

Biotechnology Use in the Real World

By Amy Chen, ABE Australia



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The projects designed by the 2023–24 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.

Master Teacher Fellowship

UNIT NAME: Biotechnology Use in the Real World

TIME FRAME: 15 hours

SUGGESTED AGE RANGE: 16–18

SUGGESTED COURSE OR CONTENT AREA:

Connection Descriptions:

Teachers will select at least one of the following lenses to act as the overlay for the unit:

- Connections/tie-ins between ABE and physics, chemistry, and earth science; marine bio,, neuroscience; and others
- Project or problem-based learning
- Professional skills in STEM/Profiles in STEM
- Eye on the news: current real-world applications for ABE concepts, content, and technologies

AUTHOR: Amy Chen

PROGRAM SITE: ABE Australia

SUMMARY OF PROJECT IDEA:

Students will deepen their understanding of how biotechnology is used in the modern day to support the sectors of agriculture, medicine, or industry.

The lesson/activity sequences are designed to start from teacher-led inquiry to introduce some key biotechnology examples and social and ethical impacts of biotech. The next sequence is student directed using learning pathways through LabXchange to continue to build student understanding of cloning and recombinant technologies. During the last activity sequences, students have the opportunity to select an example of their choice where biotechnology is linked to the UN Sustainable Development Goals.

STANDARDS/SYLLABUS POINTS ADDRESSES:

Module 6 - Genetic Change

Learning Activities at a Glance	
Section 1: Introduction to Biotechnology (2 hours)	
Activity 1.1: What Is Biotechnology and How Has It Been Used Throughout History?	Materials and Resources Needed: <ul style="list-style-type: none"> ● Computer
Section 2: Biotechnology and DNA manipulation (5–6 hours)	
Activity 2.1: Comparison of Artificial Insemination and Artificial Pollination	Materials and Resources Needed: None
Activity 2.2: Gene Cloning, PCR, and Recombinant DNA Technology	Materials and Resources Needed: <ul style="list-style-type: none"> ● LabXchange ● Computer
Activity 2.3: Whole Organism Cloning	Materials and Resources Needed: <ul style="list-style-type: none"> ● LabXchange ● Computer
Activity 2.4: Debate—Social and Ethical Implications of Cloning	Materials and Resources Needed: <ul style="list-style-type: none"> ● Poster ● Markers
Section 3: Current Research in Biotechnology (2 hours)	
Activity: Biotechnology in the Field	Materials and Resources Needed: <ul style="list-style-type: none"> ● Profiles of scientists currently working in biotechnology
Section 4: Biotechnology and the UN Sustainable Development Goals (4–5 hours)	
Activity: Use Biotechnology to Help Address and UN Sustainable Development Goal	Materials and Resources Needed: <ul style="list-style-type: none"> ● Computers ● Internet ● Posters

Section 1: Introduction to Biotechnology

Activity 1: What Is Biotechnology and How Has It Been Used Throughout History?

Overview: Students will learn about the basics of biotechnology and the use of biotechnology throughout history.

Learning Goals:

- Define biotechnology
- Describe uses of biotechnology throughout history

Key Vocabulary: biotechnology, fermentation, genetic engineering, genetically modified organisms

Materials and LabXchange Pathway(s): N/A

Teacher Preparation: Will need to prepare own resources to directly teach basic introduction to biotechnology

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. "What Is Biotechnology?" Students brainstorm and complete a Think-Pair-Share, and then bring together all ideas onto the whiteboard for the whole class to see.	10 min	Student workbook
2. Teacher directs the teaching of biotechnology and lists some examples.	15 min	
3. GMOs Are Not New Students watch the video and complete the workbook activities.	30 min	LabXchange: The Oldest GMO

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<p>4. Ancient biotechnology Case Study – Fermentation/ Cheese Making</p> <p>Students read through the Science Learning Hub link and make summary notes from the resource. Students then research either specific example of fermentation or cheese making and create a scaled timeline on how the process has changed throughout time.</p>	50 min	Computers Science Learning Hub: Ancient Biotechnology Student workbook
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Section 2: Biotechnology and DNA Manipulation

Activity 2.1: Comparing Artificial Insemination and Artificial Pollination

Overview: Students will be able to clearly distinguish the similarities between artificial insemination and artificial pollination.

