December 2025

Applications of Biotechnology

By Vanessa Gibbens, ABE Australia

ABE Master Teacher Fellowship Program

AMGEN Biotech Experience

Scientific Discovery for the Classroom

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Scientific Discovery for the Classroom

The projects designed by the 2024–25 ABE Master Teacher Fellows are a compilation of curricula and materials that are aligned with the Amgen Biotech Experience (ABE) and further support teachers and students 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 generally 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

Applications of Biotechnology

TIME FRAME: 3–4 weeks / 15 lessons

SUGGESTED AGE RANGE: Year 10 students / 15–16 years

SUGGESTED COURSE OR CONTENT AREA: Genetics and Biotechnology

CONNECTIONS DESCRIPTIONS:

- Precision and personalized medicine
- Integrating inquiry
- Data analysis/Data literacy
- Project or problem-based learning
- Eye on the news- current real-world applications for ABE concepts, content, and technologies

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PROGRAM SITE: ABE Australia

ADDITIONAL RESOURCE: *Student Booklet: Applications of Biotechnology* (attached)

Lesson 1: Introduction – What Is Biotechnology?

Learning Activity Detailed Guide

1. **Overview:** Students will learn about biotechnology and investigate the uses and applications of biotechnology (past, present and future).
2. **Learning Goals:**
   - Define biotechnology.
   - Identify basic types of biotechnology as interference by humans in an organism's breeding or life cycle.
   - Describe a range of biotechnological processes (e.g. fermentation, artificial fertilisation, genetic engineering etc.).
3. **Assessed Outcome:** Teacher asks students in each group to explain why those examples are considered biotechnology. Ensure students can correctly explain the human interference or manipulation involved.
4. **Key Vocabulary:** Biotechnology, Reproductive Technology, Genetic Technology, DNA, Gene, Recombinant DNA
5. **Materials and LabXchange Pathway(s):**
   - Student workbook: "Applications for Biotechnology"
     i. What is Biotechnology?
   - What is Biotech? card sort activity
6. **Teacher Preparation:** Teachers will need to print their own resources for 'Biotech Card Sort' activity, laminate if possible.
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
"What is Biotechnology?"	25 min	• Computer • Student booklet "Applications for Biotechnology"
"What is Biotech? Card sort activity."	25 min	• "What is Biotech? Card sort activity." Teacher resource with instructions • Printed (& laminated) cards.

Lesson 2: Biotechnology Case Studies

Learning Activity Detailed Guide

1. **Overview:** Students discuss some advantages and disadvantages of the use and applications of biotechnology.
2. **Learning Goals:**
   - Describe techniques and applications used in recombinant DNA technology, e.g., transgenic organisms in aquaculture.
   - Discuss the social implications and ethical uses of biotechnology.
3. **Assessed Outcome:** Students can explain biotechnological processes in clear, simple terms, recognizing both benefits and ethical considerations.
4. **Key Vocabulary:** Genetic Engineering, Genetically Modified Organism, Transgenic, Aquaculture, Recombinant DNA, Gene Expression,
5. **Materials and LabXchange Pathway(s):**
   - Student workbook: "Applications for Biotechnology"
     i. Case Study 1: Genetically Engineered Salmon
     ii. Case Study 2: Industrial Uses of Spider-goats
6. **Teacher Preparation:** N/A
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Students complete secondary source research on some applications of biotechnology: • Case Study 1: Genetically Engineered Salmon • Case Study 2: Industrial Uses of Spider-goats	60 min	• Student booklet "Applications for Biotechnology" • Linked articles (PDF) • Computer

Lessons 3 & 4: Tools & Techniques in Biotechnology: Micropipetting

Learning Activity Detailed Guide

1. **Overview:** A micropipette is an important tool that is used to measure and transfer very small volumes of liquids. This lesson has two parts, theory and practical, so can be done in 2 x 1 hour lessons.
2. **Learning Goals:**
   - Describe the purpose, function, and volume ranges of micropipettes.
   - Explain why accurate pipetting is essential in biotechnology and scientific research.
   - Demonstrate correct micropipette technique, including setting the desired volume and safely disposing of used tips.
3. **Assessed Outcomes:** Students can correctly identify parts of a micropipette. The teacher observes consistent, precise micropipetting techniques during practical activity.
4. **Key Vocabulary:** Micropipette, Volume, Microlitre (µL), Aspirate, Dispense, Aliquot, Calibration, Contamination
5. **Materials and LabXchange Pathway(s):**
   - Student workbook: "Applications for Biotechnology"
   - Tools & Techniques in Biotechnology: Micropipetting (LabXchange)
6. **Teacher Preparation:** Teacher or Lab Tech will need to prepare equipment and reagents for practical activity, as per Lab 1.1 From ABE Teacher Guide.
7. **Lab Safety Considerations:** As per Lab 1.1 From ABE Teacher Guide
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Watch video on how to use a micropipette.	5 min	• Computer • Projector screen
Demonstrate the correct use of micropipette, including first and second stop.	10 min	• P-20 or P-200 pipette • Box of Yellow pipettes tips
Students complete booklet sections under Tools & Techniques in Biotechnology: • Micropipetting • Lab 1.1 – How to use a micropipette	45 min	• Computer
Students complete Lab 1.1 from ABE	60 min	• As per Lab 1.1 From ABE Teacher Guide / Lab Tech Guide

Lessons 5 & 6: Tools & Techniques in Biotechnology: Gel Electrophoresis

Learning Activity Detailed Guide

1. **Overview:** Gel Electrophoresis is a technique used to sort and separate charged molecules (like DNA) by their size. This lesson has two parts, theory and practical, so can be done in 2 x 1 hour lessons.
2. **Learning Goals:**
   - Explain how gel electrophoresis separates charged molecules like DNA based on size and charge.
   - Describe applications of gel electrophoresis in genetic engineering and biotechnology (e.g. DNA fingerprinting, disease detection, and forensic science).
   - Demonstrate correct technique when loading samples into an electrophoresis gel using a micropipette.
   - Interpret banding patterns to identify molecular size differences.
3. **Assessed Outcome:** Teacher will observe students using correct technique when loading samples into an electrophoresis gel using a micropipette.
4. **Key Vocabulary:** Gel Electrophoresis, Electric Field, Agarose Gel, Banding Pattern, Molecular Size, Negative Charge, DNA Fingerprinting
5. **Materials and LabXchange Pathway(s):**
   - Student workbook: "Applications for Biotechnology"
   - Tools & Techniques in Biotechnology: Gel Electrophoresis (LabXchange)
6. **Teacher Preparation:** Teacher or Lab Tech will need to prepare equipment and reagents for practical activity, as per Lab 1.2 From ABE Teacher Guide.
7. **Lab Safety Considerations:** As per Lab 1.2 From ABE Teacher Guide
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Watch video on how to load an electrophoresis gel.	5 min	• Computer • Projector screen
Demonstrate how to load sample into a gel, including dispensing ONLY to the first stop (unlike aliquoting).	10 min	• P-20 micropipette • Box of Yellow pipettes tips • Practice gel • Red dye
Students complete booklet section under Tools & Techniques in Biotechnology: • Gel Electrophoresis • Lab 1.2 – Gel Electrophoresis	45 min	• Computer
Students complete Lab 1.2 from ABE	60 min	• As per Lab 1.2 From ABE Teacher Guide / Lab Tech Guide

Lesson 7: Tools & Techniques in Biotechnology: Polymerase Chain Reaction

Learning Activity Detailed Guide

1. **Overview:** Polymerase chain reaction (PCR) is a biotechnological process that is used to rapidly make millions of copies of a sample of DNA.
2. **Learning Goals:**
   - Outline at least one appropriate real-world application of PCR (e.g. forensic science, diagnosing genetic conditions).
   - Describe the steps of the PCR (denaturation, annealing, and extension).
3. **Assessed Outcome:** Students name the three stages of PCR in correct order and can correctly identify the role of key components (e.g. primers, DNA polymerase).
4. **Key Vocabulary:** PCR (Polymerase Chain Reaction), DNA Amplification, Denaturation, Annealing, Extension, Primers, DNA Polymerase, Nucleotides
5. **Materials and LabXchange Pathway(s):**
   - Student workbook: "Applications for Biotechnology"
   - Polymerase Chain Reaction (PCR) (LabXchange)
   - All About PCR (Learn.Genetics)
6. **Teacher Preparation:** N/A
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Watch Amoeba Sisters video on PCR.	10 min	• Computer • Projector screen
Students complete booklet section "Tools & Techniques in Biotechnology: Polymerase Chain Reaction (PCR)"	45 min	• Computer

Lesson 8: Forensic applications of biotech

Learning Activity Detailed Guide

1. **Overview:** Students will use gel electrophoresis to examine newly collected DNA evidence from a homicide case, where the person currently serving a life sentence continues to claim their innocence. After years of appeals, the court has approved the request for DNA analysis of the evidence.
2. **Learning Goals:**
   - Conduct a practical investigation using gel electrophoresis to separate DNA fragments based on size.
   - Explore how DNA evidence is analysed and interpreted in forensic investigations.
3. **Assessed Outcome:** By examining DNA evidence from a real-world-inspired case, students will engage in critical thinking to assess whether the evidence supports or contradicts the original conviction.
4. **Key Vocabulary:** Electrophoresis, DNA Ladder, DNA Fragment, Allele, Forensics, Banding Pattern
5. **Materials and LabXchange Pathway(s):**
   - Electrophoresis Forensics Lab: Wrongfully Convicted? (forensics activity, purchased kits)
   - Student's Guide: Wrongfully Convicted? Lab
6. **Teacher Preparation:**
   - Teacher's guide: Wrongfully Convicted? Lab (https://www.southernbiological.com/teachers-guide-wrongfully-convicted-lab/)
7. **Lab Safety Considerations:**
   - Wrongfully Convicted SDS
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Review forensic applications of PCR and gel electrophoresis	10 min	
Conduct Wrongfully Convicted? Lab as per Student guide	50 min	• Wrongfully Convicted? Lab kits ABE loan equipment: • Gel electrophoresis apparatus • PrepOne visualisers • Micropipettes (P20)

Lesson 9: Therapeutic Applications of Biotechnology - Monoclonal Antibodies

Learning Activity Detailed Guide

1. **Overview:** Monoclonal antibodies (mAbs) are a class of biologics that can be used to treat different diseases. These proteins work by binding to a specific target in the body.
2. **Learning Goals:**
   - Use scientific vocabulary to describe the production, function, and application of monoclonal antibodies.
   - Evaluate the benefits and limitations of monoclonal antibody treatments, including cost, accessibility, and safety.
3. **Assessed Outcome:** Students will be able to explain how monoclonal antibodies work to target specific cells in the body and identify examples of diseases treated using monoclonal antibody therapies.
4. **Key Vocabulary:** Monoclonal antibodies, Antigen, Antibody, Targeted therapy, Immunotherapy, Autoimmune disease
5. **Materials and LabXchange Pathway(s):**
   - Therapeutic Monoclonal Antibodies (LabXchange)
6. **Teacher Preparation:** N/A
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Watch videos describing what monoclonal antibodies are and how they work.	15 min	• Computer • Projector screen
Students complete LabXchange interactive pathway on Therapeutic Monoclonal Antibodies	20 min	• Computer
Students complete booklet section “Therapeutic Applications of Biotechnology Monoclonal Antibodies” by answering questions	20 min	• Computer

