
A Biotechnology Program for High School Learners

SciFun

# SciFun

SciFun curriculum is a collaborative product of Kenya Agricultural and Livestock Research Organization Science Centre and the Boyce Thompson Institute. This curriculum is funded through grants provided by the Alliance for Science.

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*With assistance from many teachers, learners, and community partners.*



KALRO Kenya Agricultural & Livestock Research Organization

BTI BOYCE THOMPSON INSTITUTE Inspired by how plants work for humanity.

ALLIANCE FOR SCIENCE Science for Humanity

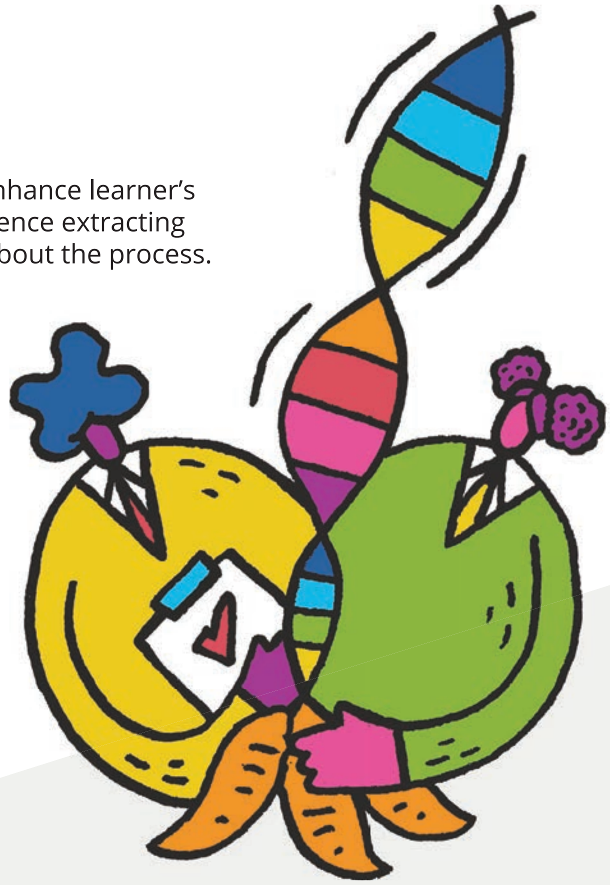
# Contents



# WHAT IS SCIFUN?

SciFun is a program run for Form 2 and Form 3 learners, to enhance learner's understanding of biotechnology and receive hands-on experience extracting DNA from fruits and vegetables, while making observations about the process. Modifications can be made for use with Form 1 learners.

- This lesson and practical was developed by teachers and was based on many factors, including its attractiveness, feasibility, and utilization of cost-effective materials.
- The materials used within the practical are easy to find and low-cost, and the practical is quick and easy to do.
- This lesson will give learners an opportunity to conduct an experiment around DNA. It will also introduce learners to concepts in biotechnology and science, as well as careers in higher education and industry.



# WHAT YOU WILL FIND IN THIS BOOKLET

In this booklet, you will find a teacher lesson guide to extract DNA from strawberries. The lesson guide will give you the instructions, material list, and procedures for the lesson. You will find background information on DNA and biotechnology to help you throughout the lesson, as well as a sample of careers in biotechnology.

At the end of this booklet you will find an Appendix of worksheets the learners may use while they are doing the DNA practical activity. You will find the following three worksheets for learners: "DNA Extraction Procedure," "What is DNA and where can we find DNA?," and "Careers in Biotechnology." You will also find pre and post lesson surveys for learners you can use to evaluate learners' knowledge before and after the lesson. A teacher resource list to gather more information is also provided.

***Are your learners interested in more after the DNA activity?*** Additional activities and information on the Cassava Challenge and an extension activity involving yeast are also included. The Cassava Challenge allows learners to gain experience growing cassava, while gaining experience growing and identifying any pests or insects with the help of scientists. You will find a soil sampling guide at the end of this booklet. The yeast extension activity allows you to continue to explore concepts related to biotechnology through hands-on experiences with yeast.

## Background Information

# INTRODUCTION ABOUT DEOXYRIBONUCLEIC ACID (DNA) AND THE CELL

DNA is a long string-like molecule that carries the genetic information for all living organisms, including humans and foods. All things that are living have DNA, even plants! DNA is like a set of instructions that tells something how to grow and what it will be like. Traits like the color of our hair, eyes, and skin are based on our DNA. Plants also use DNA to pass on their traits. For plants, these instructions make up how the plant grows, what it looks like, and other important factors.

**Deoxyribonucleic Acid (DNA):** the molecule inside cells that contains the genetic information responsible for the development and function of an organsim

*Definition from cancer.gov*

DNA is made up of four bases, adenine (A), cytosine (C), guanine (G), and thymine (T), These bases are represented by the letters A, C, G, and T. DNA is organized into sequences called genes. The way these bases are organized in genes make up the instructions for how living things grow and live. These instructions are similar to using a recipe to cook a meal. Think of a time you used a recipe to make a meal. The instructions helped you understand how to make the final product. Genes help give the instructions for building a living thing! It is also similar to letters and words. Letters themselves often do not make sense until they form words. The letters are the four bases, which create the gene sequences (the words) and the DNA strands (the sentences).

DNA is found within cells in living things. Cells are the building blocks of living things and are the basic structures and units of living things. Just like all living things have DNA, all living things have cells. DNA is found within the cell nucleus. Cells have many different parts with different functions.

"Figure 1: What Does DNA in Plants Look Like" helps to visually show what DNA is and, where it can be found. Use this figure with your learners to help them understand what DNA is and its importance. This figure can be found on page 19 of this booklet as part of the learner worksheets. You may provide this figure to each learner individually, or have one copy on hand to show the learners.

While this activity focuses on plants, plant cells, and plant DNA, you may introduce animal cells. Animal cells have different functions than plant cells, and therefore have different cell structures. Because animals do not use photosynthesis like plants to create energy, many structures of plant cells needed for photosynthesis are not seen within animal cells. You will find "Figure 2: Plant and Animal Cells" on page 20 as part of the learner worksheets. You may use this figure to help your learners understand the difference between plant and animal cells.

