she explain it?
2) How well did I understand the presentation?

There each presenter should get two marks from each group member. These marks should be collated and handed into the facilitator at the end of the session.

At the end of the presentations you should forward your notes pertaining to your presentation to other group members. Remember that these will be useful for completing the CLEs as well as helping you to revise for your module exam. You are strongly discouraged from merely reading out passages from text books; you must show that you have actually understood the material you have researched.

Expectations for the next session:

- Read Clarkson (Invertebrate Palaeontology and Evolution): Chapter 2 (Evolution and the Fossil Record).

Facilitation Session 07

Pre-Session Preparation

You should have read:

- Clarkson (Invertebrate Palaeontology and Evolution): Chapter 2 (Evolution and the Fossil Record).

Group Activity: Fossils

Within your groups answer the following questions:

1) Which are the best locations and environments to find a well preserved fossil specimen?

2) Marine invertebrate fossils are found in mountain ranges and far from the sea. Early naturalists suggested this was due to a worldwide flood. Leonardo Da Vinci realised that the fossil distribution seen today is not what you would expect from a worldwide flood. What is the world wide distribution of fossils based upon? What is the general succession of fossils found?

3) Index/zonal fossils can be very useful in the fossil record, discuss.

4) In Germany, some Jurassic fossils have anatomical characteristics of small, carnivorous, dinosaurs, with dinosaur-like teeth, braincases, hind limbs and a long tail; however, they also have feathers. What does this suggest and is there any evidence?

5) When looking at the fossil record, the Signor-Lipps and Lazarus taxon theories may have an affect on how data was recorded. Why is this? Does it create any problems for evolutionary patterns which are seen throughout the fossil record?

Expectations for the next session:

- You are encouraged to continue your own independent research.

Facilitation Session 08

Pre Session Preparation

- You are encouraged to continue your own independent research.

Group Activity: Deliverables

Within your groups work on your outstanding deliverables for this module. You are strongly advised to bring your draft deliverables and working notes to this session in order to get verbal feedback from your facilitator.

Expectations for the next session:

You should read:

- Problem Statement 03 and remind yourself of the associated deliverable.
- Jobling (Human Evolutionary Genetics: Origins, People & Disease): Chapters 7 (Humans as Apes) and chapter 8 (Origins of Modern Humans) – You are advised to focus primarily on the introductory sections of these chapters).
- Campbell & Reece (Biology): Chapter 25 (Phylogeny and Systematics)
- http://sci.waikato.ac.nz/evolution/HumanEvolution.shtml
- http://anthropology.si.edu/HumanOrigins/faq/Encarta/encarta.htm
- http://www.glendale.edu/skull/index.htm

Facilitation Session 09

Pre Session Preparation

Read

- Problem Statement 03 and remind yourself of the associated deliverable.
- Jobling (Human Evolutionary Genetics: Origins, People & Disease): Chapters 7 (Humans as Apes) and chapter 8 (Origins of Modern Humans) – You are advised to focus primarily on the introductory sections of these chapters).
- Campbell & Reece (Biology): Chapter 25 (Phylogeny and Systematics)
- http://sci.waikato.ac.nz/evolution/HumanEvolution.shtml
- http://anthropology.si.edu/HumanOrigins/faq/Encarta/encarta.htm
- http://www.glendale.edu/skull/index.htm

Group Discussion: Human Evolution

Within your groups research and discuss human evolution.

There are a lot of good websites available to provide you with an overview of human evolution. Here are two to get you started:

- http://sci.waikato.ac.nz/evolution/HumanEvolution.shtml - Evolution for Teaching, School of Science and Engineering, University of Waikato
- http://anthropology.si.edu/HumanOrigins/faq/Encarta/encarta.htm - Smithsonian Natural Museum of Natural History

In addition you are encouraged to develop your understanding of phylogeny.

You are also encouraged to read through the "Human Evolution" laboratory script. In order to work on the skulls in the practical, you will need some knowledge about the anatomy of the skulls.