Lesson 10: Case Study: Lottie's Journey

Learning Activity Detailed Guide

1. **Overview:** Lottie is a 14yo Jack Russel x Maltese Terrier who LOVES playing fetch but has been diagnosed with osteoarthritis. This case study highlights how monoclonal antibody treatments have helped Lottie.
2. **Learning Goals:**
   - Explain how new biological technologies affect the way humans interact with the environment and living things.
   - Describe how biotechnology is used to develop therapeutic products that can lead to improved health outcomes.
3. **Assessed Outcome:** Students will be able to explain how monoclonal antibodies work and their use in treating diseases like osteoarthritis.
4. **Key Vocabulary:** Monoclonal antibodies, Osteoarthritis, Inflammation, Immune system, Therapeutic.
5. **Materials and LabXchange Pathway(s):**
   - See also: list of Sources in Student Booklet under section Case Study: Lottie's Journey.
6. **Teacher Preparation:** N/A
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Students complete secondary source research on therapeutic applications of biotechnology: • Case Study: Lottie's Journey • Read article: *How Monoclonal Antibodies Helped Lottie* • Answer questions in Student Booklet	60 min	• Student booklet "Applications of Biotechnology" • Linked articles (see: Sources) • Computer

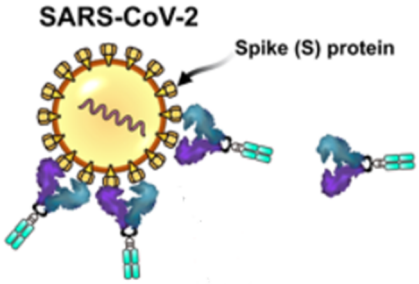
Lesson 11: Monoclonal Antibodies and COVID

Learning Activity Detailed Guide

1. **Overview:** Monoclonal Antibodies and COVID-19 - Students complete secondary source research to learn about recent advancements in therapeutic applications of biotechnology in treating COVID-19.
2. **Learning Goals:**
   - Summarise recent advancements in monoclonal antibody treatments for COVID-19.
   - Analyse scientific texts to extract and interpret key information.
   - Discuss the implications of biotechnological developments in public health.
3. **Assessed Outcome:** Teachers will observe students' participation in group discussions and review their completion of reading comprehension tasks.
4. **Key Vocabulary:** Monoclonal antibodies, SARS-CoV-2, Neutralisation, Spike protein, Variants, Immune response, Therapeutic efficacy, Immunotherapy
5. **Materials and LabXchange Pathway(s):**
   - Phys.org article - New design may boost potency of monoclonal antibodies against COVID
   - Therapeutic Monoclonal Antibodies (LabXchange)
6. **Teacher Preparation:** Print copies of the Phys.org article for students to highlight and annotate for this lesson. One copy per student.
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Individual reading: • Read article: *New design may boost potency of monoclonal antibodies against COVID*	15 min	• Printed handouts of the article (one per student) • Highlighters
Group discussion: • Students form groups to share insights from their reading of the article. • Facilitate a discussion on the advancements in monoclonal antibody treatments and their impact on managing COVID-19.	15 min	
Answer questions in Student Booklet.	15 min	• Student booklet "Applications of Biotechnology" • Computer
EXIT TICKET: Students write a summary (3-4 sentences) of what they learned about monoclonal antibodies and their role in combating COVID-19.	5 min	• Exit Ticket

EXIT TICKET



New design may boost potency of monoclonal antibodies against COVID

1. *What role does the Fc region of an antibody play in enhancing its effectiveness against COVID-19?*

2. *How might engineering the Fc domain of monoclonal antibodies improve COVID-19 treatments?*

Lesson 12: Extension Activity – How to Read a Scientific Journal Article

Learning Activity Detailed Guide

1. **Overview:** Students work in groups in a guided activity to read and annotate a scientific journal article.
2. **Learning Goals:**
   - Read and annotate a scientific abstract using guided strategies.
   - Define key scientific terminology in context.
   - Interpret and summarise the aims and findings of a peer-reviewed study.
3. **Assessed Outcome:** Teachers will observe students' participation in group discussions and review their completion of reading comprehension tasks.
4. **Key Vocabulary:** each student pair or group should create a vocabulary list of AT LEAST TEN key terms based on their group's reading level and annotations.
5. **Materials and LabXchange Pathway(s):**
   - *Nature* article: Fc-engineered antibody therapeutics with improved anti-SARS-CoV-2 efficacy
6. **Teacher Preparation:** Print copies of the Nature article for students to highlight and annotate for this lesson. One copy per group.
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Overview - class discussion: "What is a scientific journal article?" Show the abstract on the board and demonstrate strategies to help students unpack the complex science in the article, using literacy tools (e.g., colour coding, glossary builder, Cornell Notes, etc.)	15 min	• Computer • Projector screen • Link to article: https://www.nature.com/articles/s41586-021-04017-w
Group activity and discussion: • Read the first paragraph of the Main body of the article together aloud, one sentence at a time. • Annotate using strategies demonstrated with the abstract. Jigsaw activity for more advanced readers: • Students may like to cut the article into sections and each student in the group summarises the key points of their section.	40 min	• Printed handouts of the article (one per group) • Highlighters • Post-its • Cornell Notes worksheets

• Teacher facilitate a discussion within groups on strategies to effectively use the different literacy tools.		
EXIT TICKET: Students answer three questions about the article to demonstrate level of comprehension.	5 min	• Exit Ticket (print 2 to a page)

EXIT TICKET

Fc-engineered antibody therapeutics with improved anti-SARS-CoV-2 efficacy

3. *What is the purpose of this study?*

4. *How did researchers improve the antibody's action?*

5. *What is meant by "in vivo efficacy"?*

Lessons 13–15: Student Interest Research Project

Learning Activity Detailed Guide

1. **Overview:** Open inquiry – students select a field of biotech to research and create a presentation (e.g. Poster, Infographic, Prezi, Google Slide, Podcast). This can be individually, in pairs or small groups.
2. **Learning Goals:**
   - Select and use appropriate investigation methods, including secondary sources, to collect relevant information.
   - Present science ideas and findings using appropriate scientific language and representations.
3. **Assessed Outcome:** Students will present information logically, with a clear structure and support their findings with relevant scientific evidence or data from credible sources.
4. **Key Vocabulary:** each student pair or group should create a vocabulary list of FIVE key terms based on their specific research area.
5. **Materials and LabXchange Pathway(s):** N/A
6. **Teacher Preparation:** N/A
7. **Lab Safety Considerations:** N/A
8. **Sequence of Activities:**

Activity Description	*Time*	*Materials*
Student research and presentations • It is recommended that students be given more choice for this activity in terms of what aspects of biotechnology they want to research and how they present their findings. • Use the *Guided Research Questions* (see below) as a scaffold for students or groups who need more guidance on how to plan their research and present their findings.	~2 hrs	• Computer • Projector screen

Guided Research Questions

1. **Introduction to the Topic**
    - What is the name of the biotechnology field or application you are researching?
    - What problem does this biotechnology aim to solve?
    - When and where was this technology first developed or discovered?
2. **Scientific Principles**
    - What scientific concepts or processes are involved in this technology?
    - What organisms, cells, or molecules are involved?
    - How does this biotechnology interact with living systems?
3. **Applications and Uses**
    - What are some current uses of this biotechnology?
    - Who uses or benefits from this technology (e.g. doctors, farmers, scientists)?
    - Is it used in medicine, agriculture, industry, or the environment?
4. **Evidence and Data**
    - What studies or data support the effectiveness of this technology?
    - Can you find any statistics, graphs, or results from scientific sources?
5. **Ethical, Social, and Environmental Considerations**
    - What are the possible risks or ethical concerns with this technology?
    - How does it impact society, nature, or the economy?
6. **Future Potential**
    - What are scientists working on next in this field?
    - How might this biotechnology evolve or improve in the next 5-10 years?

What is biotech? Card sort activity

Teachers: Print the cards to cut them out and give each group or pair a set of cards to sort. Even better if you can laminate them. You could also attach a magnet to the back of laminated cards to do this as a class.

Step 1: Matching
Students match up the term with the corresponding image

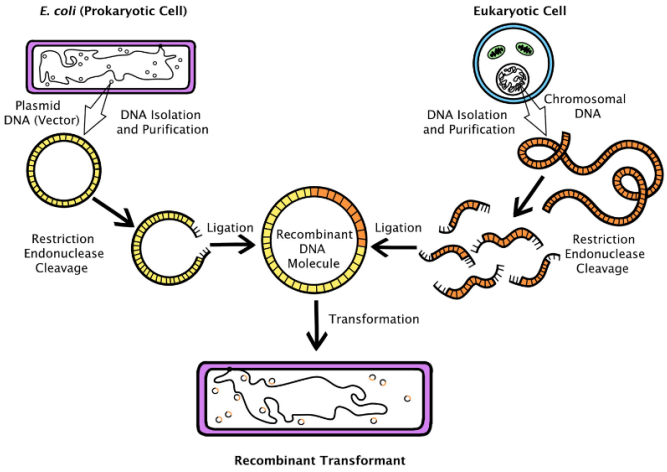
Step 2: Categories
Students will need to define each of the categories. This could be done by giving them notes to copy down, or a scaffolded activity, or a think-pair-share class discussion.

