COALINGA COLLEGE

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COALINGA COLLEGE

MULTISPECTROMETER & THERMAL SENSOR

AgSTEM Kit 2025

Instructor Guide: Multi-Spectrometer & Thermal Sensor AgSTEM Kit

Introduction

The **Multi-Spectrometer & Thermal Sensor AgSTEM Kit** gives students the opportunity to explore how light and heat detection technologies are revolutionizing agriculture. These tools help farmers monitor **plant health**, **soil moisture**, and **environmental stress**- and students will see how this data is collected, interpreted, and used for real-world decision-making.

This kit provides engaging, grade-appropriate content through **visual demonstrations**, **student activities**, and **data collection experiences** tied to Next Gen Science Standards (NGSS), Career Technical Education (CTE), and STEM competencies.

Kit Components

Each kit experience includes:

- **Age-specific presentation slides**
- **Pre/post surveys for student knowledge & interest**
- **Student worksheets & observation logs**
- **Hands-on activity using a thermal sensor and/or spectrometer**
- **Demonstration video of thermal and spectral scanning**

Sequence of Use

This lesson is structured for a **60–75 minute session** but is adaptable for shorter rotations or expanded projects.

Before the Session

1. Charge and test **thermal camera** and/or **multi-spectrometer**.
2. Prepare:
    - Student **pre-surveys** and **worksheet/logs**
    - Any sample plants or materials (leaves, soil, water bottles)
    - Download or cue up **demo video**

Delivery Outline

Segment	Description	Time
1. Welcome & Pre-Survey	Brief overview; assess baseline understanding	5–10 min
2. Presentation	Use slides to introduce thermal/spectral technology in agriculture	10–15 min
3. Video Demo	Show how thermal/spectral tools scan and capture data	5–10 min
4. Hands-On Activity	Students collect and analyze real data	25–30 min
5. Reflection & Post-Survey	Group discussion and survey wrap-up	10–15 min

Sensor Technology Overview

- **Thermal Sensor** detects **infrared radiation** to show **temperature differences**—used in agriculture to monitor **crop stress**, **irrigation needs**, and **equipment heat**.
- **Multi-Spectrometer** measures **light reflectance at different wavelengths** (like visible, red, NIR)—used to assess **plant health**, **chlorophyll levels**, and **disease indicators**.

Hands-On Activities by Grade Level Overview

All activities center around using thermal and spectral sensors to detect differences in temperature and plant health, with added complexity in upper grades.
Activities are outlined in detail in the Instructor Activity Guide and include:

- **Grades 2–3: Hot or Not?** – students scan classroom objects with a thermal sensor to compare temperatures.
- **Grades 4–5: Plant Temperature Detectives** – students use the thermal sensor to detect stress in shaded vs. sunlit or watered vs. dry plants.
- **Grades 6–8: Spectral Scouting** – students use a multi-spectrometer to compare healthy and unhealthy leaves based on light reflectance.
- **Grades 9–10: Thermal & Spectral Field Lab** – students record and analyze thermal and spectral data from a variety of plants and conditions.
- **Grades 11–12: Stress Detection Trial** – students simulate field diagnostics using sensor data to determine irrigation or pest concerns.
- **Community College: Sensor-Driven Decision Making** – students collect field data, calculate NDVI or temperature deltas, and make recommendations for real-world farm operations.

Pre/Post Surveys Overview

Surveys are tailored to each grade level and measure:

- Understanding of light and heat in plant science
- Student interest in ag technology and STEM careers
- Confidence interpreting real data

Instructor Note: Collect both for comparison or grant reporting.

Student Worksheets & Logs Overview

Each worksheet/log includes:

- Guided questions about observed temperature/light patterns
- Tables for recording multiple readings
- Simple visual or numerical comparisons

Instructor Tips:

- Encourage drawing or coloring for younger grades
- Upper grades can graph trends or complete simple calculations

Video Demonstration Overview

The video includes:

- Close-up footage of both sensors in action
- Visual scan of healthy vs. stressed plants
- On-screen interpretation of results

Instructor Notes:

- Pause to discuss how thermal "hot spots" or reflectance levels relate to plant health
- Replay key segments if needed for comparison with student data

Instructor Tips

- Choose samples that show **contrast**—e.g., one wilted and one healthy plant.
- Shade vs. sunlight provides excellent thermal comparison.
- Connect to careers: agronomist, drone technician, remote sensing analyst.
- For lower grades, simplify to "hot/cold" or "bright/dark."
- Encourage student curiosity—"What would this sensor show on a watermelon? Or soil?"

Optional Extensions

- **Graphing Project:** Use log data to build simple bar graphs or line plots.
- **NDVI Math Activity:** Introduce the formula using red/NIR reflectance.
- **Career Exploration Prompt:** "What job might use this tool every day?"

Summary

The **Multi-Spectrometer & Thermal Sensor AgSTEM Kit** connects science, technology, and agriculture in a meaningful, hands-on way. From simple temperature readings to advanced NDVI analysis, students of all ages can experience how modern tools are making farms more efficient, productive, and sustainable.