**Photosynthesis:** the process by which green plants and other organisms use sunlight to create food from carbon dioxide and water

*Background information modified from National Agriculture in the Classroom USA, https://agclassroom.org/matrix*

# INTRODUCTION TO BIOTECHNOLOGY

**BIOTECHNOLOGY is technology that utilizes biological systems, living organisms, to develop or create different products. There are many forms of biotechnology, and biotechnology can be used in different ways. Biotechnology is used within medicine, farming, and industry. Scientists are using biotechnology to create new fuels, make vaccines, help farmers fight off diseases and pests, and so much more. In agriculture, biotechnology provides farmers with tools to make production faster, less expensive, and more manageable.**

One example of biotechnology is yeast and the fermentation process. Yeast is a biological microorganism, commonly used in baking and cooking. Yeast has been used for centuries to help rise bread, and make other foods and items. The use of yeast within cooking and baking is an example of a common biotechnology. Bread is an example of something made through a process using yeast. To make it interactive for your learners, have real bread for the class to enjoy  together. You may also reference and conduct the yeast extension activity found on page 14 of this booklet to expand on the use of yeast as a tool for biotechnology. Another example of biotechnology is the use of bacteria to create yoghurt. ***A video on the process of making yoghurt is included on the resource list found on page 25.***

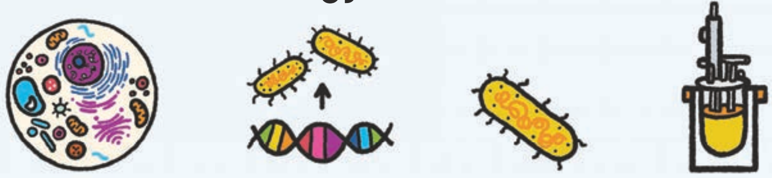
Biotechnology is a way for scientists to solve problems they see in the world. Throughout history biotechnology has been used to create vaccines and medicines, and help plants fight off diseases. Figures 3 found below shows how  biotechnology was used in the creation of insulin; a common medicine used to help people with diabetes regulate their blood sugar. ***A larger version of "Figure 3: Creation of Insulin using Biotechnology, can be found on page 23 for classroom use.***

**FIGURE 3 | Creation of Insulin using Biotechnology**

## The Problem:

People were sick with a condition called diabetes. People with diabetes cannot produce the hormone, insulin, needed to regulate blood sugar.

## The Biotechnology Solution:



Scientists used cells containing the gene that helps create human insulin. → DNA was extracted from those cells and introduced into a bacteria called *E. coli.* → One *E. coli* containing the gene for insulin is identified. → The *E. coli* with the gene for insulin is grown in large quantities to be used by humans.

## The Result:

The *E. coli* with the gene for insulin is used to make a drug. This drug is given to diabetics to help them make insulin.

As shown in the example, biotechnology uses a biological tool to help solve a problem. Diabetes was a life threatneing condition before the creation of syntheic insulin. As a result, many people would die from the condition. Before the creation of insulin using E. coli, scientists used insulin found in animals. This sometimes caused an allergic reation in people and was less effective.. The example of insulin shows how by using the the bacteria E. coli, scientists were able to create a more effective drug to treat diabetes. Biotechnology is still used to create insulin today.

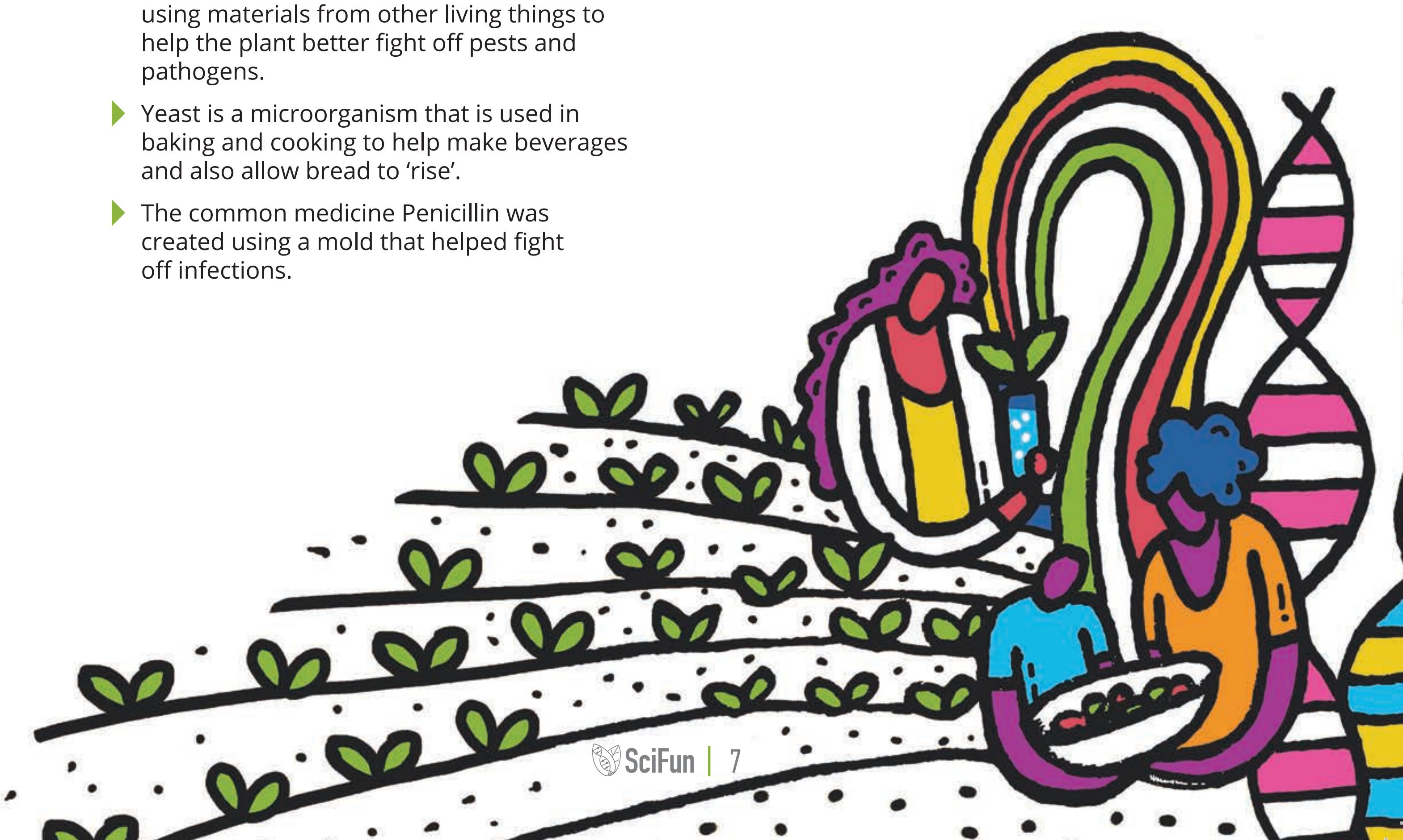
***You can learn more about the creation of insulin using biotechnology by visiting https://biotechhealth.com/how-is-insulin-made-by-biotechnology/.***

There are many examples of biotechnology in action besides insulin. Some other examples of biotechnology in action include:

- Biofuels use plants like maize and sugarcane to create energy as an alternative to gasoline fuel. Biofuels can be used to power cars, and other machinery.
- Bioremediation is the process of using organisms to clean up toxic pollutants in the environment.
- Biotechnology is used to create washing detergents to help remove stains from clothes. Scientists create enzymes found in nature, that help break down stains.
- Genetically modified plants can be created using materials from other living things to help the plant better fight off pests and pathogens.
- Yeast is a microorganism that is used in baking and cooking to help make beverages and also allow bread to 'rise'.
- The common medicine Penicillin was created using a mold that helped fight off infections.

