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Genetic Technologies Overview

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ABE Master Teacher Fellowship Program

AMGEN® Biotech Experience

Scientific Discovery for the Classroom

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The projects designed by the 2022–23 ABE Master Teacher Fellows are a compilation of curricula and materials that are aligned with Amgen Biotech Experience (ABE) and prepare students further in their biotechnology education. These projects were created over the course of a 1-year Fellowship in an area of each Fellow's own interest. Each is unique and can be adapted to fit the needs of your individual classroom. Objectives and goals are provided, along with expected outcomes. Projects can be used in conjunction with your current ABE curriculum or as an extension.

As a condition of the Fellowship, these classroom resources may be downloaded and used by other teachers for free. The projects are not edited or revised by the ABE Program Office (for content, clarity, or language) except to ensure safety protocols have been clearly included where appropriate.

We are grateful to the ABE Master Teacher Fellows for sharing their work with the ABE community. If you have questions about any of the project components, please reach out to us at ABEInfo@edc.org, and we will be happy to connect you with the author and provide any assistance needed.

AMGEN® Biotech Experience

Scientific Discovery for the Classroom

Australia

Genetic Technologies Overview - Teacher Guide

Overview

This resource provides an overview of a range of genetic technologies and connects each technology to real-world applications and examples. This will assist students in organizing and collating this information, which they can then draw upon when addressing higher-order thinking questions. Such questions include evaluating the benefits and ethical considerations of these technologies; their social, cultural, and economic influences; and their impacts on biodiversity. The overview is in the form of a series of learning pathways on LabXchange, together with associated summary templates and worksheets to complete. This resource has been designed to cover specific New South Wales Biology Stage 6 Syllabus outcomes for Australian schools; however, anyone with an interest in genetic technologies may find this resource useful.

Outcomes addressed

Upon completing the series of lessons, the following outcomes from the New South Wales Biology Stage 6 Syllabus will be covered:

Biology Stage 6 Syllabus: Module 6 Genetic Change

Inquiry question 2: How do genetic techniques affect Earth's biodiversity?

Students:

- investigate the uses and applications of biotechnology (past, present and future), including:
  - analysing the social implications and ethical uses of biotechnology, including plant and animal examples
  - researching future directions of the use of biotechnology
  - evaluating the potential benefits for society of research using genetic technologies
  - evaluating the changes to the Earth's biodiversity due to genetic techniques

Inquiry question 3: Does artificial manipulation of DNA have the potential to change populations forever?

Students:

- investigate the uses and advantages of current genetic technologies that induce genetic change
- investigate and assess the effectiveness of cloning, including but not limited to:
  - whole organism cloning
  - gene cloning
- describe techniques and applications used in recombinant DNA technology, for example:
  - the development of transgenic organisms in agricultural and medical applications
- evaluate the benefits of using genetic technologies in agricultural, medical and industrial applications
- evaluate the effect on biodiversity of using biotechnology in agriculture
- evaluating the changes to the Earth's biodiversity due to genetic techniques
- interpret a range of secondary sources to assess the influence of social, economic and cultural contexts on a range of biotechnologies

Learning activities guide and sequence

Each genetic technology listed below has its own LabXchange pathway and summary template to complete based off the resources given. The following list below provides a suggested sequence and timeframe for each learning activity. Use teacher discretion when deciding which labXchange pathway components and worksheets to spend more/less time on, or provide as extension activities. The learning objectives and summary templates will assist learners in collating the key information needed to address the syllabus outcomes.

Activity description	Time	Materials
1. Polymerase chain reaction (PCR) **Overview:** Polymerase Chain Reaction - or PCR - is known as one of the most ubiquitous and powerful techniques in life science laboratories. It is a highly sensitive and selective method to produce many copies of a particular piece of DNA. This lesson details applications of PCR and its mechanism and demonstrates how the method is used in the lab. **Learning objectives:** 1. Summarize the principle of PCR. 2. Outline the basic steps of experimental PCR. 3. Explore the current and future applications of PCR.	1 hour	• Link to LabXchange pathway: PCR • Summary template: 1 Polymerase chain reaction (PCR)
2. Gene cloning and genetic engineering **Overview:** This lesson outlines how we can use genetic engineering to manufacture proteins to treat human disease. This involves using restriction enzymes and ligases to cut and paste the gene of interest into a plasmid vector. This recombinant DNA molecule is then introduced into a prokaryotic host and grown to produce many copies of the	1 hour	• Link to LabXchange pathway: Gene cloning and genetic engineering • Summary template: 2 Gene cloning and genetic engineering