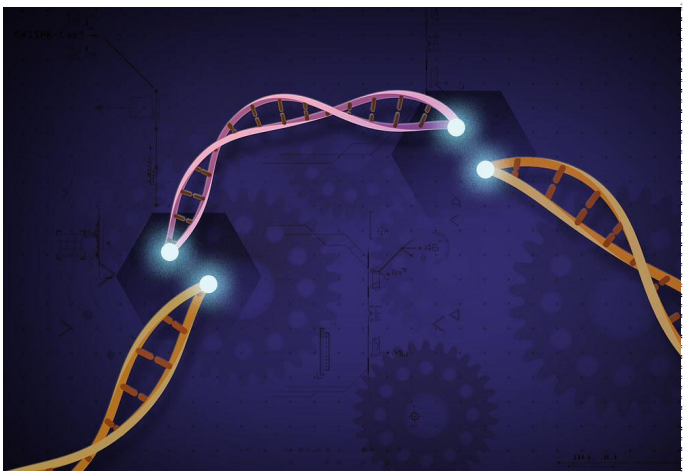
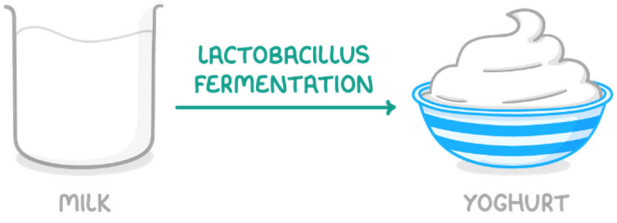
- Biotechnology
- Genetic Technology
- Reproductive technology
- Technology
- Toolkit

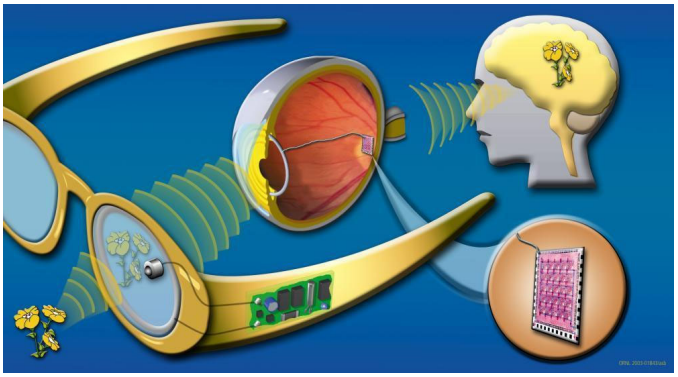
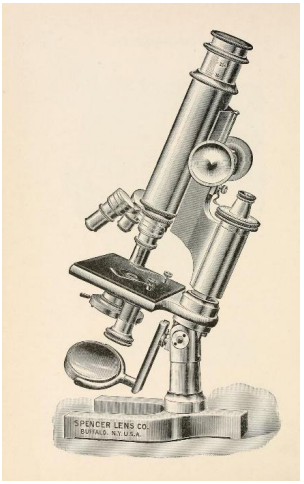
Step 3: Sorting
Students sort cards into the following categories:

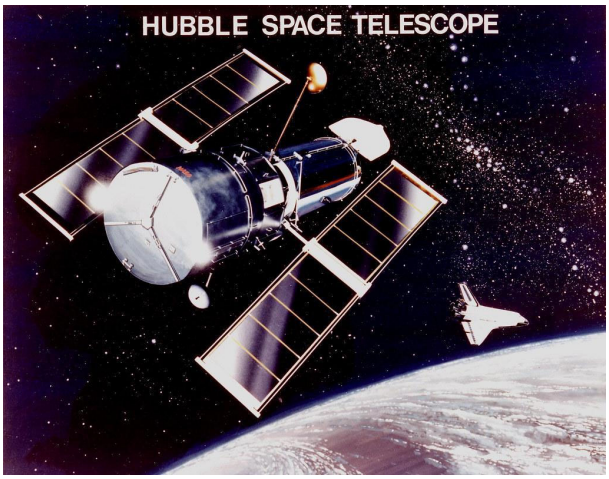
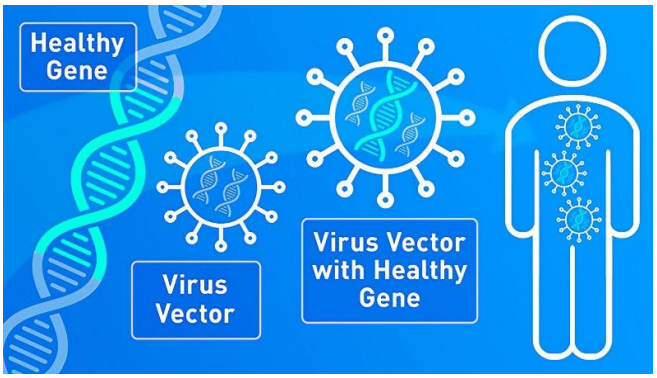
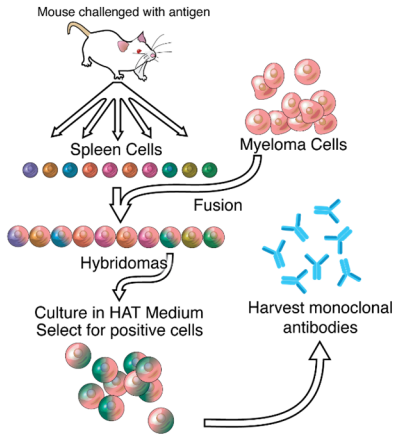
- Biotechnology
- Genetic Technology
- Reproductive technology
- Technology
- Toolkit

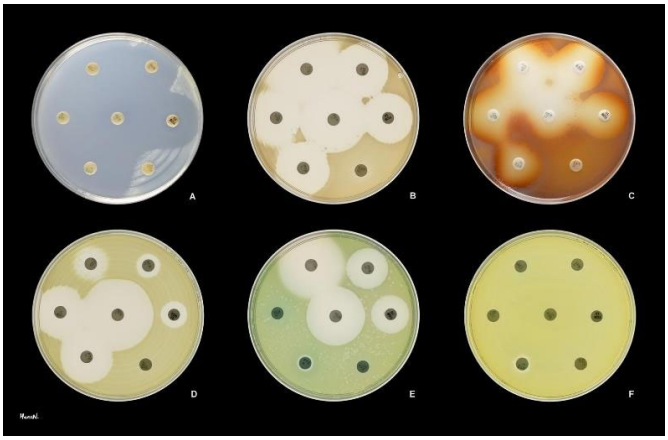
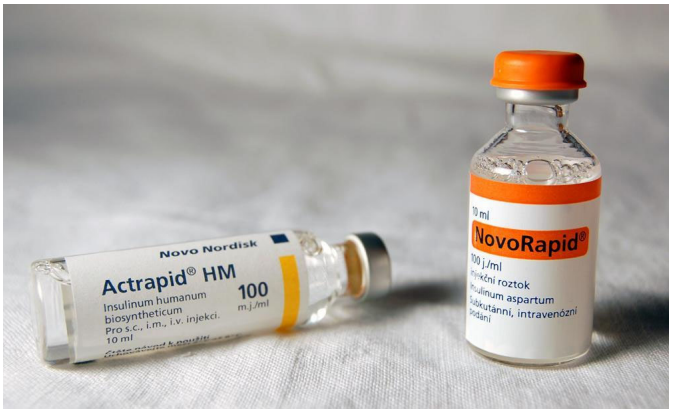
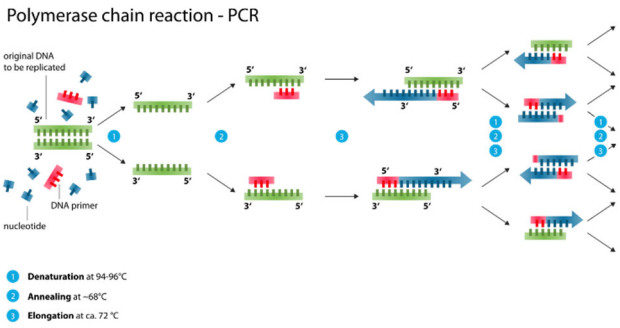
Cards for Card Sorting Activity

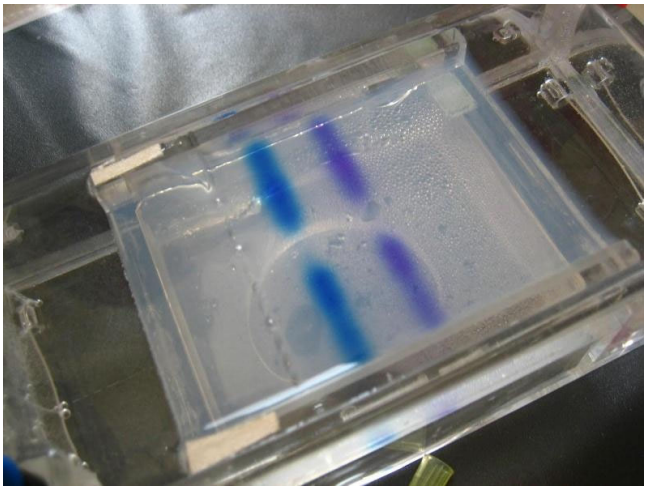
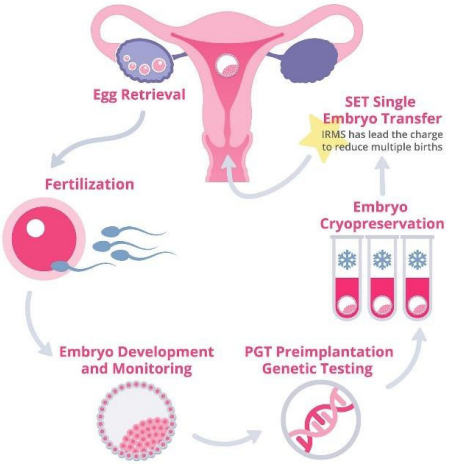
Recombinant Plasmids	
Transgenic organisms	
GMOs	

CRISPR	
Fermentation – yeast	***(Making bread)*** 
Fermentation – bacteria	***(Making yoghurt)*** 