Because biotechnology can be used in different ways, there are many different biotechnology tools. Some include researchers who study how to use living organisms to make vaccines for humans and animals, or create plants that can better fight off pests and insects. Careers in biotechnology are becoming increasingly in higher demand, as biotechnology is used to help solve problems related to climate change and food security. Some careers in biotechnology involve working within a scientific lab, while others involve working outside in an agricultural field site, or even in an office setting.

The DNA extraction activity and extra activites, such as the Cassava Challenge and the yeast experiment, will allow your learners to both see biotechnology in action and understand more about biotechnology, as well as skills related to scientific careers. DNA is a basis of many biotechnology tools and applications, and the DNA extraction activity will let your learners see DNA in real life, while learning what DNA is. After the DNA experiment, your learners will understand different careers in biotechnology. ***You may use the career examples found on page 22 in addition to the resources included on page 25 for your learners to learn more about biotechnology and biotechnology careers.***



# DNA Extraction

## Teacher Guide

**Length:** *90-95 minutes*

**Materials:**

- Strawberries, bananas, or other soft fruit
- Polythene bags, or transparent disposable cups
- Surgical spirit (cold)
- Salt
- Warm water
- Sieve
- Soap (clear liquid)
- Toothpick/splint

### Learners will

- Record their observations
- Explain observations in relation to DNA extraction
- Understand and define DNA and genes
- Understand and define biotechnology
- Identify biotechnology careers
- Relate DNA to inheritance and variation
- Relate DNA extraction to biotechnology

## Teacher Lesson Procedures

**Below you will find the steps to complete the DNA extraction practical with your learners.**

### 1. Optional: Pre-Evaluation Learner Survey (5 minutes)

**Share the "Learner Pre-Evaluation Form" found on page 17.** This form is for you to see what your learners already know about DNA and biotechnology. If you have time, have learners fill out the form. There is a post-evaluation form for your learners as well, for you to see how their knowledge changed after the lesson. You do not need to complete this step if you have limited time.

### 2. Introduction to DNA and cells (10 minutes)

**Share the "What is DNA and where can you find it?** worksheet with the learners, found on page 18. You may print one out for learners to work on by themselves, have learners work in groups to complete the worksheet, or work together as a class to complete the worksheet together

- The worksheet provides background information on DNA and cells for your learners to read through. Have them read through the information on their own, or read it together with your class.
- There are two figures attached to the worksheet for your learners to use. Figure 1: "What does DNA in plants look like?" provides a visual for your learners to see what DNA looks like and where it is located within a cell. Figure 2: "Plant and Animal Cells" helps students see what both a plant and animal cell looks like, and to see how the two types of cells are similar and different.
- Have the learners look at both figures after reading through the background informaton on DNA and cells. There are questions at the bottom of the worksheet for them to answer. You may skip having them answer questions if there is limited time.

***You may use the background information provided at the beginning of this booklet to include additonal information on DNA and cells for your learners. A resource list at the end of this booklet gives more resources for you to use.***

## 3. Introduction to Biotechnology (10 minutes)

- After introducing DNA and cells to your learners, introduce biotechnology. You will spend more time after the DNA extraction activity discussing biotechnology and careers.
- Ask your learners "What is Biotechnology?". Take any answers of what biotechnology means to your learners. If you had your learners take the pre-survey, have them share the definiton of biotechnology they wrote in the survey.
- After taking their definitions for biotechnology, share the definition of biotechnology.
    - *'Biotechnology is technology that utilizes biological systems, living organisms, or parts of these to develop or create diff erence.* Share some examples of biotechnology from the background information section, including how yeast is used for biotechnology.
- **Share "Figure 3: Creation of Insulin using Biotechnology" found on page 23 with your learners.** You may print one out for each learner or display one copy for the who Ask your learners if they know what insulin is. Read through the example of how insulin was created usingb biotechnology.
- Ask your learners if there are other examples of biotechnology.
    - *Your learners might not know other examples, and that is ok.*

## 4. DNA Extraction Practical Activity (50 minutes)

In groups, learners will extract and see DNA. We recommend groups of 2-5 depending on the amount of supplies available. This activity will involve extracting DNA from strawberries, but other fruit can be used. Each cell in a strawberry contains eight copies of its genetic information, while human cells contain only two copies! This makes it a great fruit to see DNA with the naked eye.

### Activity Steps:

- **Share the "DNA Extraction Practical Learners Worksheet" found on page 21 with your learners.** The worksheet includes a place for your learners to include observations or notes. Have them use this section of the worksheet to write down observations, or what they are seeing, what surprised them, and what they learned.
- After sharing the worksheet, have the groups follow the steps below. *These steps are also included on the learners worksheet.*

### DNA Extraction Steps

1. Put strawberries in a transparent disposable cup, mash using your hands, then add half a cup of warm salty water. Mix well until it achieves a smooth consistency.
2. Separate the tough, fibrous material by pouring the mixture through a fine sieve. Use the back of a spoon to squeeze all the juice through, leaving much of the cell material behind.
3. Add liquid soap (about 30 mL). Stir gently to avoid bubbles and leave it for 5 minutes.
4. Decant the (now undrinkable) strawberry juice into a tall glass or test tube, or transparent disposable cup.
5. Add cold surgical or methylated spirits, do this very gently on the side of the glass.
6. The spirit will form a layer on the surface. At the boundary of the two liquids, DNA will form into thread-like structures. This is the strawberry's DNA and can be gently looped out using a stick or wire loop.

### Before the activity, ask the learners,

- What do you think will happen at the end of the activity?
- Do you think you will see or find DNA within the plant?

### During the activity, ask the learners,

- What are you noticing or observing? *Encourage them to write down their observations.*
- What happened in the final step when you added the spirits?

### At the end of the activity, ask the learners,

- What surprised you most during the activity?
- What did you see at the end? What did the DNA look like?
- Why is it important for scientists to be able to remove and study DNA from plants?

Below you will find a chart that explains the steps of the DNA extraction activity, and what is happening to the cell during the process. As the learners go through the activity, reference this chart to help them understand why they are doing each step, and what is taking place inside the cell.