Expectations for the next session:

- Read Campbell & Reece (Biology): pages 497-504

Facilitation Session 10

Pre Session Preparation

- Read Campbell & Reece (Biology): pages 497-504

Group Discussion: Human Evolution

This session is to allow you to further analyse all the data you collected during the laboratory session and your own research. You should look at the results and come up with a preliminary plan of how the human evolutionary tree should look like based on the fossil record. Do you have any questions regarding these skulls that you would like to pose to your facilitator?

Expectations for the next session:

- You are encouraged to conduct your own research into bioinformatics

Facilitation Session 11

Pre Session Preparation

- You are encouraged to conduct your own research into bioinformatics.

Group Discussion: Bioinformatics

You have so far looked at the fossils and the most plausible explanation of what might have happened. With current DNA technology, you find out that DNA may have been extracted from the skulls found recently. You will be able to run your sequences during a bioinformatics practical. However, before you attend the laboratory session you should familiarise yourself with several key genetics concepts before you actually run the sequences:

- Ancient DNA analysis.
- mtDNA vs Y chromosome DNA.
- problems of contamination.

Expectations for the next session:

You should read:

- Clarkson (Invertebrate Palaeontology and Evolution): Chapter 3 (Origin and Early Diversification of Metazoans: Extinctions).
- Skelton (Evolution: A biological and palaeontological approach): Chapter 9 (Species, Speciation and Extinction), chapter 11 (Evolutionary Relationships and History) and chapter 15 (Phylogenetic Patterns).

Facilitation Session 12

Pre Session Preparation

Read:

- Clarkson (Invertebrate Palaeontology and Evolution)*:* Chapter 3 (Origin and Early Diversification of Metazoans: Extinctions).
- Skelton (Evolution: A biological and palaeontological approach): Chapter 9 (Species, Speciation and Extinction), chapter 11 (Evolutionary Relationships and History) and chapter 15 (Phylogenetic Patterns).

Group Discussion: Human Extinction

Within your groups consider the following questions:

- Define extinction and mass extinction.
- Why should fluctuating numbers mean that a population is more likely to die out?
- Does the hypothesis of groups becoming extinct merely through random extinction seem likely?

- What are the "Big Five" Phanerozoic extinctions? What caused them and what were their principle casualties?

- Why is much of our understanding of extinction patterns based on animals rather than plants, and, among animals, those that lived in the sea?

- Why, on average, is it more likely that a genus would become extinct than a family?

- Imagine a group of Recent bivalves for which the ambient temperature is a limiting factor; they can live only in the hottest shallow seas found immediately around the equator. Would an increase or decrease in global temperature seem more likely to threaten these bivalve linages with extinction, and why?

Expectations for the next session:

- You are encouraged to conduct your own research into the Sixth Extinction.

Facilitation Session 13

Pre Session Preparation

- You are encouraged to conduct your own research into the Sixth Extinction.

Group Discussion: The Sixth Extinction

There have been five major extinctions throughout geological time. It is expected that the next extinction, the "Sixth Extinction", will be a mammalian extinction, which, of course, would include *Homo sapiens*. This session aims to discuss various claims and statements regarding the next extinction.

Expectations for the next session:

You should continue your work on your deliverables (group and individual) and be prepared to show your progress during the next facilitation session.

Facilitation Session 14

Pre Session Preparation

You should have continued your work on your deliverables (group and individual) and be prepared to show your progress in this facilitation session.

Group Activity: Deliverables

This session has been set aside to allow you to work on your deliverables. Your facilitator will expect to see progress on all of your deliverables; as such you are strongly advised to bring draft/nearly completed versions to the session in order to get verbal feedback from your facilitator.

You should make use of this time to ask your facilitator any outstanding questions you may have on this module and the topics it covers.

Expectations for the next session:

You should continue your work on your deliverables (group and individual) and be prepared to show your progress during the next facilitation session.

Facilitation Session 15

Pre Session Preparation

You should have continued your work on your deliverables (group and individual) and be prepared to show your progress in this facilitation session.