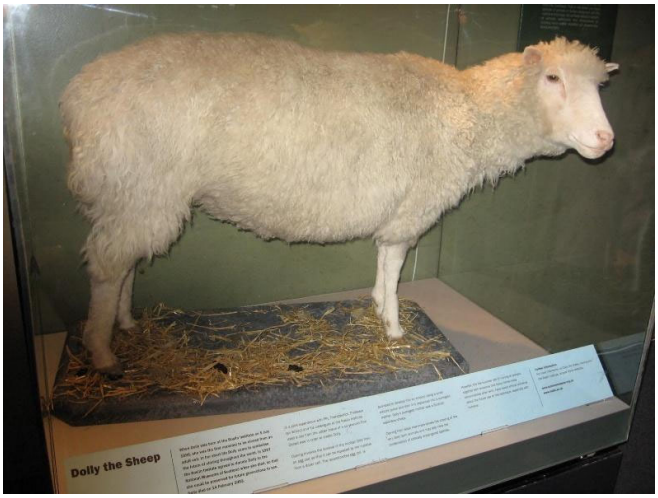
Bionic eye	
Robotic arm	
Microscopes	

Telescopes	
Gene therapy	
Monoclonal antibodies	

Production of antibiotics	
Synthetic insulin production	
PCR	

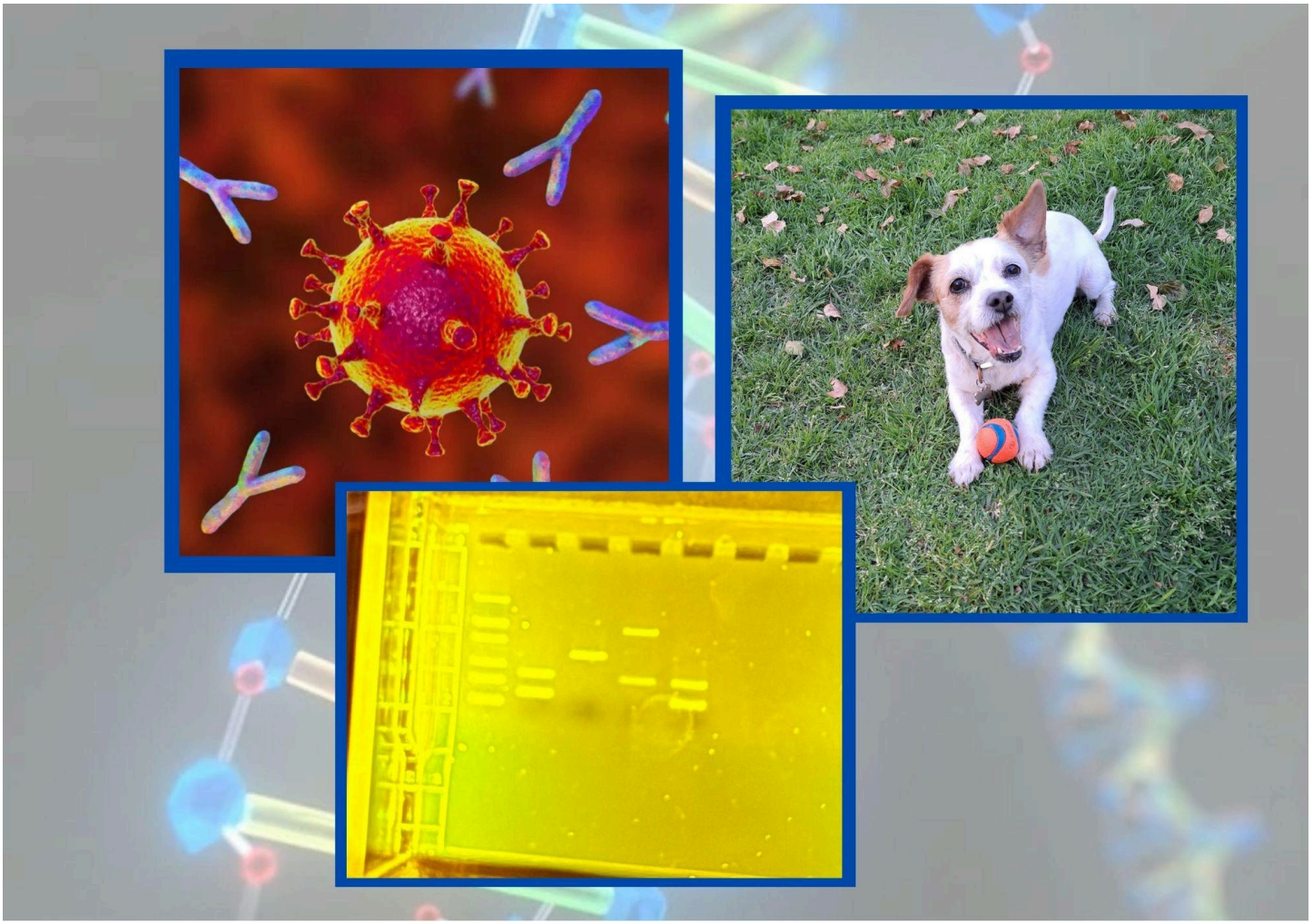
Gel electrophoresis	
DNA fingerprinting / profiling	
IVF	

Whole-organism cloning



Applications of Biotechnology

Student Booklet



This booklet is best used as an electronic Hyperdoc using Google Docs.

Table of Contents

What Is Biotechnology?

Biotechnology has been a part of human history for thousands of years, e.g., yoghurt (which is made by the bacterial fermentation of milk) is thought to have been made earlier than 3000 BC in the Middle East region. Since then, the types and forms of biotechnology have grown significantly.

1. What is biotechnology? Search for definitions and select one you think best defines the term. Quote your source.

Definition:	
Source:	

2. How does ancient biotechnology differ from modern biotechnology? Refer to specific examples and methods in your answer (*e.g., you could compare the process of fermentation to current gene modification techniques - both are considered to be biotechnology, but the methods are vastly different*).

3. When (approximately) is it thought that cheese was first made by humans?

4. How long ago was fermentation of fruit juices discovered by humans?

5. What year was “Dolly” the sheep cloned?

6. Which was cloned first, a sheep or a mouse?

7. How long did it take to make a rough draft of the Human Genome Project?

👀 Watch this Introduction to Biotechnology video to see how it is possible to transfer genes from one species to another.

8. Describe the meaning of **gene modification**.

9. What are 3 different names used to describe gene modification?

10. List 3 advantages and 3 disadvantages of using genetic engineering.

Advantages	**Disadvantages**

11. Crops such as corn have been genetically engineered to be tolerant to herbicides. This means a GE crop (genetically engineered crop) can be sprayed with herbicides to kill weeds but will not affect the corn.
    a. Outline an advantage this could have for the farmer.

    b. Pollen from these genetically engineered corn plants could fertilise wild or weedy relatives of corn plants that have not been genetically engineered. Outline a disadvantage this could have.

Case Study 1: Genetically Engineered Salmon

🔍 Read the articles about Genetically Engineered Salmon, then answer the following questions:

- FDA - AquAdvantage Salmon Fact Sheet
- First Genetically Engineered Salmon Sold in Canada - Scientific American
- Upstream battle for genetically engineered salmon - LA Times

Genes have been added to Atlantic Salmon to make them grow twice as big and twice as fast.This may be good for those who farm salmon in ponds. Super salmon take 18 months to reach the right size to be sold whereas regular salmon take three years to reach the right size. Growing super salmon would save the farmer a lot of money and there would be a lot more fish produced to sell and to feed people.However, if super salmon were introduced or escaped into the wild, the food web in the ocean would be altered. These super-sized salmon would eat much more food, mature faster and reproduce faster. So, the population of super salmon would increase rapidly. They could out-compete other fish for food resources. Super salmon were produced 18 years ago but because of their potential harm to the environment, super-sized salmon are currently not allowed to be used by farmers.

1. Briefly describe AquAdvantage salmon, including how this species is created.

2. Do you think there is an ethical obligation to label AquAdvantage salmon as GE/GMO? Why or why not?

3. In terms of how AquAdvantage salmon was created, could the technology cause harm to any living organism?

4. Does everyone have equal access to the AquAdvantage salmon?

Case Study 2: Industrial Uses of Spider-goats

🔍 Watch the videos Is Spider Silk The Next Bulletproof Material? , Silk Skin Armor and Synthetic spider silk , then answer the following questions:

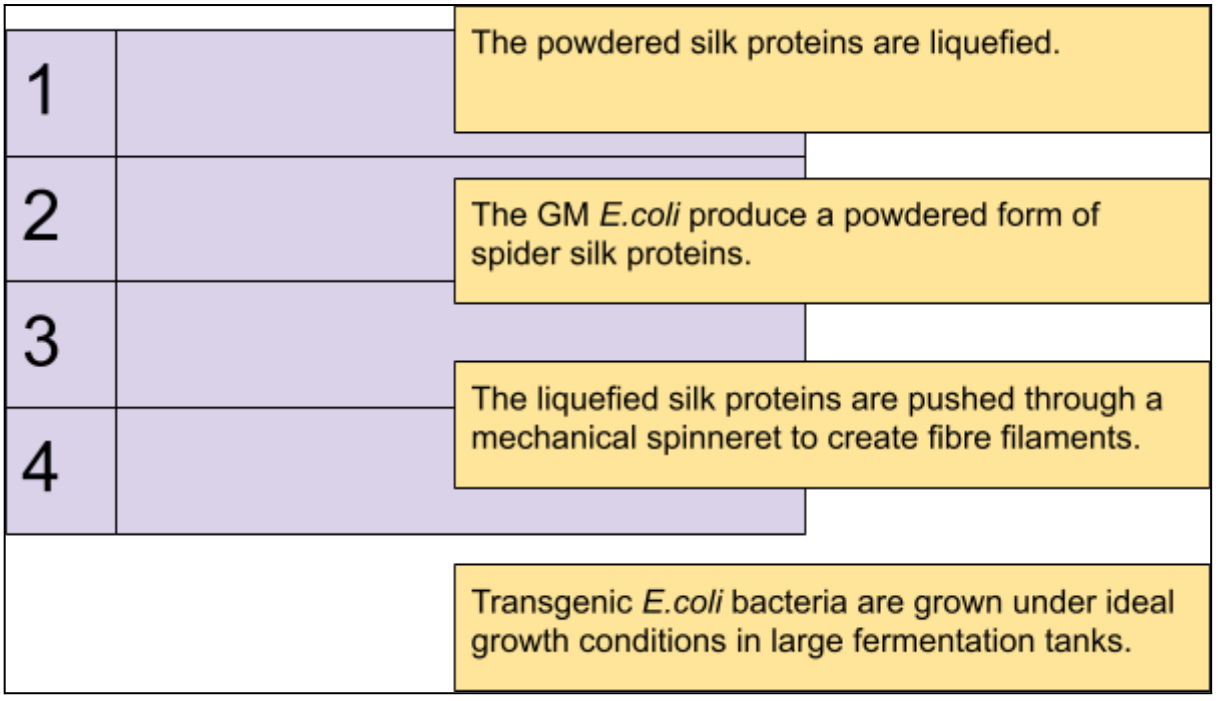
Silk has incredible strength in relation to its size. A spider gene that produces dragline silk (the strongest type of silk spiders use when they anchor their webs) has been introduced to goats. Their milk contains the spider silk. This silk can potentially be used in bulletproof vests, artificial tendons, bandages, computer chips, fibre optic cables and sutures for surgery. If these goats reproduced, they could pass the spider silk gene on. They could potentially breed with other domestic goats and with wild goats. We don't know what would happen if this milk entered the food chain. Could baby goats digest it? Would it cause disease? What would be the effect on humans if we consumed this spider silk milk either as milk, yogurt or cheese? As yet, there are fewer than 20 spider goats, and they are confined to a yard in a USA university. There has not been enough silk collected from the milk to make anything commercially.

AMSilk is a company that is an industrial supplier of synthetic spider silk as a biopolymer. Conduct some web-based research on AMSilk to answer the following questions:

1. In what country is AMSilk based?

2. Which organism is AMSilk using to synthesise silk proteins?

3. **Double-click** on the image below to **drag & drop** the steps of AMSilk's Biosteel production into the correct order:



4. **Outline** the advantages that spider silk has over traditional materials.

✏️ Remember that **outline** means to state in general terms; indicate the main features.

- Your introduction should be a single statement of the issue to be outlined. Identify each characteristic or feature - e.g., a preview list, NOT a description of each.
- The body of your response should give a brief description and example of each characteristic or feature. This should only be a brief overview of the topic - no more than two sentences per feature.
- Use linking words: for instance, for example, including, and such as to introduce your examples.
- There is no need to include a concluding paragraph.

5. Suggest TWO reasons why scientists would want to produce this silk product using goats instead of harvesting it from spiders.

6. What are some possible ethical concerns about genetically modifying goats to produce spider silk?

7. AMSilk is producing synthetic spider silk without using animals. How might this alternative be more beneficial for commercial use?