## DNA Extraction Protocol Explanation

| PROCESS | FUNCTION |
|---|---|
| Crushing/Grinding | Breaks down the cell |
| Salt (NaCl) solution | Brings the DNA together |
| Soap Solution | Breaks down the cell membrane to release DNA |
| Alcohol/ethanol/surgical spirit | Precipitates the DNA, or DNA comes out of solution |

## 5. Biotechnology Careers and Applications (15 minutes)

- **Share the "Careers in Biotechnology" worksheet found on page 22 with your learners.**
- Have them read through the sample careers, and ask them the following questions below.
- If needed, have your learners get more information about the careers and biotech careers at [www.biotech-careers.org/careers.](www.biotech-careers.org/careers)
- You will also find videos on science careers and a database of current biotechnology careers on the teacher resource list on page 25.

### Ask the learners the following questions, after or while sharing the examples of biotechnology careers:

- What career is the most exciting to you? Which career would you like to have?
- What education do you need for each career?
- What other careers in biotechnology can you think of?

## 6. Program Evaluation (5 minutes)

**Share the "Learner Post-Evaluation Survey" found on page 24 with your learners after doing the lesson.** Ask them to fill out the questions. You may use this survey to better understand the impact of the lesson on your learners. You may share completed surveys with biotechnology@kalro.org and pgrp-outreach@cornell.edu. *Please reach out for instructions on how to share the completed surveys.*

# Cassava Challenge

The Cassava Challenge is an **extra activity** that allows learners to get hands-on experience growing an agriculture crop, practice skills related to agriculture and increase their agricultural knowledge. Agriculture and crops are an important part of biotechnology, with biotechnology being used to address food security issues. During the Cassava Challange, learners will be able to plant cassava, while practicing skills related to planting, soil testing, pest management, and other related agriculture skills. Learners will be able to troubleshoot challenges that may arise during planting and growing.

Schools and learners involved in the cassava challenge will be provided a clean cassava cutting that they may plant. Prior to planting, we encourage schools to conduct soil testing to learn more about the soil properties of their land, understand soil health, and to learn how to read soil testing results. Instructions on how to conduct a soil test are provided on page 12-13.

After planting, learners may observe and collect data on their cassava cutting and how it is growing. During each observation of the plant, learners can measure how much it has grown, notice the color and size of cassava leaves, and observe any pests that may be on or around the cassava plant. Learners may collect these data in a notebook, and if available, take pictures of or draw the plant over time. These data can be used to notice any patterns or make observations about how the plant grows.

This activity can be done anytime to enhance the learner's undertanding of biotechnology. If you do not have access to a cassava cutting, you may plant another crop such as strawberries. Engage the learners by asking them what they would like to grow.

At the end of the challenge, schools and learners will be celebrated for their accomplishments. For more information, please reach out to biotechnology@kalro.org.

# Soil Sampling Instructions


Below you will find instructions on taking a soil sample of your field, prior to the cassava challange, or to be used before planting anything with your learners. Follow these instructions, and reach out to KALRO Research Laboratories with questions. Ideas to connect soil sampling with your learners and this activity are provided on page 13.

## INSTRUCTIONS FOR SOIL SAMPLING

***A soil test is only as good as the sample you take is representative of your land.***

Hence, it is very important that you collect a **representative sample.** Take to the field a notebook, soil sample containers (clean plastic bags, paper bags, cloth bags), two clean buckets, a soil sampling tool such as a spade or soil tube or soil auger (or panga) and ruler.

Make a sketch map of the field/plots to be sampled, indicating the difference in soils, which you recognize. Each soil sample should not represent more than two hectares (5 acres). These may be whole fields or sections of fields depending on the following situations:

1. Let each soil sample represent **no more than 2 hectares.** A correspondingly larger number of samples must be taken for any field or soil area larger than 2 hectares.
2. Irrespective of the field size, ***let a separate soil sample*** represent parts of the field which differ in:
   - Soil color
   - Soil texture (sand, loam, or clay)
   - Drainage
   - Slope (if contour formed, sample contour area separately)
   - Crop performance (crop quality or symptoms indicating varying degrees of nutrient deficiencies)
   - Management practices (e.g., mulched versus unmulched)

On the sketch map, list your Field or Block designation, sample numbers and indicate/mark approximate distribution of the borings (spots where a sample was taken). Remember to record your address in the soil sampling information sheet (or notebook).

### Sampling Instructions from

**Kenya Agricultural and Livestock Research Organization**

**National Agricultural Research Laboratories**
Samples and inquires can be sent to: P.O. Box 14733, 00800 NAIROBI
**Tel:** 020 2464435 **Email:** soillabs@yahoo.co.uk; soil.survey@kalro.org

## Sampling Operation:

With any of the sampling tools selected proceed as follows;

**A.** Top soil- take a soil core or cut to a depth of about 20 cm and transfer into a bucket. Repeat this at least twelve times (12 sampling points so as to cover the farm), mix thoroughly and put quarter a kilo of soil into the sample paper bag or polythene bag.

**B.** Sub soil- at every other boring (where top soil was taken) take a sub-soil sample from about 20 to 50 cm. Place into a second bucket and proceed as in (a) above.

Label the sample containers (clean plastic bags, paper bags, cloth bags) giving the Field or Block designation and sample identity with the designation "TOP" or "SUB", depth in cm, date and samplers' name.

## Please note:

- When sampling soil from fruit crops, coffee, etc., take samples within most active feeding zone, i.e., just within the leaf canopy.
- Keep samples with mulched and unmulched areas separate and indicate this on information sheet (notebook).
- Do not sample hot spots, e.g., ant-hills, knolls, fertilizer bands, terrace channels, dead furrows, areas where lime, manure, or fertilizer have been in pile or spilled, areas where brush or trash have been burned, or any other such unusual area from the field as a whole.
- Do not sample when too wet.

Have your soil re-tested after two to three years when carrying out conventional farming.

## Soil sampling with your learners

As much as possible, have the learners be involved with collecting soil samples for your testing. Soil sample before you decide to plant your cassava planting, or any other plants you plan to grow. Give the learners an opportunity to learn how to take a soil sample, and explain the importance of soil sampling. Testing your soil before you start to grow any plants or foods is an important first step to having healthy plants. Soils can sometimes lack things that plants need to survive, or have harmful substances that could harm humans and plants.

After getting the soil sampling results back, look over the results with your learners. As you review the findings with your learners, ask them questions about the results. What are some of the findings of the soil sampling, and what does it say about your soil? Was there anything surprising in your results?

***Not able to get soil sampling completed with Kenya Agricultural and Livestock Research Organization?***
Please reach out or search for local research laboratories, universities, or agencies to find soil sampling resources.