Group Activity: Deliverables

This session has been set aside to allow you to work on your deliverables. Your facilitator will expect to see progress on all of your deliverables; as such you are strongly advised to bring draft/nearly completed versions to the session in order to get verbal feedback from your facilitator.

You should make use of this time to ask your facilitator any outstanding questions you may have on this module and the topics it covers.

Expectations for the next session:

You should continue your work on your deliverables (group and individual) and be prepared to show your progress during the next facilitation session.

Facilitation Session 16

Pre Session Preparation

You should have continued your work on your deliverables (group and individual) and be prepared to show your progress in this facilitation session.

Group Activity: Deliverables

This session has been set aside to allow you to work on your deliverables. Your facilitator will expect to see progress on all of your deliverables; as such you are strongly advised to bring draft/nearly completed versions to the session in order to get verbal feedback from your facilitator.

You should make use of this time to ask your facilitator any outstanding questions you may have on this module and the topics it covers.

Deliverables

DELIVERABLE	TYPE	FILENAME	DUE	WEIGHT
CLE01	I	PA3016_I_CLE01_*username_yymmdd*.pdf	Week 2, Day 1	7.5%
CLE02	I	PA3016_I_CLE02_*username_yymmdd*.pdf	Week 3, Day 1	7.5%
CLE03	I	PA3016_I_CLE03_*username_yymmdd*.pdf	Week 4, Day 1	7.5%
CLE04	I	PA3016_I_CLE04_username_yymmdd.pdf	Week 5, Day 1	7.5%
D01 – Graptolite & Echinoderm problem	I	PA3016_I_D01_GraptoliteProblem_username_yymmdd.pdf	Week 5, Day 2	20%
D02 - Human Evolution problem	I	PA3016_I_D02_HumanEvolution_username_yymmdd.pdf	Week 5, Day 2	20%
D03 - Radio Podcast	G	PA3016_G_D01_Podcast_groupletter_yymmdd	Week 5, Day 2	30%

Core Learning Exercise 01

1. The diagram in your CLE pack shows some of the important events in the history of life (These are marked by the time in evolution). Pick four different dates and describe the events that possibly took place and why it is an important event in the evolution of life. Two examples are given below:

Examples:

4600Mya The formation of earth through bombardment of meteorites and rocks. As the temperature cooled, some form of life became sustainable

3800Mya Replicating molecules (the precursors of DNA) form. [10]

2. Two factors are recognized as influencing the evolution of new species and the extinction of existing species. They are the biotic context and the physical context.
   a) What is the biotic and physical context? [5]
   b) Why does each play an important role in speciation? (Explain using an example) [5]

3. What is the Linnaeus Classification? Using this classification (starting at kingdom level), fill in the categories for the following species: *Apis mellifera* (Honey bee); *Drosophila melanogaster* (fruit fly); *Danio rerio* (zebrafish); *Pan troglodytes* (chimpanzee); *Homo sapiens* (modern human). [10]

4. Why are mutations important in evolution and how do they become fixed in the population? [5]

5. Starting with the two genes below, draw all the possible genotypes and state all the phenotypes for the following questions

   F0 Maternal genotype: HHdd
   F0 Paternal genotype: hhDD

   a) F1 generation (no crossover). Would having a crossover have any impact on the phenotype of this F1 generation? [5]

   b) F2 generation with one crossover in only one of the F1 parents [5]

   c) F2 generation with one crossover in each of the F1 parents [5]

   d) How does the arising of new combination of genes play a role in evolution? [5]

6. The Hardy-Weinberg Theory.
   a) What is the Hardy-Weinberg equilibrium theory? [5]

   b) What are the criteria that must be met for a population to be in Hardy-Weinberg equilibrium? [5]