Tools & Techniques in Biotechnology:

Micropipetting

A micropipette is an important tool that is used to measure and transfer very small volumes of liquids.
Video: How to use the micropipette
You can learn about the micropipette by using this LabXchange interactive - Tools & Techniques in Biotechnology: Micropipetting.

1. Complete the following table of unit conversions:

Conversion Hints

1 Litre = 1,000 millilitres (mL)
1 millilitre = 1,000 microlitres (µL)
Therefore, 1 Litre = 1,000,000 microlitres (µL)

Litres (L)	**Mililitres (mL)**	**Microlitres (µL)**
1		
	250	
0.5		
		3,500
0.002		
	100	
		275,000
0.025		

2. Ms Gibbens has a cup of coffee every morning. Her reusable coffee cup holds approximately 325mL of coffee. How many microlitres of coffee does she drink each morning?

3. What is the purpose of using a micropipette?

4. Why do you think it is necessary to use very small and exact volumes of reagents in biotechnology?

5. When loading or dispensing a solution, why is it important to actually see the solution enter or leave the pipette?

6. Why is it important to use a new tip for each sample?

7. It is best practise to avoid contact with the pipette tips - for example, putting the pipette tip on without using your hands and using the ejector button to remove the tip. If you were working with DNA, why would these precautions be important?

8. Describe the correct steps for using a micropipette to draw up 10uL or liquid.

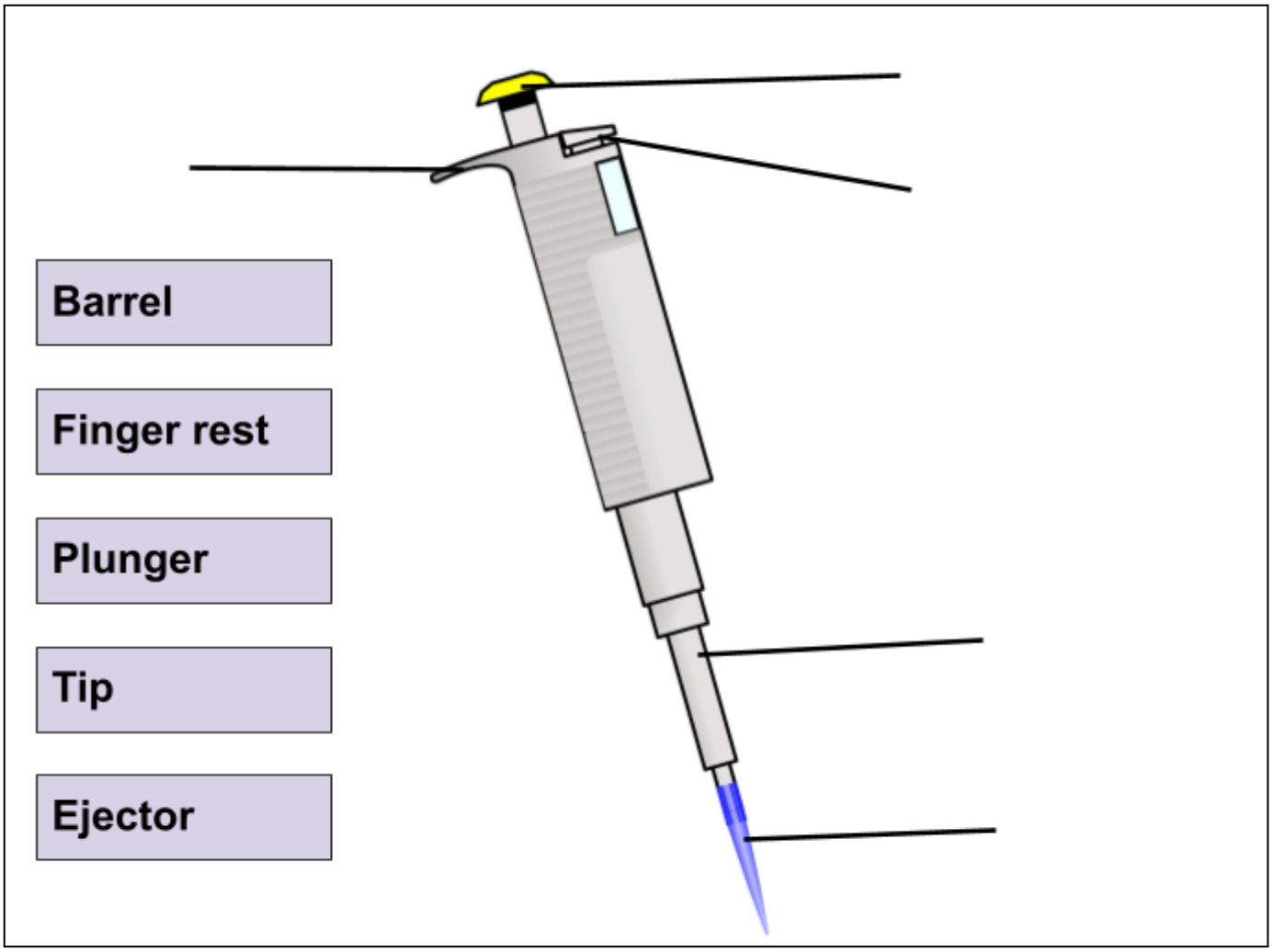
9. How do you choose the correct micropipette for the volume you want to measure?

10. What might happen if you push the plunger all the way down *before* drawing up liquid?

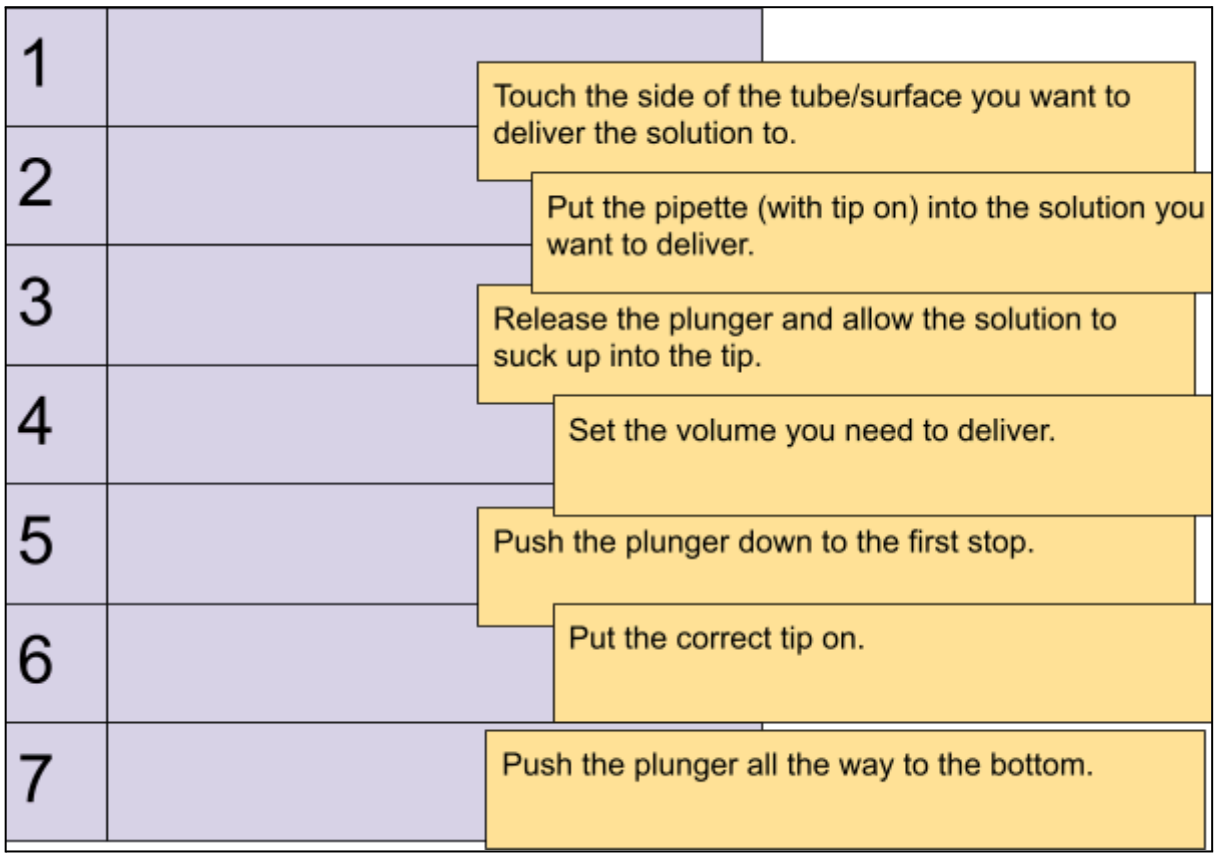
Lab 1.1 - How to Use a Micropipette

Follow the instructions in the ABE Student Guide on pp.18-23 to conduct Lab 1.1

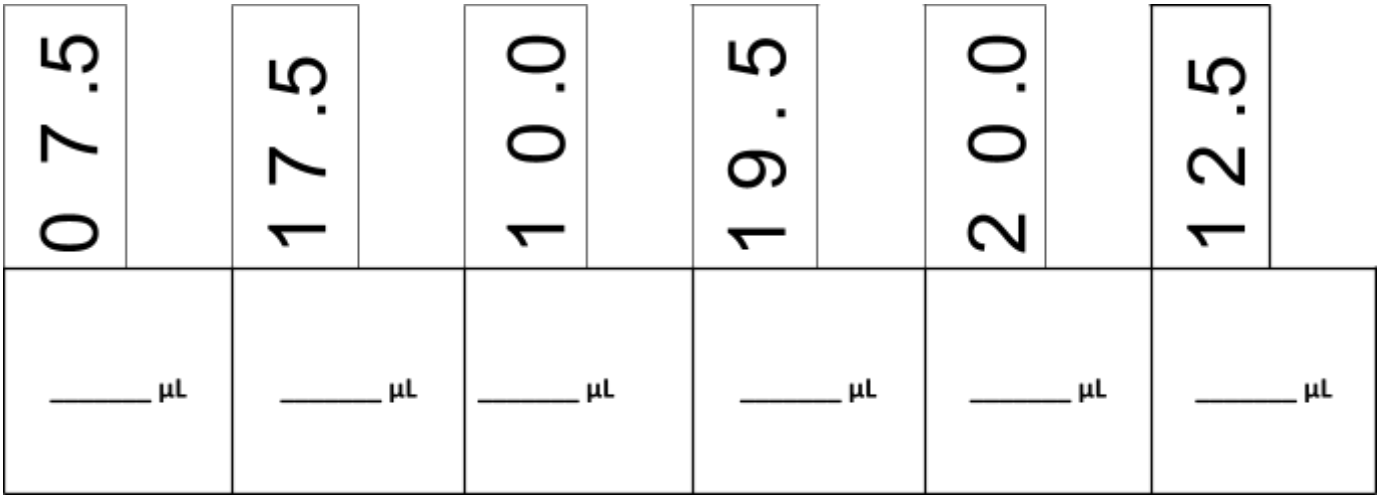
1. **Double-click** on the image below to **drag & drop** and correctly label the following diagram of a micropipette:



