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A LEVEL
Topic Exploration Pack

BIOLOGY B (ADVANCING BIOLOGY)

H422
For first teaching in 2015

The Development of Species

Version 2

www.ocr.org.uk/biology

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This Topic Exploration Pack should accompany the OCR resource 'The Development of Species: Evolution and Class' learner activities, which you can download from the OCR website.

This activity offers an opportunity for English skills development.

Introduction

Aims and Objectives:

1. To understand, interpret and construct phylogenetic trees.
2. To understand and explain the selection pressures that led to the evolution of human behavioural, physiological and anatomical adaptations.
3. To consider the evolution of language as an example of a scientific topic that is difficult to address because of a lack of direct evidence.

Topic Overview:

Section 3.1.3 of the specification introduces some key biological concepts, such as classification, evolution, adaptation and biodiversity, in the context of *Homo sapiens*.
Student will examine the principles of classification and the types of evidence used to classify organisms (3.1.3 a-d of the specification). Students are introduced to the concept of hierarchical taxonomic ranks and the different definitions of species that exist. 3.1.3d looks at how species can be organised in phylogenetic trees to indicate their evolutionary relationships. One of the threads that should run through the delivery of this material is that scientific theories are subject to change. Different types of evidence can be used in classification (eg observable features and molecular evidence); this evidence is often conflicting and can be interpreted in different ways. An emphasis should be placed on the changeable nature of science as a result of the discovery of new evidence.

In 3.1.3 e-g, students learn about the fundamental components of evolution – genetic variation and the presence of selection pressures, which result in natural selection of organisms with beneficial traits (ie adaptations). Students will look at different types of adaptation – behavioural, anatomical and physiological – in the context of both human and plant evolution. Examining theories for the evolution of language provides an opportunity to discuss fundamental scientific questions such as “what is science?”, “does science need to produce theories that are testable?” and “how can scientific research be conducted when little direct evidence exists?”

3.1.3 h-i in the specification introduce students to the idea that biodiversity can be studied at different levels (ie genetic biodiversity within a population, species biodiversity within an ecosystem, or ecosystem biodiversity within a region). Students will have the opportunity to calculate genetic diversity and compare the biodiversity of populations.

The following suggested activities look at particular aspects of this topic.

Suggested Activities

Task 1 is designed to provide practice in the interpretation and construction of evolutionary trees. The activity offers the opportunity to consider how new evidence and different interpretations of evidence can result in different phylogenetic trees. In preparation for this task, students should have looked at a few phylogenetic trees and be aware of some fundamental principles (eg nodes represent common ancestors; the more recently two species have branched and diverged, the more closely they are related). One misconception students might have is that all extinct species on a phylogenetic tree are ancestors of extant (living) species. It is important to emphasise that nodes/branching points in a tree represent common ancestors of species. It is also important to emphasise that phylogenetic trees are not fixed; new evidence can cause re-evaluation of evolutionary relationships and rearrangement of trees. Task 1 should help to underline this point. In addition, questions 4 and 5 offer the chance to discuss and embed the ideas of classification and taxonomy.

Task 2 gives students the opportunity to consider specific examples of human adaptations and to discuss how they might have evolved. This could be set as a group discussion or research task. It would be beneficial for students to have been introduced to the principles of selection pressure and the different categories of adaptation (behavioural, physiological and anatomical) prior to this task. There are often several possible explanations for the evolution of an adaptation. It can be emphasised to students that competing theories and conflicting evidence might exist. The links between adaptations can also be emphasised (eg the evolution of bipedalism allowing hands to be used for tool making; the correlation between the increase in brain size and the development of tool use).

Task 3 offers students the chance to consider how scientific hypotheses can be formed when there is a lack of direct evidence, using the theories of language evolution as examples. Students should be used to thinking about empirical scientific evidence from experiments. This task presents examples of scientific research in which evidence is scarce and experiments are difficult to perform.

Several questions can be asked about language evolution. When did language evolve? What was the selection pressure that drove the evolution of language (ie what benefits did language produce for humans)? What did language evolve from and were there any intermediate stages (ie what structures in the brain might have existed that allowed language to evolve)?

The activity could be set as a homework research task or carried out in a classroom with internet access. Students could be provided with direct references or prompted to use particular search terms. The lesson could include a general discussion of what makes something scientific – what can and what cannot be studied by science? The idea of science requiring testable hypotheses can be discussed. What approaches can be taken when a question needs to be answered and little direct evidence exists? Students could be asked to think why language evolution is difficult to study (eg lack of direct evidence, such as fossils, which can be used to study anatomical evolution, and we know relatively little about language genetics).