Additional Activity:

# Yeast Exploration

**Length:** *50 minutes*

**Materials:**

- 3 disposable plastic bags that can seal or close
- 45 mL of yeast
- 60 mL of sugar
- 375 mL of warm water

### Learners will

- Record and explain their observations
- Learn how yeast is connected to biotechnology
- Understand and define biotechnology
- Conduct an experiment related to yeast as a biotechnology tool
- Understand the importance of yeast

## Background information on yeast and biotechnology (10 minutes)

Yeast is a great example of biotechnology in action. Yeast, a single celled microorganism, is a member of the fungus kingdom and is a powerful tool used in baking, food science, industrial ethanol production, and in bioremediation. Bioremediation is the use of plants and biological materials to extract heavy metals and pollutants from contaminated soils and waters. Many popular drinks and foods, such as bread, use yeast to help create the final food product. The act of using yeast to make these items is a form of biotechnology.

***But how does yeast work? Why is this microorganism used as a tool in biotechnology?*** The yeast exploration activity allows learners to see yeast in action, and see in real time how yeast helps dough 'rise'. Dough rising is caused by a process called fermentation. During fermentation, yeast feeds off sugars, which break down into carbon dioxide, alcohol, and other components. Carbon dioxide, or $CO^2$, is a gas. CO2 is released by the yeast as they consume the sugar, causing the dough to rise. The alcohol created as yeast feeds off the sugar is also a major factor that causes dough to rise. The alcohol created by the fermentation process is a liquid, but it changes into a gas while it is being baked. The combination of the $CO^2$ gas, and the transformation of alcohol from a liquid to a gas while it bakes, causes bread to rise.

In this activity, learners will create different mixtures of sugar, water, and yeast, and will watch in real time as yeast ferments with flour and water to 'rise' the dough. Different combinations of water, yeast, and flour will be made to see what will cause the dough to rise the most. Learners will be able to see the fermentation process take place before their eyes in the span of 15-30 minutes, depending on the conditions of the room the experiment is taking place in. In addition, at the end of the lesson you may also have fresh bread available for your learners to taste together as a class.


### Before the experiment, ask the learners the following questions:

- What is yeast?
- What do we use yeast for?
- How does yeast connect to biotechnology?

Explain what fermentation is, and how fermentation is used to make baked goods. Feel free to share other uses for yeast as described above. If possible, have yeast available for students to look at up-close.

*Lesson credit to Ann Butkowski and Andrea Gardner, with Minnesota Agriculture in the Clasroom and National Center for Agricultural Literacy*

## Yeast Experiment (40 minutes)

You will be putting together three separate bags to see how yeast reacts to different levels of sugar. *Figure 4 is provided below that shows what the materials and experiment will look like.*

1. After discussing yeast with your learners, help them set up an experiment to see yeast in action.
2. Label your three bags, by writing the number 1 on one bag, the number 2 on the second bag, and the number 3 on the third bag.
3. Each bag will get a different mixture of sugar but will all get the same amount of yeast and water. Learners will see whether the amount of sugar that yeast gets will impact how much the mixture will rise.
4. Fill each disposable plastic bag with 15 mL of yeast per bag.
5. Add 15 mL of sugar to bag two, and 45 mL of sugar to bag three. ***No*** sugar will be added to bag one.
6. Place 125 mL of warm water in each bag and seal the bag. Push as much air out of the bag as possible as you seal the bag. Mix the contents of each bag thoroughly with your fingers. Have your learners help mix the bags.
7. If necessary, set a timer for 20 minutes, and set the bags aside. Be cautious over the next 20 minutes to watch for any chances the plastic bags might pop.

***Note:*** ***The temperature of the room might affect the experiment. Cold rooms might have a slower reaction compared to warm rooms. It is best to test out this experiment in the room the experiment will take place to understand the reaction time.***

**While the bags are resting, have the learners discuss what they think will happen to the bags. Ask them the following questions, and have them discuss in groups or as a class:**
What do you think is going to happen to each bag? Why?
We added a different amount of sugar to each bag. Do you think this will cause different things to happen to each bag? If so, what different things will happen to each bag and why?

Have learners write down or discuss their predictions for each bag. After 20 minutes, look at the bags to see if there are any differences between them. Figure 4 below will show what should happen to the bags over the 20-minute rest period. If desired, to conclude the lesson, have bread available for learners to taste.

**FIGURE 4 | Shows how the experiment will look, and what should take place with the bags after 20 minutes.**


Image Credit: Ann Butkowski and Andrea Gardner

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*Yeast activity modified from "Food Science: Bread Dough Challenge" to Ann Butkowski and Andrea Gardner, with Minnesota Agriculture in the Classroom and USA National Center for Agricultural Literacy https://agclassroom.org/matrix.*

# Appendix

*In the appendix, you will find the following documents:*



# SciFun and DNA Extraction Practical

## Learner Pre-Evaluation Survey

Learners, answer the following questions about your current knowledge of DNA and biotechnology, before you do the activity. There are no right or wrong answers!

**Your school:** ______________________________

**Your grade:** ______________________________

| | Disagree/ No, I don't understand | I'm not sure | Agree/ Yes, I do understand |
|---|---|---|---|
| I understand what DNA is. | | | |
| I understand that plants have DNA. | | | |
| I understand what biotechnology is. | | | |
| I understand how to extract DNA from strawberries. | | | |
| I know more about careers in biotechnology and science. | | | |
| I am interested in learning more about biotechnology. | | | |

**Describe what you think biotechnology is, in your own words.**

______________________________

______________________________

______________________________

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**What do you know about DNA?**

______________________________

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# What is DNA and where can we find DNA?

DNA is a long string like molecule that carries the genetic information for all living organisms, including humans and foods. All things that are living have DNA, even plants! DNA is like a set of instructions, that tells something how to grow and what it will be like. The color of our hair, eyes, and skin are based on our DNA. DNA is organized into sequences called genes, which carry instructions for life.

DNA is found within cells in living things. Cells are the building blocks of living things and are the basic structures and units of living things. Just like all living things have DNA, all living things have cells. DNA is found within the cell nucleus. Cells have many different parts with different functions.

DNA material is made up of four bases, which are adenine (A), cytosine (C), guanine (G), and thymine (T). These bases are represented by the letters A, C, G, and T. The way these bases are organized in the DNA make up the instructions for how living things grow and live.

These instructions are similar to using a recipe to cook a meal. Think of a time you used a recipe to make a meal. The instructions helped you understand how to make the final product. The combinations of A, C, G, and Ts and how they form genes within the DNA help make the instructions for a living thing like a recipe. These 'instructions' help determine our hair color, eye color, and other features. For plants, these instructions make up how the plant grows, what it looks like, and other important factors for the plant.

On the next pages you will see "Figure 1: What is DNA and Where Can You Find DNA" and "Figure 2: Plant and Animal Cells" that shows where DNA is located inside a plant, what DNA looks like, and an example of a plant and animal cell.

## Look at the figures, and answer the following questions:

What do you notice about the four bases for DNA (A, C. G, and T)? Is there a pattern to the way A, C, G, and T connect together?