Based on your understanding of the Hardy – Weinberg theory, answer the following questions. You have sampled a population in which you know that the percentage of the homozygous recessive genotype (aa) is 36%. Using that 36%, calculate the following:

c) The frequency of the "aa" genotype. [5]

d) The frequency of the "a" allele. [5]

e) The frequency of the "A" allele. [5]

f) The frequencies of the genotypes "AA" and "Aa." [5]

g) The frequencies of the two possible phenotypes if "A" is completely dominant over "a." [5]

Within a population of butterflies, the color brown (B) is dominant over the color white (b). And, 40% of all butterflies are white. Given this information, calculate the following:

h) The percentage of butterflies in the population that is heterozygous. [5]

i) The frequency of homozygous dominant individuals. [5]

After graduation, you and 19 of your closest friends (let's say 10 males and 10 females) charter a plane to go on a round-the-world tour. Unfortunately, you all crash land (safely) on a deserted island. No one finds you and you start a new population totally isolated from the rest of the world. Two of your friends carry (i.e. are heterozygous for) the autosomal recessive cystic fibrosis allele (c). Assuming that the frequency of this allele does not change as the population grows, what will be the incidence of cystic fibrosis on your island? [5]

7. What is a genetic algorithm? For what type of computing problems might a genetic algorithm be a useful method of solution? [5]

8. Critically analyse the following question in about 700 words

   As artificial selection processes such as cloning and *in-vitro* fertilisation become more successful and common, would the natural process of evolution be disrupted? [20]

Core Learning Exercise 02

1. When Darwin published "On the Origin of Species" in 1859, it was seen as controversial as it contradicted religious beliefs that underlay the then current theories of biology, and it generated much discussion on scientific, philosophical and religious grounds. The scientific "Theory of Evolution" has itself evolved since Darwin's contributions, however, what were the key observations Darwin made during his research, and what inferences did he draw from them? [10]

2. Darwin's voyage of the Beagle took him to the Galapagos Archipelago where he recorded information concerning several varieties of finch. At the time, he did not appreciate their evolutionary significance. Why, once he got back from his voyage, did he decide to study the birds further and what did they show? Name each species and accredit a beak shape/feeding technique to each. [20]

3. Using examples, describe Adaptive Radiation and how it occurs. [10]

4. Define speciation. What are Allopatric, Parapatric, Peripatric and Sympatric Speciation? Which one is illustrated by Darwin's Finches? [10]

5. What are the main characteristic differences between vertebrates and invertebrates? [10]

6. What is the taxonomic hierarchy? [5]

7. What are the main invertebrate phyla studied in palaeontology? Where appropriate, give examples of classes found in each.

8. What problems can be encountered when studying evolution in the fossil record? [10]

9. What are "Lagerstatten" and how are they "exceptionally preservation"? How can these "Lagerstatten" aid in the reconstruction of evolution within the fossil record?

10. What are Graptolites? What is their geological range and why do they have an especial geological importance as zonal fossils?

11. Using diagrams, describe the changes in graptolite theca throughout their evolutionary history.

12. What are echinoderms? What is their geological range and can they be used to study microevolution in the fossil record? [10]

Core Learning Exercise 03

1. Define the following terms [5]
   a) Hominoid

   b) Hominid

   c) Hominin

2. The following are members of the Order Primate. Draw a phylogeny tree for these animals giving your reasons behind their positions in the tree. [5]

3. What characteristics (derived and behavioural) do primates have that set them apart from the other mammals? [10]

4. Primates as a group are twice as encephalized as other mammals. How might this character have arisen? [5]

5. Hominids are known to be the most closely related species to humans. Hominid fossils can be used to examine for characteristics that differ between humans and apes as well as their likely position in the phylogeny. However, hominid fossils are extremely rare. Why do you think this is the case? [5]

6. What evolutionary factors are most important in shaping the history of human evolution? [5]

7. What is the Out of Africa expansion theory? [5]

8. In what ways can DNA sequences lead to phenotypic variation? [5]

9. Give 3 features of mtDNA which makes it an ideal source for ancient DNA analysis. [3]

10. One way to understand the origin of modern humans is through the use of phylogeny trees. Human phylogeny trees can be drawn using several different resources. Discuss how three of them are used and compare and contrast the benefits and drawbacks of each of these methods. You should not exceed 1000 words. [15]