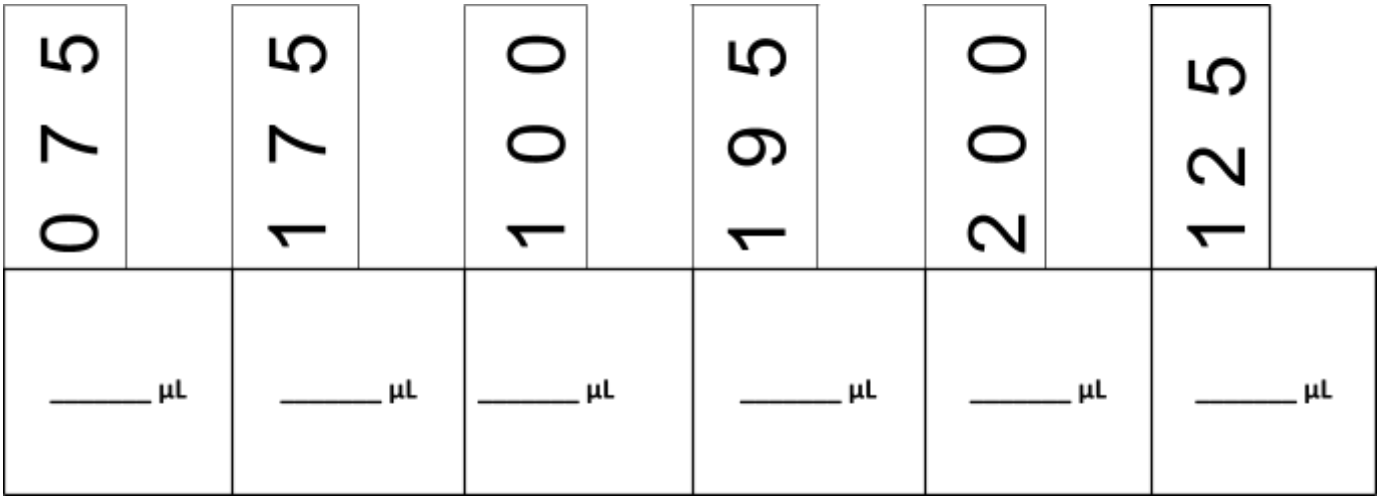
2. **Double-click** on the image below to **drag & drop** the steps of how to use a micropipette into the correct order:



3. If you are using a **P20** micropipette, what volume will be dispensed with the following settings?



4. If you are using a **P200** micropipette, what volume will be dispensed with the following settings?



5. In your lab you have **P20** and **P200** micropipettes available. For each volume, determine what micropipette is the best option, then show what the dial would look like when set to that volume.

Volume:	What pipette is best for this volume?	Setting:
2 µL	_____	
60 µL	_____	
95 µL	_____	
4 µL	_____	

6. Draw the settings on the **P20** micropipette for:

20 µL 12.4 µL 5.5 µL 2.0 µL

7. Draw the settings on the **P200** micropipette for:

200 µL 137µL 48 µL 25 µL

Gel Electrophoresis

Gel Electrophoresis is a technique used to sort and separate charged molecules (like DNA) by their size.

- ☐ Watch the video: How to load your electrophoresis gel
- ☐ Complete the Virtual Lab: Gel Electrophoresis
- ☐ You can also learn about Gel Electrophoresis using this LabXchange Interactive - Tools & Techniques in Biotechnology: Gel Electrophoresis

1. In what circumstances might it be important to use gel electrophoresis to separate and identify short linear pieces of DNA?

2. What is the importance of micropipettes and gel electrophoresis in genetic engineering?

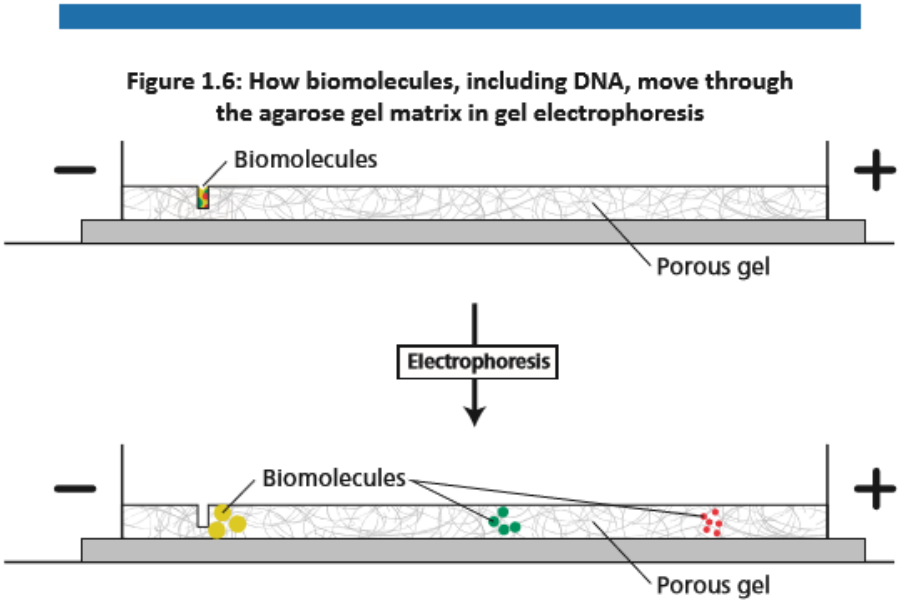
3. Read the extract on Gel Electrophoresis in DNA Fingerprinting (below) and summarise the impact advancements in biotechnology have had on society:

DID YOU KNOW?

Gel Electrophoresis in DNA Fingerprinting

DNA fingerprinting uses gel electrophoresis to distinguish between samples of genetic material. In DNA fingerprinting, human DNA molecules are treated with enzymes that chop them at certain characteristic points, thereby reducing the DNA to a collection of smaller and more manageable pieces. The DNA fragments are loaded into a gel and placed in an electrical field, which electrophoretically sorts the DNA fragments into various bands. These bands can be coloured with a dye to make them visible to imaging techniques. Methods of DNA identification have been applied to many branches of science and technology, including medicine (prenatal tests, genetic screening), conservation biology (guiding captive breeding programs for endangered species) and forensic science. In the latter discipline, analysis of the pattern of DNA fragments that results from the action of restriction enzymes enables us to discriminate between suspects accused of a crime, or potential fathers in a paternity suit.

Figure 1.6 shows how charged molecules can move through a gel based on their size.

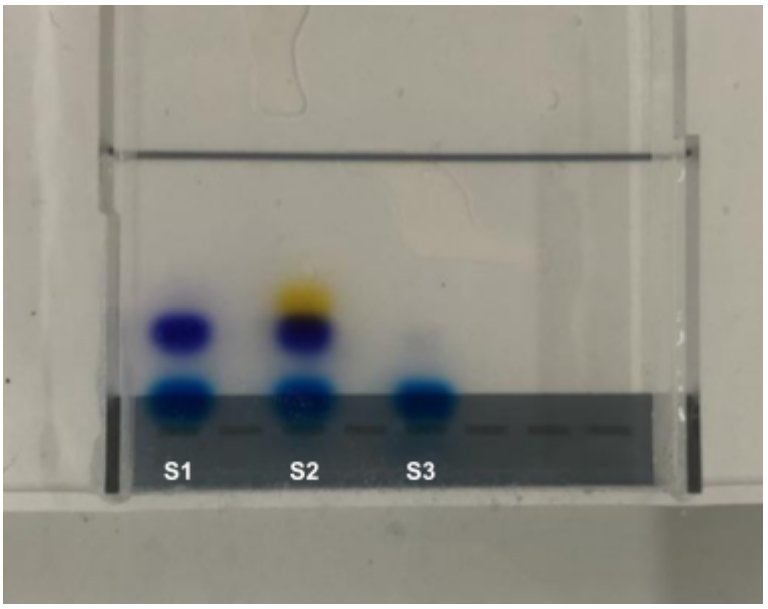


4. DNA has a negative charge. What do you predict will happen when it's placed in an electric field?

5. How might the size of a molecule affect how far it moves through the gel?

6. What would happen if the gel was placed the wrong way in the chamber?

7. The following image shows a gel where three different dye samples have been separated using gel electrophoresis.



a. How many different pigments are present in each of the samples?

Dye Sample	Cyan present?	Purple present?	Orange present?
S1	☐	☐	☐
S2	☐	☐	☐
S3	☐	☐	☐

b. What electrical charge do the dyes have? Explain your reasoning.

c. Observing the gel and how far away from the starting point each pigment has travelled, which of the pigments do you think is the largest molecule? Justify your answer.

Lab 1.2 - Gel Electrophoresis

Follow the instructions in the ABE Student Guide on pp.26-31 to conduct Lab 1.2

1. When you have completed the lab 1.2, insert a photo of your group's gel here:

The dyes you are separating are orange G (yellow), bromophenol blue (purple) and xylene cyanol (blue).

2. Based on the results of the gel, which solution (S1, S2 or S3) contained a single dye?

3. Based on the results of the gel, what charge are dyes in solutions S1, S2 and S3?

4. If all three dyes have a similar shape and charge, which dye has the smallest molecular weight? Justify your answer.

Polymerase Chain Reaction (PCR)

Polymerase chain reaction (PCR) is a biotechnological process that is used to rapidly make millions of copies of a sample of DNA. It involves amplifying a sample by using multiple cycles of replication, heating and cooling. This very quickly produces large quantities of the required DNA.