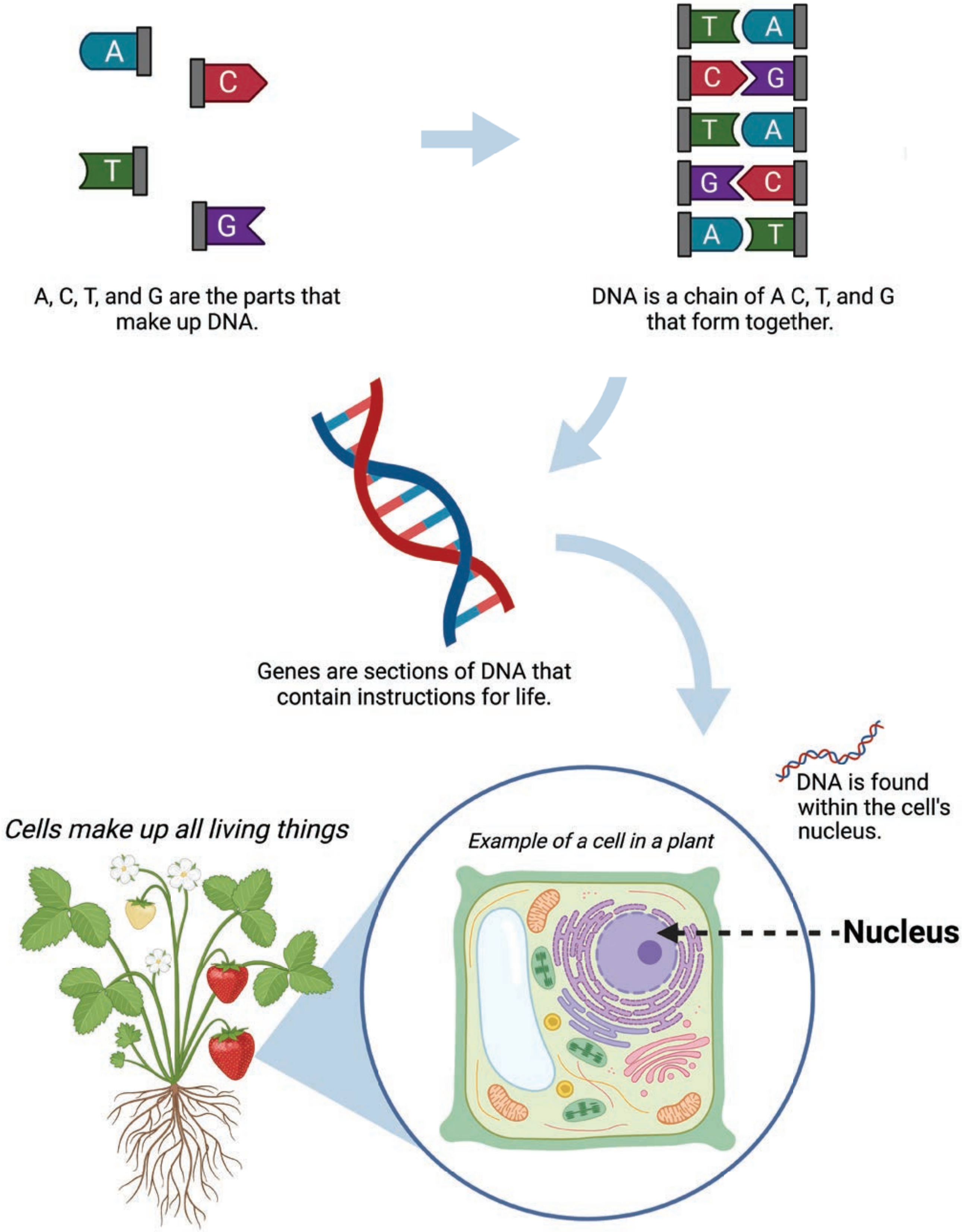
Cells look different for animals and plants. The diagram shows some differences between the cells of a plant and an animal. What are some differences you see?

Why do you think the cells between a plant and animal are different?

What is something else you would like to know about DNA, that has not been answered so far?

Learner copy

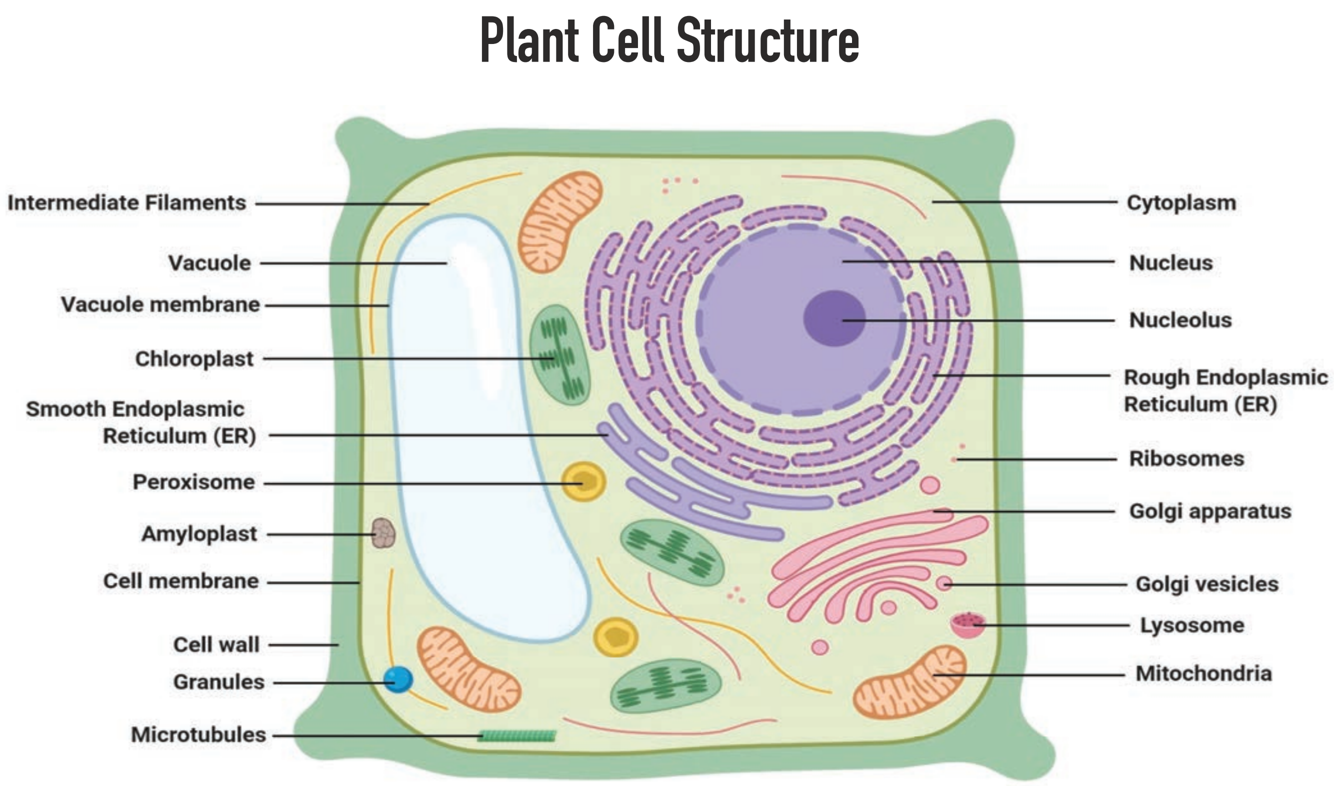
**FIGURE 1 | What does DNA in plants look like?**