desired protein (e.g., insulin to treat diabetes). Recombinant DNA can also be introduced into eukaryotic hosts to express a desired gene. **Learning objectives:** 1. Outline the steps of gene cloning and the importance of restriction enzymes, ligases, and plasmids in this process. 2. Explain how gene cloning can be used to produce proteins to treat a specific disease. 3. Recognise how recombinant DNA technology can be used to create transgenic plants and animals.		
3. Whole organism cloning **Overview:** This lesson outlines the different types of cloning and their applications, with a focus on whole organism cloning. Explore the process of whole organism cloning with a simulation. Ethical issues related to cloning are discussed. **Learning objectives:** 1. Identify the three types of artificial cloning and describe their applications. 2. Outline the process of whole organism cloning. 3. Discuss the potential uses and ethical concerns related to cloning.	1 hour	• Link to LabXchange pathway: Whole organism cloning • Summary template: 3 Whole organism cloning • Animal cloning worksheet (Animal cloning – DNAdots by miniPCR) • Why clone? From learn.genetics • Cloning interactive: Clone a mouse
4. Genetically modified organisms (GMOs) **Overview:** This lesson outlines the uses and applications of genetically modified organisms (GMOs) in medicine and agriculture and discusses the benefits and risks to society as well as ethical concerns associated with these technologies.	2 hours	• Link to LabXchange pathway: GMOs • Summary template: 4 Genetically modified organisms (GMOs) • Genetically modified organisms (GMOs) worksheet (Genetically Modified Organisms (GMOs) – DNAdots by miniPCR)

Learning objectives: 1. Identify that recombinant DNA technology is used in the production of GMOs. 2. Describe the uses and applications of GMOs in medicine and agriculture with named examples. 3. Discuss the ethical concerns with using GM animals. 4. Justify the use of GM technology including benefits vs. risks to society and the potential impacts on biodiversity.		• Learn genetics: Transgenic species- uses and ethical concerns • Genetically modified foods from learn.genetics
5. DNA fingerprinting and DNA profiling **Overview:** This lesson outlines the discovery and process of DNA fingerprinting and how the technique has evolved into modern day DNA profiling. Learn which genetic markers are used in these techniques and the applications of these technologies in solving crime and linking blood relatives. **Learning objectives:** 1. Outline the process of DNA fingerprinting and DNA profiling. 2. Identify the genetic markers used in these techniques. 3. Explain how these technologies have improved with time. 4. Give examples of applications of DNA profiling in solving crime and linking blood relatives. 5. Analyse data from a crime scene to solve a case.	1.5 hours	• Link to LabXchange pathway: DNA fingerprinting and DNA profiling • Summary template: 5 DNA fingerprinting and DNA profiling • DNA fingerprinting worksheet (DNA fingerprinting – DNAdots by miniPCR) • CSI Wildlife HHMI Biointeractive activity
6. DNA sequencing **Overview:** This lesson outlines the process of DNA sequencing and gives some examples of its many applications.	2 hours	• Link to LabXchange pathway: DNA sequencing • Summary template: 6 DNA sequencing • Personal genetic ancestry testing worksheet (Personal

Learning objectives: 1. Outline the first DNA sequencing method, the Sanger Method, or Chain Termination Method. 2. Describe the Human Genome Project. 3. Explore applications of DNA sequencing including linking genes to disease, creating species databases (DNA barcoding), screening fetal DNA, and sequencing DNA samples from the environment.		genetic ancestry testing – DNAdots by miniPCR) • The Human Genome Project worksheet (The Human Genome Project – DNAdots by miniPCR) • Environmental DNA worksheet (Environmental DNA (eDNA) – DNAdots by miniPCR)
7. Gene editing **Overview:** This lesson explores the potential wide-ranging applications of gene editing technology with CRISPR-Cas9, ranging from curing genetic diseases to modifying the entire genome of a species. Listen to scientists discuss their current work in this field. Read about other gene editing tools aside from CRISPR, including advantages and disadvantages of each tool. The ethical problems associated with the use of gene editing technology are discussed. **Learning objectives:** 1. Outline how CRISPR-Cas9 technology can be used to edit genetic sequences. 2. Describe examples of gene editing technology in the fields of medicine, agriculture and environmental engineering. 3. Evaluate the ethical issues associated with the current and potential future use of gene editing technology.	1 hour	• Link to LabXchange pathway: Gene editing • Summary template: 7 Gene editing • CRISPR worksheet (CRISPR/Cas-9 – DNAdots by miniPCR)
8. Biotechnology into the future **Overview:** With next-generation sequencing technologies, we can now read genetic material faster and cheaper than ever before. This has opened the	1 hour	• Link to LabXchange pathway: Into the future • Summary template: 8 Biotechnology into the future

door to personalised (precision) medicine, enables tracking of infectious agents, identification of species, and even testing for microbes in space! **Learning objectives:** 1. Explore future directions of genetic technologies made possible with Next Generation Sequencing. 2. Assess the benefits and risks that the field of personal genomics could bring. 3. Discover how developments have made genetic technologies cheaper and more portable, enabling us to explore and collect data from new environments.		