- ☐ Watch the video: PCR (Polymerase Chain Reaction) (Amoeba Sisters)
- ☐ Check out this PCR article to find out how the PCR process works
- ☐ You can learn more about PCR using this LabXchange Interactive - Polymerase Chain Reaction (PCR)

1. Complete the table below using the information in the virtual lab:

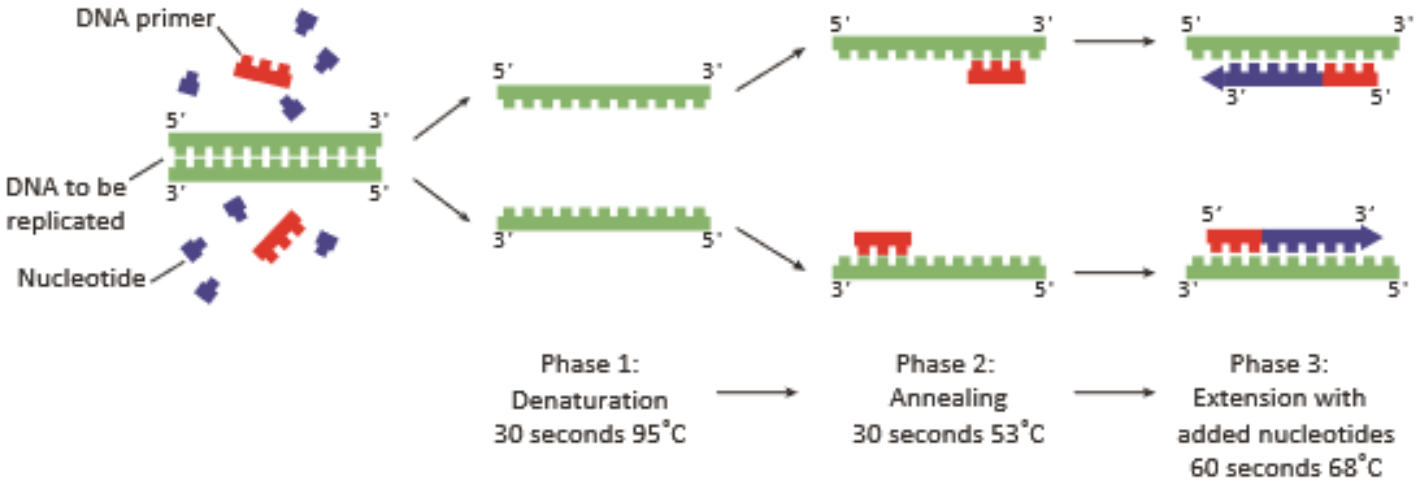
Substance	What is it?	Why is it used in PCR?
Primers		
DNA polymerase		
Nucleotides		

2. Use the word bank below to complete the following **cloze passage**:

billion **cellular** **cooled** **copied** **PCR** **polymerase** **primers** **sample** **thermal** **tube** **unwind**

The following steps outline the process of polymerase chain reaction (_____):

1. A DNA _____ is extracted from a _____ source, e.g., a hair follicle.
2. The DNA sample, primers, DNA polymerase and nucleotides are added to a PCR _____ .
3. The PCR tube is placed in a machine called a _____ cycler.
4. The first cycle begins with high heat to _____ the double-stranded DNA.
5. The first cycle then has the temperature _____ , to allow _____ to attach to the target DNA.
6. The first cycle then has DNA _____ attach to the single-stranded DNA after each primer. The DNA polymerase facilitates the addition of complementary nucleotides.
7. Multiple cycles are repeated, allowing the target DNA sequence to be _____ many times.
8. After 30 cycles, there will be over a _____ copies of the target DNA sequence present.



3. **List** the four substances that are required in a PCR tube to allow PCR to take place:

4. Explain the role of temperature changes in PCR.

5. Why are multiple cycles of denaturation, annealing and extension required?

6. Under what circumstances might it be important to copy DNA quickly using PCR?

7. Gene cloning can be carried out in vivo by adding genes to recombinant plasmids and ensuring that they are replicated inside bacterial cells. Gene cloning can also be carried out in vitro by using PCR (the phrase in vivo refers to a process that takes place inside a living organism, whereas in vitro refers to a process that takes place outside a living organism, for example, in a test tube).
   Outline what might be some advantages of using PCR to make many copies of a gene.

8. Primers must be made to bind to the target DNA sequence through complementary base pairing. **Identify** what must be known about the target DNA sequence to create suitable primers.

Therapeutic Applications of Biotechnology

Monoclonal Antibodies

Monoclonal antibodies (mAbs) are a class of biologics that can be used to treat different diseases. These proteins work by binding to a specific target in the body.

- ☐ Watch the videos: GCSE Biology - Monoclonal Antibodies and How do monoclonal antibodies work? Rituximab, infliximab, adalimumab and others
- ☐ You can also learn about monoclonal antibodies by using this LabXchange interactive - Therapeutic Monoclonal Antibodies.

1. Define the term monoclonal antibody.
2. Describe how monoclonal antibodies are produced in a lab.
3. Outline the role of mouse cells in the production of monoclonal antibodies.
4. Describe the role of a tumour (myeloma) cell in creating monoclonal antibodies.
5. Describe how monoclonal antibodies identify and bind to specific cells or molecules.
6. Why are monoclonal antibodies described as “targeted” treatments?
7. Identify at least THREE types of diseases that monoclonal antibodies can be used to treat.
8. Outline how rituximab works to treat diseases like lymphoma or rheumatoid arthritis.
9. Describe the role of infliximab or adalimumab in managing autoimmune diseases.
10. Describe how monoclonal antibodies help in cancer treatment and explain why they are often used alongside chemotherapy or other treatments.

11. Define the term "immunotherapy".

12. **Explain** how therapeutic monoclonal antibodies avoid damaging healthy cells.

✏️ *Remember that **explain** means to relate **cause and effect**; make the relationships between things evident.*

- *Responses should include topic sentences at the beginning of each point on causes followed by explanation and examples to illustrate each cause.*
- *Use linking words between each point (such as: therefore, thus, as a result, leading to), to illustrate the relationship.*
- *Examples are essential to show the direct link between cause and effect.*

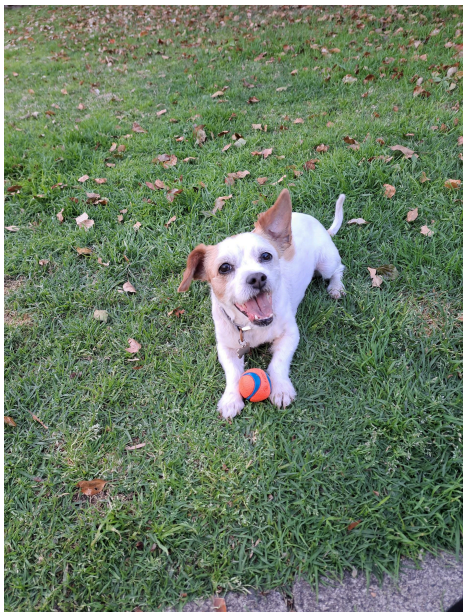
13. Suggest what might happen if a monoclonal antibody binds to the wrong target.

14. Discuss how monoclonal antibody technology could be used in the future to treat other diseases (e.g., Alzheimer's, COVID-19).

Case Study: Lottie's Journey

Read the article "***How Monoclonal Antibodies Helped Lottie***" to help you answer the following questions:

How Monoclonal Antibodies Helped Lottie

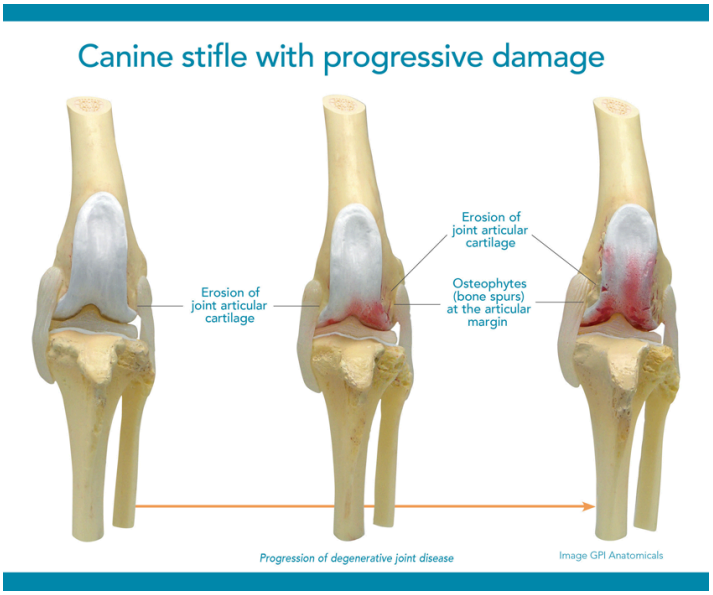


Meet Lottie. She is a 14yo Jack Russell x Maltese Terrier who LOVES playing fetch. She is pictured here with her favourite ball that she just loves chasing after and even jumping up to catch it mid-air.

A year ago, Lottie woke up one day with a sore leg. She couldn't even walk properly, nevermind trying to run after her beloved ball. Her owner knew something wasn't right, so she was taken to the vet straight away. After some scans and blood tests to rule out some other things, it was determined that Lottie was most likely showing some early signs of arthritis.

Arthritis is a condition that is caused by the inflammation of one or more joints, causing pain and stiffness that can worsen with age. There are many types of arthritis, but Lottie has the type where the protective cartilage that cushions the ends of the bones wears down over time, called **osteoarthritis**. The symptoms can be managed but the disease can't be cured and the damage to joints can't be reversed.

The symptoms that were impacting Lottie would be the pain associated with the inflammation of the joints in her legs. As the cartilage wears down, there is more bone-to-bone contact which causes inflammation in the area. This can then lead to swelling and pain.



Inflammation is a normal part of the body's response to injury or infection. Inflammation occurs when the body releases chemicals that trigger an immune response to fight off infection or heal damaged tissue. In this case, Lottie's immune system is trying to repair the damage to her joints. The problem is that this type of damage can't be repaired, but the immune system will keep releasing chemicals to the area anyway, leading to the inflammation that is causing Lottie's pain.

Since we can't reverse the damage to Lottie's joints, we had to find a way to manage her symptoms. Pain relief is one option, and she was given some pain medication on that first visit to the vet. They gave her an injection of a stronger medication, and sent her home with a week's worth of **n**on-**s**teroidal **a**nti-**i**nflammatory **d**rugs (often called **NSAIDs**) in tablet form. This helped her initial recovery, but this was not a sustainable ongoing treatment option and NSAIDs can cause damage to the liver and kidneys if taken long-term.

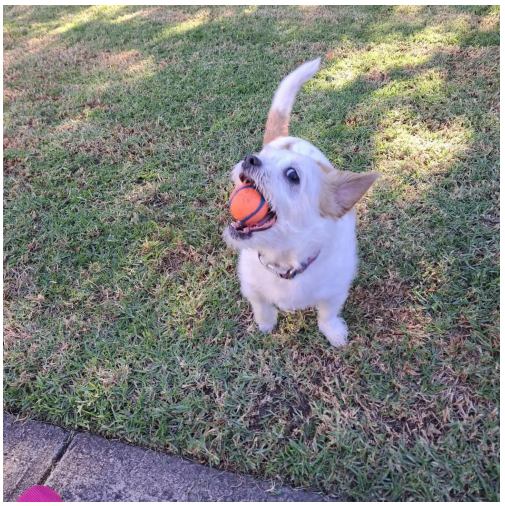
The vet discussed treatment options to help manage Lottie's symptoms, one of those was a monthly injection of a drug that would reduce the inflammation (and therefore the pain) by stopping Lottie's immune system from

reacting to the damaged cartilage. This treatment is a **monoclonal antibody**, which works by signalling to her immune system that it should ignore this damage and not send out the chemicals to that area that cause the inflammation. To do this without suppressing her entire immune system and making her vulnerable to other infections, the drug has to be specially designed so that it only slows down the action of specific molecules.