Learning Goals:

- Describe the processes of artificial insemination and artificial pollination using examples
- Explain the differences between artificial insemination and artificial pollination using examples

Key Vocabulary: artificial pollination, artificial insemination

Materials and LabXchange Pathway(s):

- Computers
- Student workbook

Teacher Preparation: Will need to prepare own teaching materials to directly teach artificial insemination and artificial pollination

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Powerwrite – “What do you know about artificial pollination and artificial insemination?” Students spend 5 minutes doing the powerwrite individually, and then they swap with a peer, read the other response, and try to add one additional relevant point.	15 min	Student workbook
2. Teacher direct teaches artificial pollination and artificial insemination. Students complete a comparison table in their workbook comparing the two processes in general.	30 min	Student workbook
3. Artificial Pollination of Kiwi Fruit – Science Learning Hub	20 min	Science Learning Hub Video: Artificial Pollination

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<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
Students watch the video and address the questions in the student workbook. Students to discuss responses as small groups to check understanding.		Student workbook
4. Artificial Insemination Example Students use computers to research their own examples of artificial insemination and address the questions within the workbook.	30 min	Student workbook Computers

Section 2: Biotechnology and DNA Manipulation

Activity 2.2: Understanding Gene Cloning and recombinant DNA Technology

Overview: Students will learn about gene cloning, recombinant DNA technology, PCR techniques, and the link to creating transgenic organisms.

Learning Goals:

- Outline the processes of gene cloning and recombinant DNA technology
- Assess current applications of gene cloning and recombinant DNA technology

Key Vocabulary: DNA, gene cloning, ligation, restriction enzyme, plasmid, digestion, sticky ends

Materials and LabXchange Pathway(s):

- Computers
- Student workbook
- LabXchange Text: [What Is Genetic Engineering?](#)
- LabXchange: [GMO](#)
- LabXchange: [Restriction Enzyme Digest](#)
- LabXchange: [Ligating DNA Fragments](#)

Teacher Preparation: N/A

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Teachers assigns pre-quiz on genetic engineering.	5 min	Computers LabXchange: Pre-quiz
2. Students learn about genetic engineering, specifically gene cloning.	20 min	Computer LabXchange Text: What Is Genetic Engineering?
3. Students create a flow chart outlining the process of gene cloning.	10 min	Student workbook (depth can vary dependent on student ability)
4. Students learn about recombinant DNA technologies from a general description of the process and use	2 hours	Recombinant DNA Britannica LabXchange: GMO

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Activity Description	Time	Materials
simulations to understand specific stages.		LabXchange: Restriction Enzyme Digest LabXchange: Ligating DNA Fragments
5. Students create a flow chart outlining the process of recombinant DNA.	15 min	Student workbook (depth can vary dependent on student ability)

Section 2: Biotechnology and DNA Manipulation

Activity 2.3: Whole Organism Cloning

Overview: Students will learn about the different processes of whole-organism cloning and some of its uses, and will model the cloning process.

Learning Goals:

- Describe two types of artificial cloning
- Outline the process of whole organism cloning
- Explain potential uses of whole organism cloning

Key Vocabulary: cloning, somatic cell, embryo

Materials and LabXchange Pathway(s): N/A

Teacher Preparation: If using a paper model, printouts of the mouse cloning activity will need to be made.