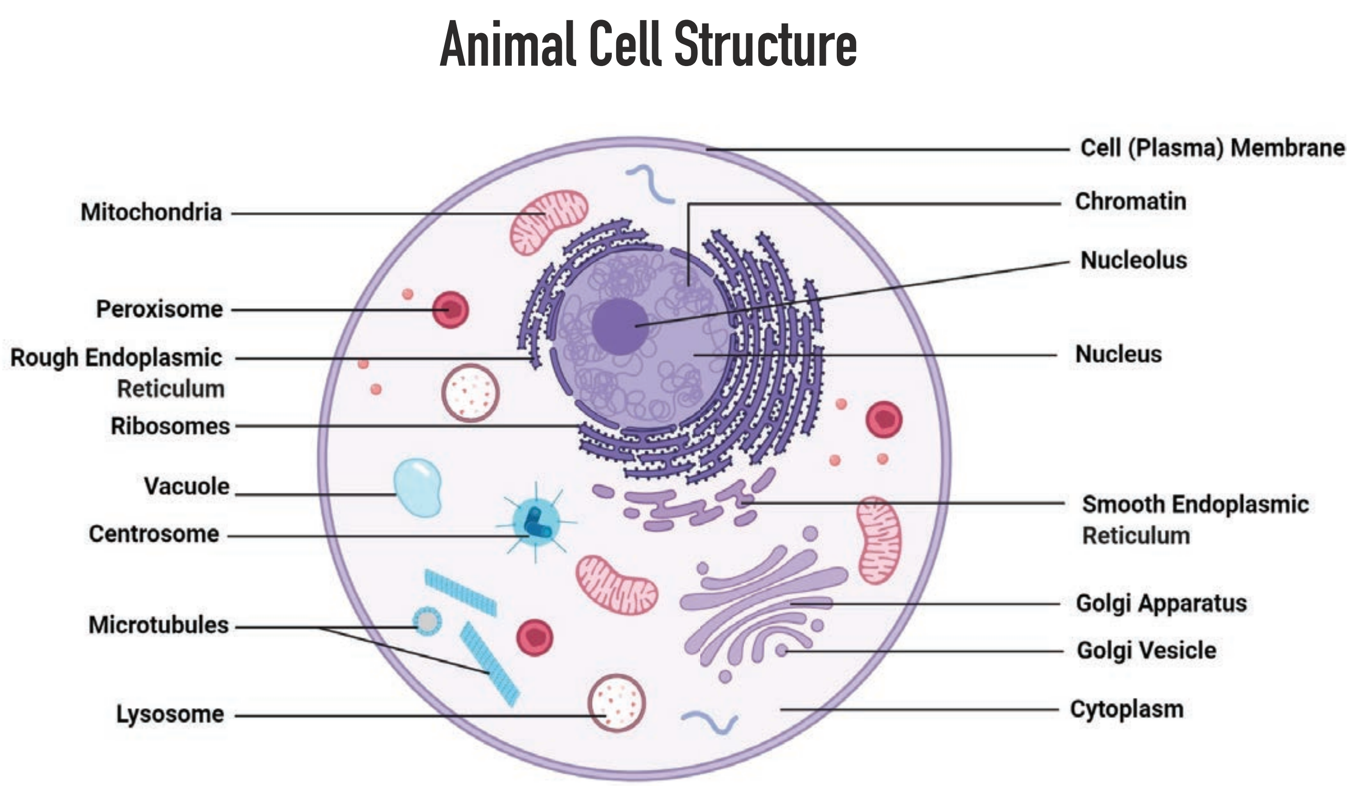

Created with BioRender.com

Learner copy

**FIGURE 2** | **Plant and Animal Cells**




*Plant Cell Structure, Image Copyright® Sagar Aryal, www.microbenotes.com*




*Animal Cell Structure, Image Copyright © Sagar Aryal, www.microbenotes.com*

# DNA Extraction Procedure

## Learner Worksheet


**In your groups, follow the steps below to extract DNA from a strawberry.**

1. Put 2 strawberries in a disposable party cup, mash using your hands then add half a cup of warm salty water. Mix well until it achieves a smooth consistency.
2. Separate the tough, fibrous material by pouring the mixture through a fine sieve. Use the back of a spoon to squeeze all the juice through, leaving much of the cell material behind
3. Add liquid soap (about 30ml). Stir gently to avoid bubbles and leave it for 5 minutes.
4. Decant the (now undrinkable) strawberry juice into a tall glass or test tube, or transparent disposable cup.
5. Add cold surgical or methylated spirits, do this very gently on the side of the glass.
6. The spirit will form a layer on the surface. At the boundary of the two liquids, DNA will form into thread-like structure. This is the strawberry's DNA and can be gently looped out using a stick or wire loop.

**During the procedure, record your observations in the space below.**

## Observations:

# Careers in Biotechnology

There are many careers in biotechnology! Read through the following careers and jobs in biotechnology. Which one is most exciting to you?

## Molecular Biologist

A molecular biologist works on understanding how molecules and cells work and function. They look closely at the activity between different cells and within cells. Molecular biologists often work with DNA and sometimes clone genes! A lot of molecular biologists study cells and molecules in plants. They work in a lab, and have a lot of tools to help them study cells and DNA. They use microscopes, as well as tools to see and extract DNA.

## Virologist

Virologists work on medicine and human health by studying viruses that aff ect humans, animals, plants, and other living things. They use biological materials to help create vaccines and other medical treatments. Virologists use DNA and other materials to create treatments for diseases. Virologists can work in hospitals or in research labs and use a lot of tools to create their devices, including computers.

## Biotechnology Greenhouse or Field Technician

Greenhouse and field technicians spend their days working either in a greenhouse or outside taking care of plants. A lot of biotechnology involves research on plants, and they make sure the plants used in research are healthy and growing well. They work to understand what each plant needs, and spend their days planting, looking for diseases or pests harming the plant, watering them, and harvesting.