Polymerase chain reaction

Link to LabXchange pathway: PCR

Learning objectives:

1. Summarize the principle of PCR.
2. Outline the basic steps of experimental PCR.
3. Explore the current and future applications of PCR.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

Gene cloning and genetic engineering

Link to LabXchange pathway: Gene cloning and genetic engineering

Learning objectives:

1. Outline the steps of gene cloning and the importance of restriction enzymes, ligases, and plasmids in this process.
2. Explain how gene cloning can be used to produce proteins to treat a specific disease.
3. Recognise how recombinant DNA technology can be used to create transgenic plants and animals.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

Extra resources:
Past HSC exam questions

Whole organism cloning

Link to LabXchange pathway: Whole organism cloning

Learning objectives:

1. Identify the three types of artificial cloning and describe their applications.
2. Outline the process of whole organism cloning.
3. Discuss the potential uses and ethical concerns related to cloning.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

*Extra resources:

- Animal cloning worksheet (Animal cloning – DNAdots by miniPCR)
- Why clone? From learn.genetics
- Cloning interactive: Clone a mouse
- Past HSC exam questions

Genetically modified organisms (GMOs)

Link to LabXchange pathway: GMOs

Learning objectives:

1. Identify that recombinant DNA technology is used in the production of GMOs.
2. Describe the uses and applications of GMOs in medicine and agriculture with named examples.
3. Discuss the ethical concerns with using GM animals.
4. Justify the use of GM technology including benefits vs. risks to society and the potential impacts on biodiversity.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

*Extra resources:

- Genetically modified organisms (GMOs) worksheet (Genetically Modified Organisms (GMOs) – DNAdots by miniPCR)
- Learn genetics: Transgenic species- uses and ethical concerns
- Genetically modified foods from learn.genetics
- Past HSC exam questions

DNA fingerprinting and DNA profiling

Link to LabXchange pathway: DNA fingerprinting and DNA profiling

Learning objectives:

1. Outline the process of DNA fingerprinting and DNA profiling.
2. Identify the genetic markers used in these techniques.
3. Explain how these technologies have improved with time.
4. Give examples of applications of DNA profiling in solving crime and linking blood relatives.
5. Analyse data from a crime scene to solve a case.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

*Extra resources:

- DNA fingerprinting worksheet (DNA fingerprinting – DNAdots by miniPCR)
- CSI Wildlife HHMI Biointeractive activity
- Past HSC exam question

DNA sequencing

Link to LabXchange pathway: DNA sequencing

Learning objectives:

1. Outline the first DNA sequencing method, the Sanger Method, or Chain Termination Method.
2. Describe the Human Genome Project.
3. Explore applications of DNA sequencing including linking genes to disease, creating species databases (DNA barcoding), screening fetal DNA, and sequencing DNA samples from the environment.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

*Extra resources:

- Personal genetic ancestry testing worksheet (Personal genetic ancestry testing – DNAdots by miniPCR)
- The Human Genome Project worksheet (The Human Genome Project – DNAdots by miniPCR)
- Environmental DNA worksheet (Environmental DNA (eDNA) – DNAdots by miniPCR)

Gene editing

Link to LabXchange pathway: Gene editing

Learning objectives:

1. Outline how CRISPR-Cas9 technology can be used to edit genetic sequences.
2. Describe examples of gene editing technology in the fields of medicine, agriculture, and environmental engineering.
3. Evaluate the ethical issues associated with the current and potential future use of gene editing technology.

Outline of technique	
Uses and applications	
Benefits to society	
Discuss any ethical, social, cultural, and/or biodiversity issues	

*Extra resources:

- CRISPR worksheet (CRISPR/Cas-9 – DNAdots by miniPCR)

Biotechnology into the future

Link to LabXchange pathway: Into the future

Learning objectives:

1. Explore future directions of genetic technologies made possible with Next Generation Sequencing.
2. Assess the benefits and risks that the field of personal genomics could bring.
3. Discover how developments have made genetic technologies cheaper and more portable, enabling us to explore and collect data from new environments.