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Students learn about the process of whole organism cloning and some of its uses.	30 min	Genetic Science Learning Centre — What Is Cloning? Uses of cloning — Why Clone?
2. Students outline the somatic cell nuclear transfer process in a flow chart.	10 min	Student workbook (depth can vary dependent on student ability)
3. Students model the cloning process using “mice.” Students can use either the paper model or the online simulation. (The paper model is slightly easier for students to understand and is online.)	30 min	Teacher Guide with printouts Student Instructions with questions Petri dishes Forceps Scissors Glue Online simulation of “ Click and Clone ”

Section 2: Biotechnology and DNA Manipulation

Activity 2.4: Social and ethical implications of cloning and genetic modification

Overview: Students will learn about the ethical and social considerations in cloning and genetic modification and develop their critical thinking skills

Learning Goals:

- Explain examples of social and ethical implications
- Evaluate the ethics and social factors within the use of cloning and genetic modification

Key Vocabulary: ethics, social implications, cloning, genetic modification

Materials and LabXchange Pathway(s): N/A

Teacher Preparation: Teacher will need to prepare a statement or a few statements that can be used for the debate activity.

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Students read about the ethics of genetic modifications of farm animals	15 min	LabXchange: Ethics of GM of Farm Animals
2. Students read about the ethics of cloning.	15 min	National Human Genome Research Institute: Cloning Fact Sheet Britannica – Cloning and ethical controversy
3. Students undertake a debate on the ethics and social implications of cloning using philosophical chairs teaching method. Teacher provides a statement for the debate. This activity can be conducted in smaller groups depending on the class dynamics.	15–30 min	
4. Students write a reflection on the debate	15 min	Student workbook (depth can vary dependent on student ability)

Section 3: Current Research in Biotechnology

Activity: Biotechnology in the Field

Overview: Students will learn about specific examples of current biotechnology research in different fields and delve into future applications of biotechnology

Learning Goals:

- Describe current fields of biotechnology research
- Assess future applications of biotechnology

Key Vocabulary: biotechnology

Materials and LabXchange Pathway(s): N/A

Teacher Preparation: N/A

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Innovations in Biotechnology Students read about examples of innovation in biotechnology and consider the benefits and implications.	20 min	LabXchange: Next Generation Sequencing LabXchange: Personal Genomics
2. Where to Next? Students read the article and identify the key considerations of biotechnology going into the future.	15 min	Article: The Next 25 Years
3. Meet Some Scientists Students explore the profiles of scientists currently working in biotechnology and their research areas.	30 min	LabXchange: Operations Profiles Video: Meet the Scientist: Bioengineering Video: Meet the Scientists: Chemical Engineering Video: Meet the Scientist: Biomedical Engineering

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<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
4. Future Biotechnology in Medicine/ Agriculture/Industry Students research and identify specific examples of biotechnology being researched and discuss benefits and current implications.	30–40 min	Computers Student workbook

Section 4: Biotechnology and the UN Sustainable Development Goals

Activity: Use Biotechnology to Help Address and UN Sustainable Development Goal

Overview: Students bring together all of their understanding about biotechnology and use it to research and develop an idea on how biotechnology can be used to solve a global problem.

Learning Goals:

- Apply biotechnology use to solving global problems within the fields of agriculture, medicine or industry

Key Vocabulary: sustainability, biotechnology, poverty, inequality

Materials and LabXchange Pathway(s): computer

Teacher Preparation: Teacher will need to decide if posters are to be digital or printed, etc.

Lab Safety Considerations: N/A

Sequence of Activities

<i>Activity Description</i>	<i>Time</i>	<i>Materials</i>
1. Introduction to UN Sustainable Development Goals Students explore the 17 UN Development Goals and select a specific area to where they could apply an example of biotechnology.	30 min	UN Development Goals
2. Students research and develop a poster showcasing how a specific example of biotechnology can be used to address one of the 17 UN Development Goals. Their poster should address: <ul style="list-style-type: none"> ● The specific development goal the biotechnology is going to combat ● A detailed description of the biotechnology example chosen ● A detailed explanation into how the biotechnology can be used to address the goal ● An assessment of ethical and social considerations for their biotechnology 	3–4 hours	Student workbook Computers Poster

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3. Poster presentation in the form of a gallery walk. This can be the assessable component to bring together all the student learning.	1–2 hours depending on class size	
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Student Workbook



