

Teaching ideas for Topic 3: Genetics

This topic covers both the basics of theoretical genetics and also up-to-date aspects of genetic engineering and biotechnology. There is ample scope for addressing ethical issues surrounding genetically modified (GM) foods, use of DNA technology in forensic science and the use of gene transfer techniques for human benefit. Some students find theoretical genetics difficult and require lots of practice to become proficient in genetics problems. It is important that HL students can do this in preparation for more advanced genetics in Topic 10, *Genetics and evolution (HL)*.

Ideas for the lesson

- Having reviewed the structure of DNA and introduced the relevant terms, it is useful to address the idea of what happens when mutations occur. Genetic mutation is covered well at the following website, where there are a number of video clips: www.brightstorm.com. Single base substitutions in hemoglobin and the consequences are interesting and important. Follow the consequence of the base substitution through mRNA production and polypeptide formation to the assembly of defective hemoglobin. This provides a good opportunity to review protein structure and prepare for Topic 10.
- Supply students with a series of karyograms so they become familiar with interpreting them for abnormalities. A discussion of the techniques used to obtain them and the ethical issues involved is very useful. As an alternative to photographs, karyograms can be obtained on the internet and sorted on screen.
- Comparisons of chromosome numbers are a useful way of comparing genomes of different species and highlight the differences in genome size.
- Meiosis can be confusing for students. Encourage them to model the stages of meiosis using pipe cleaners, modelling clay or paper models. The development of trisomies and crossing over can be demonstrated well in this way.
- The work of Mendel is crucial to the understanding of inheritance but also provides a good opportunity to discuss reliability of scientific evidence.
- Students find the study of genetic ‘diseases’ very interesting but it is important to distinguish between genetic conditions (‘diseases’) and infectious diseases.
- Although it is possible to carry out simple gel electrophoresis in the lab, there are many good video demonstrations on the internet for students to view, for example, at www.dnatube.com.
- Provide students with examples of DNA profiles and encourage them not only to appreciate the benefit of these in forensic work but also to consider the reliability of DNA evidence in law and how such evidence must be carefully considered in any trial. Consider who ‘owns’ the information that has been discovered and whether companies have the right to use it for commercial gain, such as to develop medical treatments to which they hold the copyright.
- Provide students with a range of views on genetically modified crop plants, including maize, tomatoes and oranges, and animals such as sheep, which produce milk containing human proteins for medical treatment. Discussion of pros and cons of GM of organisms has occurred ever since the techniques were discovered, a positive view on the techniques and benefits can be viewed at www.uctv.tv (search for ‘genetically modified food’). Other sites, such as Greenpeace, give an opposing view: www.greenpeace.org.uk (search for ‘genetic tyranny’). Various websites provide different perspectives on, and discuss of, the topic, for example, www.gov.uk and www.nature.com. Ask students to compile a ‘balance sheet’ of benefits and disadvantages from a scientific point of view.
- Students could conduct a discussion on the evidence provided from data on the risks to the monarch butterfly from genetically modified maize crops containing the Bt gene. There are many issues to discuss including reliability, vested interest and field versus laboratory studies.

Practical activities

- If laboratory space and time are sufficient, students gain huge benefits from performing simple crosses with different types of *Drosophila*. The patience needed for genetic experiments is clearly demonstrated with this species and can provide a starting point for discussion of the work of Morgan.
- Students can create their own ‘cloned’ plants from cuttings from any plant that easily forms roots in water or a gel medium. Cloning in this natural way can be compared with other methods of cloning using embryos, stem cells or tissue samples in plants and animals.

ICT

- ICT can be used to research the occurrence of a particular gene or allele in different parts of the world. Blood groups and lactose intolerance provide good examples of variation between ethnic groups caused by genetics.
- Databases such as GenBank and BLAST can be used to investigate differences in nucleotide sequences between organisms and this provides a good introduction to Topic 10, *Genetics and evolution (HL)*, and Option B, *Biotechnology and bioinformatics*.

Common problems

- Meiosis can be confusing for students to follow and any practical work is helpful. Students can be encouraged to model meiosis using pipe cleaners, modelling clay or paper models. A way of doing so using LEGO® is shown on in online video clips, for example, at <http://video.mit.edu> (search for ‘lego animation meiosis’).

Theory of knowledge (TOK)

- The high frequency of the mutation causing sickle-cell anemia in areas where malaria is prevalent provides a good example of a correlation and a cause that are clearly linked.
- Comparison of the risks associated with amniocentesis and chorionic villus sampling provides a useful way to introduce a discussion on the right to choose such a test and the rights of an unborn child. Also, students might ask to what extent it is right to define a ‘normal’ person.
- DNA profiling has helped solve many crimes and bring criminals to justice but there are ethical issues to consider in retaining DNA from people who have never been convicted. The law differs in different countries so this is also a useful International mindedness link. A video clip providing a good starting point for discussion can be found at <http://scicast.org.uk/films> (search for ‘DNA profiling’).
- Reproductive and therapeutic cloning are topics that can be discussed from an ethical standpoint. Which, if either, produces the greater good?

International mindedness

- Genome sequencing has shown that all humans worldwide share the majority of their DNA. What are the consequences of this knowledge to biologists?
- Sickle-cell anemia is a condition that used to be prevalent in areas where malaria is common. With the increased mobility of people throughout the world, many countries now face the challenge of treating people with the condition. It is important to raise awareness of the symptoms and problems sufferers face.
- Some cultures favour the birth of one sex over another and karyotyping can be used to determine the sex of an unborn child. What are the ethical issues involved in different countries?
- The economic benefits of genetically modified crops may be different in different countries. Students can consider who will benefit and who will not, and why.