Useful sites:

General

http://humanorigins.si.edu/research

http://www.newscientist.com/topic/human-evolution

Language evolution

http://www.newscientist.com/data/doc/article/dn19554/instant_expert_6_-_the_evolution_of_language.pdf

Could language have evolved to aid learning?

http://www.scientificamerican.com/article/could-language-have-evolved/

Could language have evolved as "social grooming"?

http://www.newscientist.com/article/mg20026834.200-monkey-gossip-hints-at-social-origins-of-language.html

http://www.cogsci.ucsd.edu/~johnson/COGS184/3Dunbar93.pdf

Phylogenetic trees

http://www.nature.com/scitable/knowledge/library/overview-of-hominin-evolution-89010983

http://www.nature.com/scitable/knowledge/library/primate-speciation-a-case-study-of-african-96682434

http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/P/Primates.html

http://evolution.berkeley.edu/evolibrary/article/evograms_07

Suggested answers

Task 1: Understanding Evolutionary Trees

1. Explain why the branch for *Ramapithecus* does not extend as far as the other species.

Ramapithecus is extinct. Only brands for extant (living) species will extend to the present.

2. To which extant species (ie a species that is alive on Earth today) are humans most closely related, according to this tree?

Chimpanzees

3. On the diagram, circle the most recent common ancestor shared by gorillas and humans.

A circle should be drawn around the node at the base of the gorilla branch.

4. A student studied the tree and suggested that “humans and orangutans are unrelated”. Discuss whether this statement can be considered correct

A correct statement would be “humans are less related to orangutans than they are to chimpanzees and gorillas.” Humans and orangutans are both in the same family, therefore their evolutionary relationship is closer than relationships with organisms in other families. They share a high percentage of genetic information.

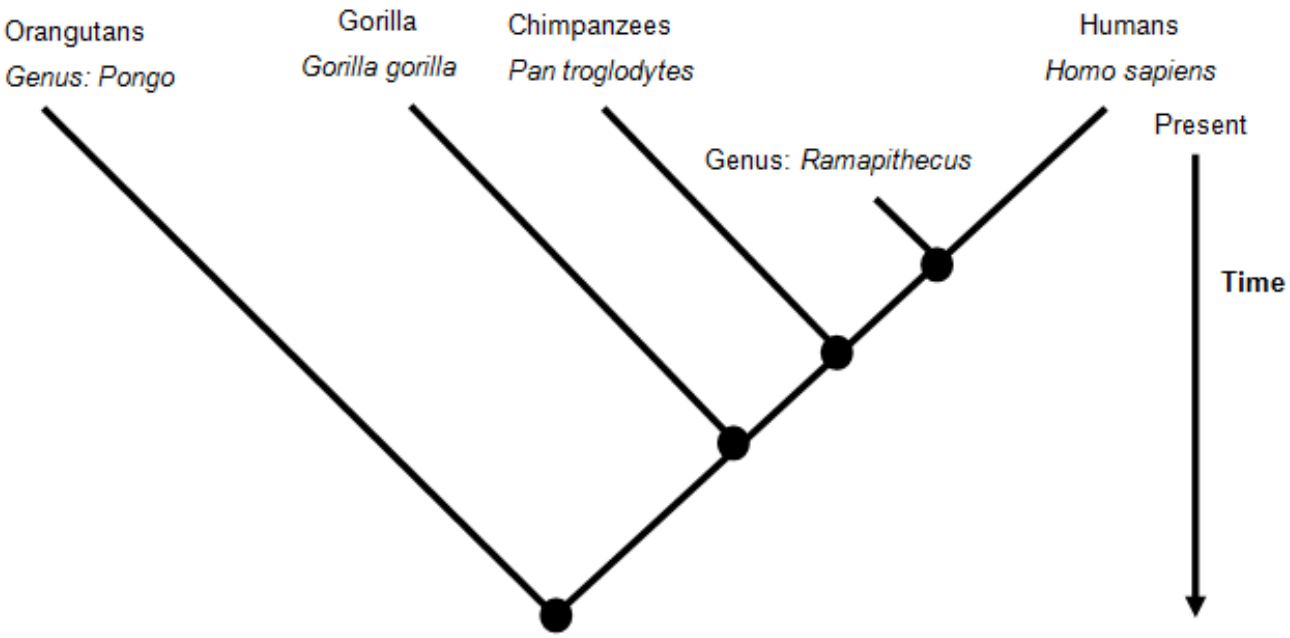
5. The position of *Ramapithecus* on the phylogenetic tree was based on the appearance of fossils in comparison with living species. Since then, additional evidence has been found that indicates the following:

- Humans are more closely related to chimpanzees and gorillas than this diagram suggests.
- Chimpanzees have the closest evolutionary relationship to humans of any living species.
- Another species, *Pan paniscus*, commonly known as the bonobo, has been identified. Bonobos are in the same genus as chimpanzees.
- The *Ramapithecus* genus is now thought to be part of an extinct genus known as *Sivapithecus*. The closest living relative of *Sivapithecus* is the *Pongo* genus.