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LESSON SEQUENCE



Learning Activities at a Glance	
Section 1: Introduction to Biotechnology (2 hours)	
Activity 1.1: What Is Biotechnology and How Has It Been Used Throughout History?	Materials and Resources Needed: <ul style="list-style-type: none"> • Computer
Section 2: Biotechnology and DNA Manipulation (5–6 hours)	
Activity 2.1: Comparison of Artificial Insemination and Artificial Pollination	Materials and Resources Needed
Activity 2.2: Gene Cloning, PCR, and Recombinant DNA Technology	Materials and Resources Needed: <ul style="list-style-type: none"> • LabXchange • Computer
Activity 2.3: Whole Organism Cloning	Materials and Resources Needed: <ul style="list-style-type: none"> • LabXchange • Computer
Activity 2.4: Debate – Social and Ethical Implications of Cloning	Materials and Resources Needed: <ul style="list-style-type: none"> • Poster • Markers
Section 3: Current Research in Biotechnology (2 hours)	
Activity 3.1: Biotechnology in the Field	Materials and Resources Needed: <ul style="list-style-type: none"> • Profiles of scientists currently working in biotechnology
Section 4: Biotechnology and the UN Sustainable Development Goals (4–5 hours)	
Activity 4.1: Use Biotechnology to Help Address and UN Sustainable Development Goal	Materials and Resources Needed: <ul style="list-style-type: none"> • Computers • Internet Posters

CHECKPOINT LOG

Activity:	Date of Completion	Teacher Signature
Activity 1.1		
Activity 2.1		
Activity 2.2		
Activity 2.3		
Activity 2.4		
Activity 3.1		
Activity 4.1 (research)		
Activity 4.1 (poster)		

SECTION 1: INTRODUCTION TO BIOTECHNOLOGY



ACTIVITY 1: WHAT IS BIOTECHNOLOGY AND HOW HAS IT BEEN USED THROUGHOUT HISTORY?

KEY VOCABULARY: BIOTECHNOLOGY, FERMENTATION, GENETIC ENGINEERING, GENETICALLY MODIFIED ORGANISMS

WHAT IS BIOTECHNOLOGY?

Question: Write your brainstorm points in the box below.

GMOS ARE NOT NEW

Watch the video “The Oldest GMO” and answer the following questions.