## Animal Biotechnology

An animal biotechnologist works with animals in a lot of different ways. Some will use animals for research to understand how medicine work for humans. Others are using biotechnology to create vaccines to help protect animals. Animal biotechnologists were able to clone the first animal,Dolly the sheep, in 1997! They worked to understand animal cells and DNA to clone the animal.

Learner copy

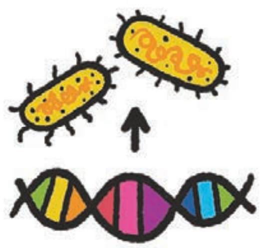
## FIGURE 3 | Creation of Insulin using Biotechnology

### The Problem:

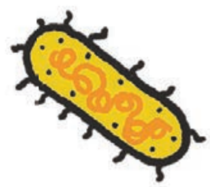
People were sick with a condition called diabetes. People with diabetes cannot produce the hormone, insulin, needed to regulate blood sugar.

### The Biotechnology Solution:

Scientists used cells containing the gene that helps create human insulin. →



DNA was extracted from those cells and introduced into a bacteria called *E. coli.* →



One *E. coli* containing the gene for insulin is identified. →

The *E. coli* with the gene for insulin is grown in large quantities to be used by humans.

↓

### The Result:

The *E. coli* with the gene for insulin is used to make a drug. This drug is given to diabetics to help them make insulin.

# SciFun and DNA Extraction Practical

## Learner Post-Evaluation Survey

Learners, answer the following questions *after* doing the DNA extraction activity.

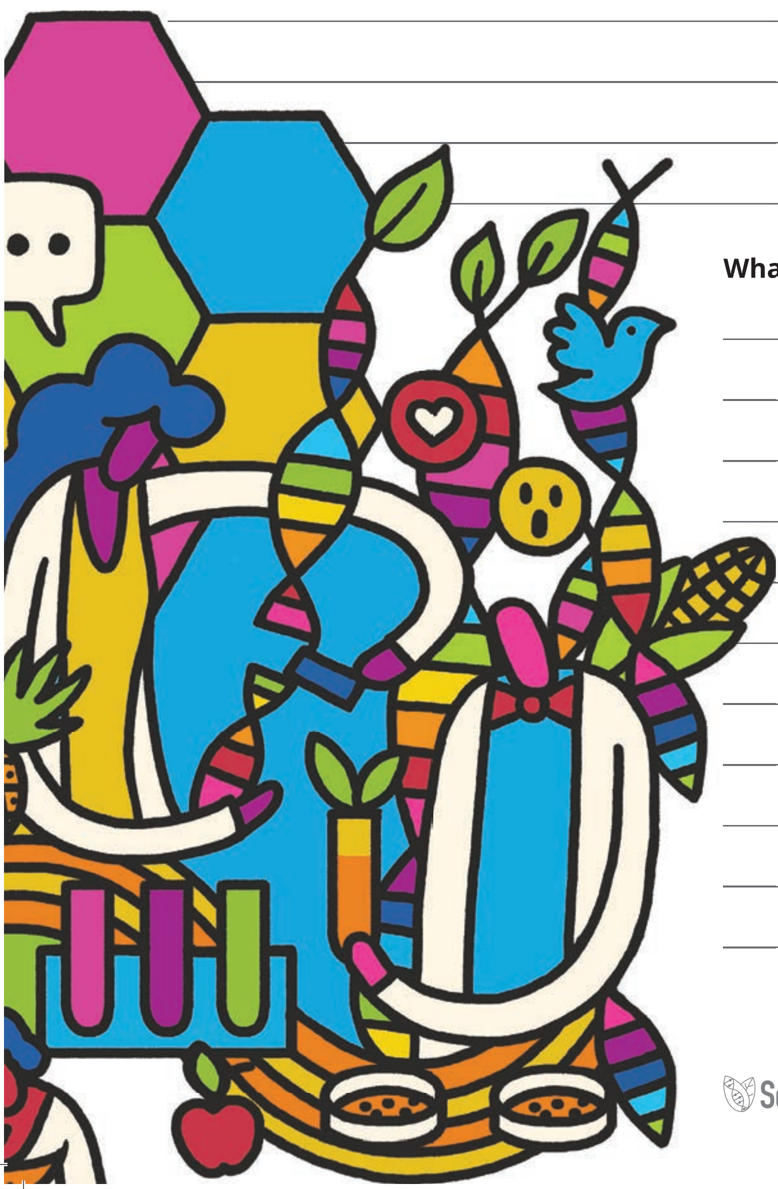
**Your school:** ______________________________

**Your grade:** ______________________________

| | Disagree/ No, I don't understand | I'm not sure | Agree/ Yes, I do understand |
|---|---|---|---|
| I understand what DNA is. | | | |
| I understand that plants have DNA. | | | |
| I understand what biotechnology is. | | | |
| I understand how to extract DNA from strawberries. | | | |
| I know more about careers in biotechnology and science. | | | |
| I am interested in learning more about biotechnology. | | | |

**Describe what you think biotechnology is, in your own words.**

**What do you know about DNA?**



**What about this lesson did you enjoy most?**

# Resource List

Using the following resources as needed to help explore topics around DNA, cells, and biotechnology with your learners. You will find webpages with further explanations of each topic, news articles to help provide more information and examples of biotechnology in action.

## For more information on DNA and cells:

Use the following websites to find more information on DNA and cells.

- National Human Genome Research Institute: **"Deoxyribonucleic-Acid"** https://www.genome.gov/genetics-glossary/Deoxyribonucleic-Acid
- Your Genome: **"What is DNA"** https://www.yourgenome.org/facts/what-is-dna/
- Your Genome: **"What is a Cell"** https://www.yourgenome.org/facts/what-is-a-cell/

## For more information on biotechnology:

- Biotechnology videos and interactive simulations: **"Foundational Concepts and Techniques in Biotechnology"** https://www.labxchange.org/library/clusters/lx-cluster:abe *Contains a mix of videos and simulations that allow your learners to learn more about biotechnology, and to practice lab techniques.*
- Article on current status of biotechnology in Africa, and viewpoints on how biotechnology can be used: **"Advancing biotechnology to solve Africa's food challenges" by Bidi-Aisah Wadvalla** https://www.nature.com/articles/d44148-022-00106-8Wadvalla, B. (2022). Advancing biotechnology to solve Africa's food challenges. Nature Africa.
- Video on making yoghurt: **"Making Yoghurt | Health | Biology | FuseSchool"** https://youtu.be/1ZSoYrHyX9c

## For more information on careers in biotechnology:

- Database of different biotechnology careers: **Biotech Careers** https://www.biotech-careers.org/careers
- Videos that highlight different scientists and researchers: **Science IRL YouTube Channel** https://www.mollyedwards.me/science-irl

# SciFun

A Biotechnology Program for High School Learners

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