Core Learning Exercise 04

1. How do palaeontologists date an extinction event? [5]

2. What is the P-T boundary, when was it, and what happened? [5]

3. What is the K-T boundary, when was it, and what happened? [5]

4. What are the possible causes of mass extinctions? [10]

5. Many palaeontologists think that we are expecting the next mass extinction to be primarily mammals. The “sixth extinction” will be a wide spread, mass extinction during the modern Holocene epoch. Modern extinctions are directly attributed to human influences; explain why, using notable examples of modern extinctions of mammal fauna.

Deliverable 01: Podcast

As a group you will need to produce a short podcast lasting 5-8 minutes. You may choose the topic of the podcast as long as it relates to evolution and contains real academic content at the level you have been studying in this course. The topic should be chosen to illustrate your ability to critically analyse an issue succinctly. You may choose to present the topic in any manner that you see fit, i.e as an interview, a scripted piece etc.

You are *strongly advised* to check your chosen topic with your facilitator to ensure that it is appropriate. A debate over Evolution versus Creationism will not be acceptable for this podcast.

Recording equipment (two USB microphones compatible with student tablets) is available from the IScience office. Please note that these microphones are *only* for use *in the department* during office *hours*; you are therefore advised to time table your recording schedule accordingly. Please *do not* leave all of your recording to the last week as you may find that other groups have booked the equipment out.

Support for planning, recording and editing a podcast will be provided in your Methods and Techniques module in parallel with this core module. You are strongly encouraged to bring podcast plans, scripts etc to the Methods and Techniques sessions.

Deliverable 02:

Your reports are expected to be ~2000-2500 words, unless more space is required to satisfactorily discuss the subtleties of the science involved. Please note that increasing the length of the essay alone will not gain you marks; you are expected to present the required information in a logical and concise manner.

The reports should contain a full level of technical detail. There is no prescriptive style provided; you are encouraged to select your own style that is appropriate for the presentation of the material (this will be a factor in the assessment). You may find it useful here to revisit your Report Writing Skills notes.
You are also encouraged to consult the marking criteria in your Course Handbook for the general guidelines that the markers will use to assess your work for both content and presentation.

Deliverable 03: Human Evolution

You have been provided with a box containing assorted human-like fossils; however, none of the fossils are labelled and the relevant accompanying information has been lost. You must sort through these fossils and identify them. Furthermore you are required to produce a human evolutionary tree, placing these fossils in the appropriate location, and explain why you think the tree should be set out in that particular way.

Note: Some further samples of skulls will be provided in one of your laboratory sessions and whilst these will be primarily marked within the laboratory session they will also help you to build the evolutionary tree.

You should provide a document of 2000-3000 words in length identifying each of the fossils, and any additional fossils you find during your research, as well as explaining the reasoning behind the layout of the evolutionary tree.

Supplementary Materials

Contact your facilitator for supplementary material.

Meta tags

Author: Page, A.; Cane, C.; Howes, P.; Zalasiewicz, J.

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Title: Interdisciplinary Science Evolution Student Document

Classification: PA3019 / Evolution

Keywords: Earth Sciences; Geology; Biology; Palaeontology; Problem-Based Learning; sfsoer; ukoer

Description: Evolution by Natural Selection is the fundamental theorem of the biosciences, and it is a concept which is increasingly applied to other areas including computing, economics and statistics. This module aims to introduce the fundamental concept of evolution by selective adaptation and then to analyse an in-depth example of evolutionary change.

Language: English

File Size: 2.1MB

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Version: 1.0

Additional Information

This module pack is the open student version of the teaching material. An expanded module pack for facilitators and additional information can be obtained by contacting the Centre for Interdisciplinary Science at the University of Leicester. http://www.le.ac.uk/iscience

This pack is the Version 1.0 release of the module.