*Question 1: **Outline** some products that are the results of modifying food.*

*Question 2: **Describe** an example of ancient “biotechnology”.*

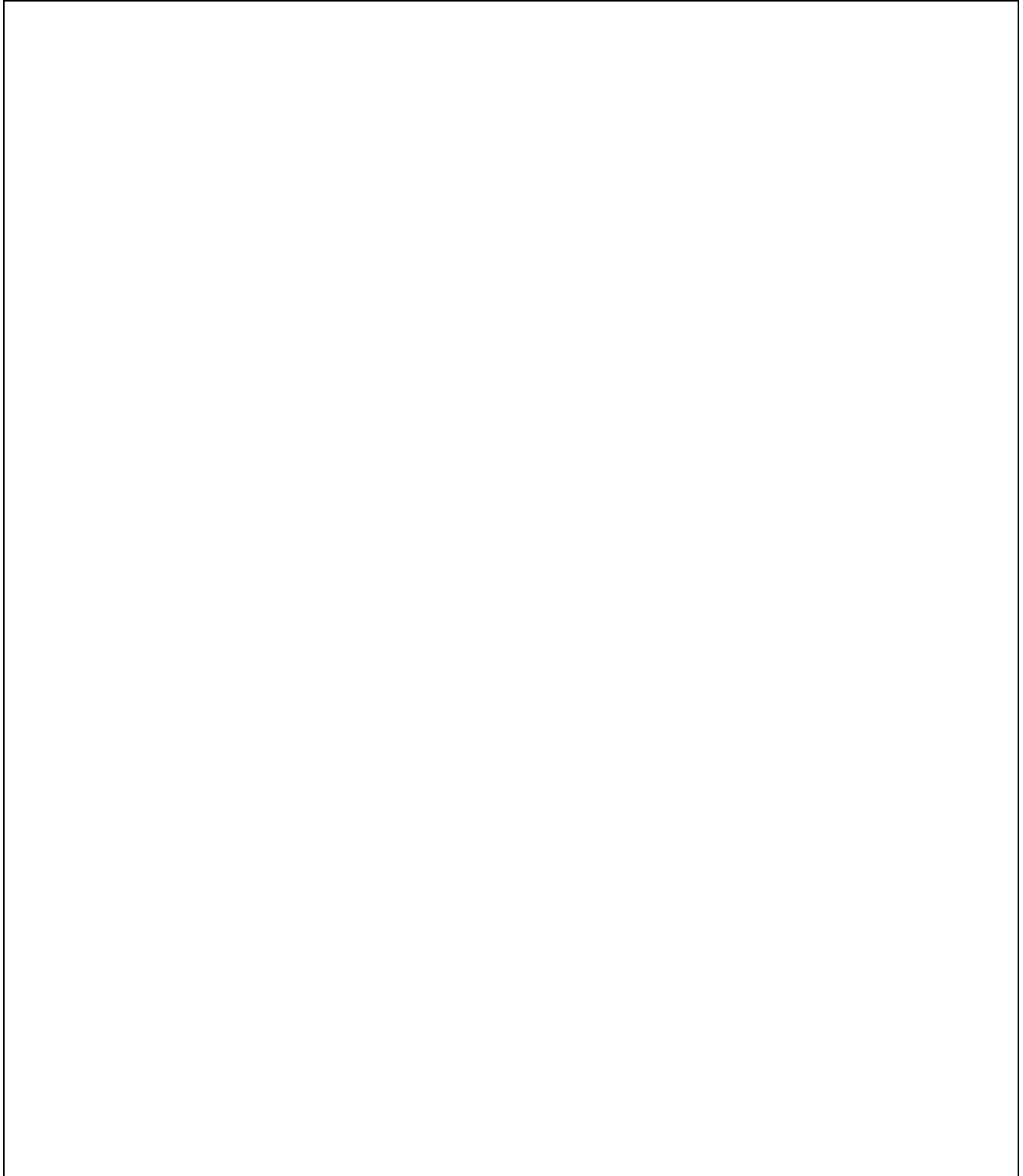
Question 3: **Outline** some reasons for artificial selection.

Question 4: **Describe** some tools being used in biotechnology.

Question 5: **Explain** the importance of agrobacterium in GMOs.

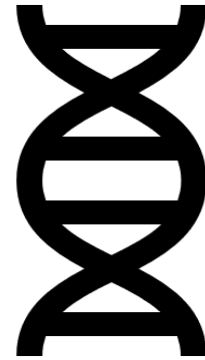
Question 6: **Assess** the examples of GMO use from the video.

Question 2. Create a **scaled** timeline on the development of either the process of fermentation or cheese making.

A large, empty rectangular box with a thin black border, intended for the student to draw a scaled timeline. The box is currently blank.

SECTION 2: BIOTECHNOLOGY AND DNA MANIPULATION

ACTIVITY 2.1: COMPARING ARTIFICIAL INSEMINATION AND ARTIFICIAL POLLINATION



KEY VOCABULARY: ARTIFICIAL POLLINATION, ARTIFICIAL INSEMINATION

POWERWRITE

What do you know about artificial pollination and artificial insemination?

Question 1: Complete the following comparison table.

	Artificial Insemination	Artificial Pollination
Similarities (consider the process/outcome)		
Differences (consider the process/outcome)		

ARTIFICIAL POLLINATION ON THE KIWI FRUIT

Question 1: **Outline** the artificial pollination process of kiwi fruit.

Question 2: **Explain** the importance of artificial pollination for kiwi fruit.

Question 3: **Describe** the research being conducted into artificial pollination of the kiwi fruit.

Question 4: **Justify** the importance of the research being conducted.