Suggest the types of additional evidence that might have been used to reassess the evolutionary relationships of hominid species.

- Additional fossil samples (eg with greater detail, more complete skeletons and giving a larger sample size).
- Genetic information (eg the human genome project, and other primate genome projects have allowed detailed comparisons of DNA sequences in different species, indicating how genetically similar they are and when their evolutionary paths diverged).
- Immunological evidence.

(i) Using the information above, construct a new phylogenetic tree for the Hominidae family.



Expected duration: 30-40 minutes.

Task 2: Considering examples of adaptations

Adaptation	Type of adaptation	Selection Pressure	Benefits of the adaptation
Bipedalism	Anatomical	One explanation is that climate change caused some forest habitats to be replaced with grassland. Natural selection would have favoured humans who were able to walk on two feet in these new habitats.	Hands free for communication and tool use. Greater endurance. Improved hunting ability.
Tool use	Behavioural	The availability of large, protein-rich animals that could be hunted.	Improved hunting (ie easier to hunt animals using tools/weapons).
Opposable thumbs	Anatomical	The requirement to manipulate objects (eg for tool making).	Enabled tool use.
Skin pigmentation (melanin production)	Physiological/ biochemical	Greater skin exposure to UV-B radiation following the evolution of a reduction in body hair in humans.	Melanin production provides protection by absorbing UV radiation, thereby reducing skin cancer risk.
Human dentition (evolving smaller teeth and different types of teeth)	Anatomical	Omnivorous diet. The evolution of larger brains and language.	Several types of teeth for different types of food. Smaller teeth evolved, allowing more room for the brain case and the ability to produce the complex sounds required for language.

Adaptation	Type of adaptation	Selection Pressure	Benefits of the adaptation
The ability to increase breathing rate	Physiological/ Biochemical	The requirement for intense periods of physical activity.	Enabled escape from predators and enabled prey to be caught.
An extended childhood and longer dependency on parents	Behavioural	The requirement to learn complex physical and social tasks.	Provides a greater opportunity for learning during early life.

Other adaptations that students might consider include: language, concealed ovulation, lactose tolerance, large brain size.

Expected duration: 40+ minutes (depending on whether the task is delivered as a discussion exercise or a research task).

Task 3: Researching the Evolution of Language

Research and describe the types of evidence scientists have used to produce theories about when, how and why language evolved.

- Computer simulations
- Comparisons with other species (eg some scientists believed that the evolution of a lower larynx enabled language by making it easier to produce speech. It has now been found that many other species have a 'descended larynx' without having language. This suggests evolution of the brain is responsible for human language).
- Neuroscience/brain anatomy
- Archaeology
- Genetics (eg the FOXP2 gene is found in many organisms, but humans have a unique variant of the gene that might be involved in language. DNA from the fossils of human ancestors allows estimations of when mutations linked to language might have occurred. Recently genes linked to dyslexia and autism have been identified; these genes might provide insights into language development).

Some of the research points that students might discover include:

The gossip/grooming hypothesis

Theory: As human social groups became larger, 'vocal grooming' (ie making pleasing sounds to others, and using gossip) replaced physical grooming as a way of maintaining social bonds. This could then have developed slowly into a more complex language.

Evidence: Comparisons of other primate groups – eg brain development is correlated with group size

Criticism: Does not explain how the simple sounds used for vocal grooming could evolve into a complex language.

'Mother tongues'

Theory: Words and a basic language could have evolved for communication between mothers and offspring.

Evidence: Little direct evidence.

Criticism: Why have other animals not evolved language for communication between mother and offspring? How did language extend to communication between non-relatives?

The gestural theory

Theory: Language might have initially been communicated through physical gestures rather than sounds.

Evidence: Other apes use gestures in a deliberate and communicative way. Some of these gestures appear to be the same as human gestures. Gestures and language use similar neural pathways and the parts of the brain that control gestures and language neighbour each other.

Criticism: Can it explain the switch from using gestures to using sounds? This could be a result of the need to communicate in the dark or while carrying tools.

Language as a learning aid

Theory: Language might have evolved in individuals to help improve their thinking speed and efficiency.

Evidence: Experimental evidence with human volunteers. The presence of words – even if the words are nonsensical and meaningless – help people sort objects.

Expected duration: 60 minutes research time. 20-30 minutes discussion time.

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