

## Is DNA the answer to classification?

### Introduction

This activity introduces students to the basics of how DNA is used in classification of organisms.

### The activity

Remind students of the importance of accurate identification of species for any evaluation of biodiversity and discuss traditional methods for species identification.

Show the PowerPoint presentation providing a very simple explanation of how DNA can be used to identify species.

The biology should be kept as simple as possible, and the discussion used to emphasise the importance of international collaboration of scientists. Some students may be confused between barcodes and DNA fingerprint techniques. There is a useful explanation of the differences here, mainly for teachers. <http://www.i-sis.org.uk/DNAidentikit.php>.

Students use the resources suggested, along with the textbook and any other resources to compare DNA technology and traditional methods of classification.

### Resources

<http://phe.rockefeller.edu/barcode/>

<http://www.ncbi.nlm.nih.gov/Genbank/index.html>

#### How Science Works

**Ai** Identifying and classifying living things is fundamental to understanding their variety. Scientists make, preserve and study collections of specimens as a valuable source of information which can help to answer important

**Eg** The desire to be first to a new discovery or breakthrough is a powerful motivation for scientists, and can lead to competition. Much scientific work, however, nowadays involves collaboration, in large interdisciplinary teams, often from several countries. This is particularly common where the work requires expensive equipment or the collection and processing of very large amounts of data.

**Fa** The interests and concerns of society influence the directions of scientific research and technological development, and the extent of funding for work in different areas.

#### Science explanations

**Pb** Classifying living things helps to identify relationships between and within species, and to decide how best to protect the individual species that are part of the world's biodiversity.

**Pc** New DNA technologies are changing the scientific approach to classification.

## Suggested answers to questions

1)

DNA technology	Traditional methods
Can identify species from small parts of the organism.	Whole organisms or large parts are needed to compare anatomical features.
Can identify eggs and larval stages.	Mature forms usually needed for full identification.
Can distinguish species which look very similar, for example species that mimic each other.	Species that look very similar can be confused.
Introduces the potential for immediate field-based identification using electronic DNA bar coding devices.	Identification can be complex, requiring comparison with standard type specimens.
Helps to show evolutionary relationships between species.	Superficial similarities may not relate to evolutionary relationships.
Relies on laboratory techniques and equipment.	Can be carried out without sophisticated laboratory facilities.
Variation within species may be great. It is not always possible to confirm the category of species. This ultimately relies on individuals being able to interbreed.	Appearance, biochemical and anatomical similarities do not always define species. There is a need to observe reproductive behaviour is also important – as members of a species, by definition, interbreed.

Students would not be expected to come up with or remember more than 2 or 3 of the above differences.

2)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	?
Human	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys	
Yeast	Gly	Ser	Ala	Lys	Ala	Gly	Ala	Thr	Leu	Phe	Lys	Thr	Arg	Cys	Glu	Leu	Cys	His	Thr	Val	Asp	Ala	14
Pig	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Lys	3
Chicken	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Lys	4
Wheat	Gly	Asn	Pro	Asp	Ala	Gly	Ala	Lys	Leu	Phe	Lys	Thr	Arg	Cys	Ala	Gln	Cys	His	Thr	Val	Asp	Ala	12
Drosophila	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Leu	Phe	Val	Gln	Arg	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Ala	7
Dogfish	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Val	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Asn	6

3) Pig

4) Yeast

- 5) Use this activity to discuss the importance of an international DNA database such as Genbank to allow scientists to collaborate in agreeing taxonomic categories and evolutionary relationships between species. It is not possible to catalogue species, count them and map any changes over time unless there is international agreement on classification.
- 6) Sequencing, PCR and other DNA technologies which allow identification have broad and important applications in the fields of medicine, forensics and classification. The role of this technology in classification is acknowledged as having the potential to allow more efficient and effective monitoring and measurement of biodiversity. The funding tends to follow areas of science which have economically important applications.

June 2009 Revised January 2011



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DNA technologies have advanced the science of taxonomy. The sequence of bases in certain genes can be compared across individuals to see how closely related they are. As DNA mutates over time, if groups of organisms do not interbreed, their DNA will become more and more different. Traditional taxonomy is based on similarities and differences in anatomical structures, biochemistry and physiology of organisms. The definition of a species also relies on individual members of the species being able to interbreed. If they can't produce live offspring, no matter how similar they appear to be, or how similar their DNA – they are not the same species.

### The Activity

Use the textbook pages, 175-178, and the web sites below to help you answering these questions.

<http://phe.rockefeller.edu/barcode/>

This site has an interesting article 'Barcode of Life' and a good summary 'Barcoding life: 10 reasons'

<http://www.ncbi.nlm.nih.gov/Genbank/index.html> This site gives you access to actual databases of sequences.

- 1) Watch the PowerPoint presentation about use of DNA in taxonomy, and use other sources to find out about DNA and traditional methods.  
Complete a table with two columns to compare the use of DNA and more traditional methods for defining species.
- 2) Enzymes are proteins that catalyse chemical reactions in living organisms. An enzyme called **cytochrome c** is essential for cell respiration. This enzyme is present in every animal, plant and protozoan (not bacteria).

Human **cytochrome c** contains 104 amino acids. DNA analysis has found that 37 of these 104 amino acids are always in exactly the same position in every organism that has been analysed. A primitive microbe ancestor of all these animals and plants must have contained the ancestral cytochrome c molecule. Over billions of years, changes to the amino acid sequence of some sections of the molecule have occurred, and this is just one measurable difference between different species. The cytochrome C gene has been chosen for animal barcodes because it does show mutation over time and between species but does not have the very high mutation rate found in non-coding DNA sequences.

Cytochrome c sequences can be compared by identifying the similar and different amino acids in each position in the protein.

The table below shows 22 amino acid of human cytochrome c, and the corresponding sequences from six other organisms.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	?
Human	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Ile	Met	Lys	Cys	Ser	Gln	Cys	His	Thr	Val	Glu	Lys	
Yeast	Gly	Ser	Ala	Lys	Ala	Gly	Ala	Thr	Leu	Phe	Lys	Thr	Arg	Cys	Glu	Leu	Cys	His	Thr	Val	Asp	Ala	
Pig	Gly	Asp	Val	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Lys	
Chicken	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Ile	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Lys	
Wheat	Gly	Asn	Pro	Asp	Ala	Gly	Ala	Lys	Leu	Phe	Lys	Thr	Arg	Cys	Ala	Gln	Cys	His	Thr	Val	Asp	Ala	
Drosophila	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Leu	Phe	Val	Gln	Arg	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Ala	
Dogfish	Gly	Asp	Ile	Glu	Lys	Gly	Lys	Lys	Val	Phe	Val	Gln	Lys	Cys	Ala	Gln	Cys	His	Thr	Val	Glu	Asn	

Using a highlighter or coloured pencil, highlight all the amino acids that are different from the human cytochrome c sequence. Enter the number of differences for each in the last column. The first two columns have been done for you.

Assume that the more similar two molecules are, the more recently they have evolved from a common ancestral molecule. Also assume that the more similar the molecules, the more closely related are their owners.

- 3) Which organism appears to be most closely related to humans?
- 4) Which organism appears to be most distantly related to humans?
- 5) Discuss the importance of an international database of species' DNA sequences to promote cataloguing and measuring of biodiversity.
- 6) Suggest why many funding bodies including governments and large companies have funded the development of DNA technologies for use in identifying similarities and differences between individuals and between species.