ARTIFICIAL INSEMINATION CASE STUDY

*Question 1: **Create** a flow chart of the artificial insemination process in your chosen example.*

*Question 2: **Justify** the use of artificial insemination in your chosen example.*

*Question 3: **Explain** some ethical considerations of the use of artificial insemination in your chosen example.*

ACTIVITY 2.2: UNDERSTANDING GENE CLONING AND RECOMBINANT DNA TECHNOLOGY

KEY VOCABULARY: DNA, GENE CLONING, LIGATION, RESTRICTION ENZYME, PLASMID, DIGESTION, STICKY ENDS

GENE CLONING

Use the space below to make notes on the process of gene cloning:

*Question 1: Create a flow chart **describing** the process of gene cloning:*



RECOMBINANT DNA TECHNOLOGIES

Use the space below to make notes on the process of recombinant DNA technologies:

*Question 1: Create a flow chart **outlining** the process of recombinant DNA:*

ACTIVITY 2.3: WHOLE ORGANISM CLONING

KEY VOCABULARY: CLONING, SOMATIC CELL, EMBRYO

PROCESS OF WHOLE ORGANISM CLONING

Question 1: Outline some uses of whole organism cloning

*Question 2: **Describe** the process of somatic cell nuclear transfer using a flow chart.*

ACTIVITY 2.4: SOCIAL AND ETHICAL IMPLICATIONS OF CLONING AND GENETIC MODIFICATION

KEY VOCABULARY: ETHICS, SOCIAL IMPLICATIONS, CLONING, GENETIC MODIFICATION

ETHICS OF GM ON FARM ANIMALS

Use the space below to note down key points from the reading.

ETHICS AND CLONING

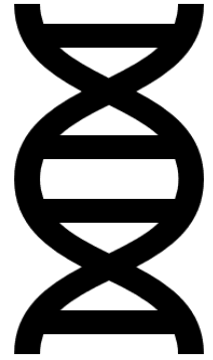
Use the space below to note down key points from the reading.

ETHICAL AND SOCIAL IMPLICATIONS OF CLONING

DEBATE TOPIC:

Some space for you to develop your arguments and ideas:

SECTION 3: CURRENT RESEARCH IN BIOTECHNOLOGY



KEY VOCABULARY: BIOTECHNOLOGY, INNOVATION

INNOVATIONS IN BIOTECHNOLOGY

*Question 1: **Outline** some benefits and implications of biotechnology innovation.*

*Question 2: **Identify** the key considerations of biotechnology moving into the future.*

*Question 3: **Assess** THREE examples of future biotechnology from agriculture/medicine or primary industry.*

BIOTECHNOLOGY SCIENTISTS

Complete the table as you explore some profiles on some current biotechnology scientists

Biography details	Area of Research	Other points of interest

SECTION 4: BIOTECHNOLOGY AND THE UN SUSTAINABLE DEVELOPMENT GOALS

KEY VOCABULARY: SUSTAINABILITY, BIOTECHNOLOGY, POVERTY, INEQUALITY

INTRODUCTION TO THE UN SUSTAINABLE DEVELOPMENT GOALS

Website: <https://sdgs.un.org/goals>



Figure 1 The 17 UN Sustainable Development Goals. Image sourced from <https://www.supplychainschool.org.au/learn/sdgs/>

The 'UN Sustainable Development Goals' are a set of 17 goals developed to promote a global partnership with all countries to end poverty and other pivotal deprivations. These goals were adopted in 2015 by 193 countries to establish a long term agenda until 2030. Underlying the goals is an understanding of the need to improve health and education, reduce inequality and spur economical growth. There are a total of 169 targets all designed to address a variety of global challenges.

With the rapid growth of biotechnology in the last few decades, this industry presents itself to being able to be used as a key tool to reach many of the 169 targets.

ACTIVITY DESCRIPTION

Research and develop a poster/presentation (can be in a digital format) to showcase how a specific example of biotechnology can be used to address ONE of the 17 goals and the targets within the chosen goal. The following criteria must be covered:

- **Identification** of the specific UN development Goal and targets the biotechnology is going to address
- A detailed **description** of the specific biotechnology chosen and desired outcome
- A detailed **explanation** of how the biotechnology will be used (including development, implementation and economic considerations)
- **Evaluation** of social and ethical considerations of the use of the chosen biotechnology example