This medication is called *bedinvetmab* and it is a monoclonal antibody (the 'mab' at the end of the drug's name is how we know it is a **m**onoclonal **a**nti**b**ody). It binds to and inhibits something called Nerve Growth Factor (NGF), which is elevated in dogs with osteoarthritis as it is one of the chemicals released in joint tissue as part of the inflammation process. NGF binds to receptors in the immune cells, which then send pain messages to the brain through the nervous system. By inhibiting the action of this NGF, we can effectively slow the inflammation response and stop the pain messages going to Lottie's brain.

If it's just a complicated and more expensive way of relieving pain, what makes it different from the other drugs she was initially given? What makes monoclonal antibodies different is that they are a protein, which the body is better at metabolising without making the liver and kidneys work too hard to process it. Any drugs that Lottie is given, her body will eventually break down so it can be excreted. Proteins are easier to break down than other substances like NSAIDs. As long as the injections are effective, Lottie can keep getting treatment to manage her pain without damaging other vital organs like her liver and kidneys.

Lottie has been getting monoclonal antibody injections for over a year now, and clinical signs show that her pain is well managed with this treatment. Remember that with osteoarthritis, the damage can't be reversed, but we can slow down the progression of the disease by reducing the immune system's inflammation response.
Blood tests can also confirm that Lottie's kidneys have not been negatively impacted – and she still loves playing fetch as much as possible!



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Questions

1. Identify the condition that Lottie was diagnosed with.
2. Outline the main symptoms of osteoarthritis in dogs, as experienced by Lottie.
3. Describe what causes the pain and inflammation associated with osteoarthritis.
4. Describe how the immune system contributes to the inflammation in osteoarthritis.
5. Describe the long-term impact of the immune system’s response to joint damage and explain why this can be harmful to dogs like Lottie.
6. Define the term NSAIDs.
7. Outline how NSAIDs were used in Lottie's initial treatment.
8. Explain why NSAIDs are not a sustainable long-term treatment option for Lottie.
9. Describe the potential side effects of long-term NSAID use in dogs.
10. Define the term monoclonal antibody.
11. How are monoclonal antibodies identified in drug names?
12. Explain how the monoclonal antibody treatment of monthly injections helps manage Lottie's condition.

13. Define the term Nerve Growth Factor (NGF).

14. Outline the role of NGF in osteoarthritis.

15. Explain how inhibiting NGF reduces pain and inflammation in dogs.

16. **Compare** monoclonal antibody treatments to traditional pain medications like NSAIDs.

✏️ *When **comparing** features ensure they are referring to the same point (the potential side effects of the treatment, for example).*

- ***Whereas** is a good connective to use.*

  *…….. **whereas** ……*
- *e.g., NSAIDs are made of molecules that are difficult to metabolise in the body **whereas** monoclonal antibodies are made of proteins that are much easier to metabolise and therefore put less strain on the patient's liver and kidneys.*

17. Explain how the body is able to metabolise monoclonal antibodies more easily than NSAIDs.

18. How do monoclonal antibodies target specific molecules without suppressing the entire immune system?

19. Discuss how Lottie's condition has improved since starting treatment with monoclonal antibodies.

20. Assess the importance of ongoing monitoring (like blood tests) during long-term monoclonal antibody treatment.

21. How can the success of monoclonal antibody treatment in dogs like Lottie influence human arthritis treatment?

22. **Discuss** the ethical or financial considerations that might arise when choosing monoclonal antibody treatments for pets.

✏️ ***Discuss*** *means to identify issues and provide points for and / or against.*

- *Introduction should outline the issue to be discussed.*
- *State the issue from your own point of view, making your preferred side clear.*
- *Avoid using "I statements" - e.g., instead of "I believe this treatment, while expensive, is worth the cost", make sure your statement is objective and evidence-based: "This treatment has a higher cost than traditional pain relief like NSAIDs, however, the benefits far outweigh the financial impacts as there are fewer side effects and has greater potential to improve quality of life for beloved pets."*
- *You MUST include points both FOR and AGAINST.*
- *Topic sentence at the beginning of each paragraph, followed by explanation and examples.*
- *Use linking words: therefore, because, however, for instance, for example…*

👀Read this article from ABC News about a pet owner's experience: Pet owners preparing class action against osteoarthritis drug maker over dog deaths

23. Outline the main claim or concern being made in the ABC article.

24. Examine the ABC article and determine if there is any scientific evidence provided to support this claim.

25. Discuss how the article addresses scientific uncertainty. e.g., does the article mention limitations of its claims, or refer to regulatory bodies such as the Australian Pesticides and Veterinary Medicines Authority (APVMA)?

26. Consider the reliability of the ABC article:

Is the source credible and well-known?	
Does it cite verifiable evidence?	
Is it balanced or biased?	
Does it reflect scientific consensus?	

27. Compare the ABC Article to ONE of the sources listed in Lottie's case study:

Criteria	**ABC News Article**	**Scientific Source: _____**
Main claim		
Type of evidence		
Scientific terminology used?		
Bias or emotive language?		
Overall reliability?		

Monoclonal Antibodies and COVID-19

Monoclonal antibodies have an important function in the immune response. There have been recent advancements in monoclonal antibody treatments for COVID-19.

- ☐ Watch the video short: What is a MONOCLONAL ANTIBODY TREATMENT for Long COVID?
- ☐ Read the article New design may boost potency of monoclonal antibodies against COVID
- ☐ You can also review from our previous lesson on monoclonal antibodies this LabXchange interactive - Therapeutic Monoclonal Antibodies.

1. In the article “New design may boost potency of monoclonal antibodies against COVID”, highlight key vocabulary terms. Identify and define key vocabulary terms in the table below:

Key Term	Scientific Definition

2. Summarise the article in your own words, in one paragraph.
   You may use the following wordbank in your summary: ***monoclonal antibodies, COVID-19, treatment, design, immune system***

   The article is about...

3. Why are scientists changing the design of monoclonal antibodies?

   Scientists want to improve them because...

4. Describe the role of monoclonal antibodies in the body when preventing infection.

5. Identify the part of the virus that antibodies target.

6. Explain how antibodies stop the virus from spreading in the body.
   You may use the following wordbank in your response: ***stopping entry, neutralising, preventing binding, blocking infection***

7. Explain how this new treatment could help someone already sick with COVID-19.

8. Suggest at least TWO reasons why scientists want antibodies that work against many variants.

9. **Assess** the advantages and disadvantages of using monoclonal antibody treatments as a public health strategy for COVID-19.
   You may use the following wordbank in your response: ***cost, resistance, not effective for all, side effects, treat more people, prevent infection, stop outbreaks, global use.***

✏️ ***Assess*** *means to make a judgement of value, quality, outcomes, results or size.*

- *Introduction should include a statement of the topic to be assessed which reflects your viewpoint. You should also 'preview' (list without elaboration) the points to be addressed.*
- *Topic sentences at the beginning of each paragraph should be followed by an explanation and examples to illustrate each point. You should aim to have at least three main points and elaborate on each of them in the body of your answer.*
- *Use linking words such as: therefore, because, however, for instance, for example, as a result.*
- *Use examples to justify your viewpoint!*
- *Use diagrams where applicable if it will help to illustrate your point!*
- *Conclusion: You MUST make a judgement either for OR against the argument based on the value, quality or outcomes of the topic. Do not say you 'partially agree' or that you 'both agree and disagree'. Be confident and stick to your viewpoint!*

MEDICAL & BIOTECH

First Genetically Engineered Salmon Sold in Canada

US firm AquaBounty Technologies says that its transgenic fish has hit the market after a 25-year wait

By Emily Waltz, Nature on August 7, 2017

Credit: FDA

Genetically engineered salmon has reached the dinner table. AquaBounty Technologies, the company in Maynard, Massachusetts, that developed the fish, announced on August 4 that it has sold some 4.5 tons of its hotly debated product to customers in Canada.

The sale marks the first time that a genetically engineered animal has been sold for food on the open market. It took AquaBounty more than 25 years to get to this point.

The fish, a variety of Atlantic salmon (*Salmo salar*), is engineered to grow faster than its non-genetically modified counterpart, reaching market size in roughly half the time — about 18 months. AquaBounty sold its first commercial batch at market

price: US$5.30 per pound ($11.70 per kilogram), says Ron Stotish, the company's chief executive. He would not disclose who bought it.

AquaBounty raised the fish in tanks in a small facility in Panama. It plans to ramp up production by expanding a site on Canada's Prince Edward Island, where local authorities gave the green light for construction in June. In the same month, the company also acquired a fish farm in Albany, Indiana; it awaits the nod from US regulators to begin production there.

The sale of the fish follows a long, hard-fought battle to navigate regulatory systems and win consumer acceptance. "Somebody's got to be first and I'm glad it was them and not me," says James West, a geneticist at Vanderbilt University in Nashville, Tennessee, who co-founded AgGenetics, a start-up company in Nashville that is engineering cattle for the dairy and beef industries. "If they had failed, it might have killed the engineered livestock industry for a generation," he says.

SWIMMING UPSTREAM

AquaBounty's gruelling path from scientific discovery to market terrified others working in animal biotechnology, and almost put the company out of business on several occasions. Scientists first demonstrated the fast-growing fish in 1989. They gave it a growth-hormone gene from Chinook salmon (*Oncorhynchus tshawytscha*), along with genetic regulatory elements from a third species, the ocean pout (*Zoarces americanus*). The genetic modifications enable the salmon to produce a continuous low level of growth hormone.

AquaBounty formed around the technology in the early 1990s and approached regulators in the United States soon after. It then spent almost 25 years in regulatory limbo. The US Food and Drug Administration (FDA) approved the salmon for consumption in November 2015, and Canadian authorities came to the same decision six months later. Neither country requires the salmon to be labelled as genetically engineered.

But unlike in Canada, political battles in the United States have stalled the salmon's entry into the marketplace. The law setting out the US government's budget for fiscal year 2017 includes a provision that instructs the FDA to forbid the

sale of transgenic salmon until it has developed a programme to inform consumers that they are buying a genetically engineered product. Senator Lisa Murkowski (Republican, Alaska), who inserted the provision, has called AquaBounty's salmon "fake fish".

Activists in both the United States and Canada have demanded that regulators reconsider their decisions, and some have filed lawsuits. The Center for Food Safety, an environmental-advocacy group in Washington DC, sued the FDA last year in an attempt to overturn its salmon decision. The group says the agency lacks the legal authority to oversee genetically engineered animals, and that it made its decision without fully considering the environmental risks.

The announcement that AquaBounty's fish are landing on Canadian tables is sure to dredge up opposition, says Stotish. He argues that the genetically engineered fish are good for the economy — attractive because they can be grown near metropolitan areas rather than being flown in from overseas, bringing salmon-farming jobs back to the United States and Canada. And because the AquaBounty salmon are grown in tanks, he adds, they don't encounter many of the pathogens and parasites that often afflict salmon raised in sea cages.

"I think the larger market is viewing it as a more predictable, sustainable source of salmon," Stotish says. "As a first sale this was very positive and encouraging for us."

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