Table of Contents

Pre-Presentation Survey: "Light and Farming!" (2^{nd}–3^{rd} Grade)
Name: ______________________ Date: ______________________

1. Have you ever heard of light helping plants grow?
☐ Yes ☐ No ☐ Not sure

2. What do you think light can help with on a farm? (Check all that you think are true!)
☐ Make plants grow
☐ Help plants sleep
☐ Take farm pictures
☐ Cook food

3. Which of these sounds like a real job?
☐ Engineer
☐ Remote Sensing Specialist
☐ Superhero
☐ Drone Operator

4. Would you like to learn more about how farmers use light?
☐ Yes ☐ Maybe ☐ No

Post-Presentation Survey: "Light and Farming!" (2nd–3rd Grade)

Name: _________________________ Date: _________________________

1. What is one way farmers use light to help plants?

____

____

____

2. What color light helps plants grow strong roots?

☐ Red ☐ Blue ☐ Green ☐ Rainbow

3. Which job sounds the most fun to you?

☐ Engineer
☐ Drone Operator
☐ Data Scientist
☐ Something else: _______________

4. What would you like to learn more about?

____

____

____

Pre-Presentation Survey: "Exploring Light and Farming" (4th–5th Grade)

Name: ________________________ Date: ________________________

1. Have you ever learned about how light helps plants grow?
☐ Yes ☐ No ☐ Not sure

2. What do you think light is used for on a farm? (Check all that apply.)
☐ Helps plants grow
☐ Cooks food
☐ Takes pictures
☐ Makes the soil warm

3. Which of these careers have you heard of or want to learn more about?
☐ Agriculture Engineer
☐ Drone Operator
☐ Plant Scientist
☐ Remote Sensing Specialist

4. What is one question you have about how farmers use light?

___

___

___

Post-Presentation Survey: "Exploring Light and Farming" (4th–5th Grade)

Name: ________________________ Date: ________________________

1. What is one thing you learned about light and farming today?

___

___

___

2. Which color of light helps plants grow strong stems?

☐ Red ☐ Blue ☐ Yellow ☐ White

3. Which job from the presentation did you find the most interesting?

☐ Agriculture Engineer
☐ Drone Operator
☐ Plant Scientist
☐ Environmental Scientist

4. What would you like to learn more about next?

___

___

___

Pre-Presentation Survey: "Exploring Light and Farming" (6^{th}–8^{th} Grade)

Name: _________________________ Date: _________________________

1. Have you ever studied how light affects plant growth?

☐ Yes ☐ No ☐ Not sure

2. What do you think light technology can do on a farm? (Check all that apply.)

☐ Help plants grow
☐ Collect data from fields
☐ Make soil disappear
☐ Help identify crop health

3. Which of these careers have you heard of or are curious about?

☐ Agricultural Engineer
☐ Remote Sensing Specialist
☐ Data Scientist
☐ Drone Operator/Technician

4. What is one thing you hope to learn during this presentation?

____

____

____

Post-Presentation Survey: "Exploring Light and Farming" (6th–8th Grade)

Name: ________________________ Date: ________________________

1. What is one new thing you learned about the electromagnetic spectrum in agriculture?

2. Which color of light helps with strong root development in plants?
☐ Red ☐ Blue ☐ Green ☐ Yellow

3. Which career discussed today do you think uses the most data?
☐ Environmental Scientist
☐ Drone Operator
☐ Data Scientist
☐ Agricultural Engineer

4. What part of light technology in farming did you find most interesting?

Pre-Presentation Survey: "Energy, Sensors, and Agriculture" (9^{th}–12^{th} Grade)

Name: ________________________ Date: ________________________

1. Have you learned about the electromagnetic spectrum before?

☐ Yes ☐ No ☐ Not sure

2. Which uses of energy in agriculture are you already familiar with? (Check all that apply.)

☐ Photosynthesis
☐ Infrared imaging
☐ Drone mapping
☐ I'm not familiar with any of these

3. What do you hope to learn about during this presentation?

____

____

____

4. Which of the following careers are you interested in learning more about?

☐ Agricultural Engineer
☐ Remote Sensing Specialist
☐ Data Scientist
☐ Drone Operator
☐ Environmental Scientist

5. How confident are you in explaining how energy and sensors help modern farmers?

☐ Very confident
☐ Somewhat confident
☐ Not confident

Post-Presentation Survey: "Energy, Sensors, and Agriculture" (9th–12th Grade)

Name: __________________________ Date: __________________________

1. What is one new concept you learned about the electromagnetic spectrum?

2. How can multispectral or thermal sensors support farming practices?

3. Which career pathway presented stood out to you the most and why?

4. What other field besides agriculture might benefit from similar sensor technology?

Pre-Presentation Survey: "Energy and Agriculture Technology" (Community College)

Name: ________________________ Date: ________________________

1. How familiar are you with the electromagnetic spectrum?
☐ Very familiar
☐ Somewhat familiar
☐ Not familiar at all

2. What role do you think visible light plays in agriculture?

____

____

____

3. Which of the following technologies have you heard of or used? (Check all that apply.)
☐ Thermal sensors
☐ Multispectral cameras
☐ Soil moisture sensors
☐ None of the above

4. What are you most interested in learning from this presentation?

____

____

____

Post-Presentation Survey: "Energy and Agriculture Technology" (Community College)

Name: ________________________ Date: ________________________

1. What is one concept you learned about the electromagnetic spectrum?

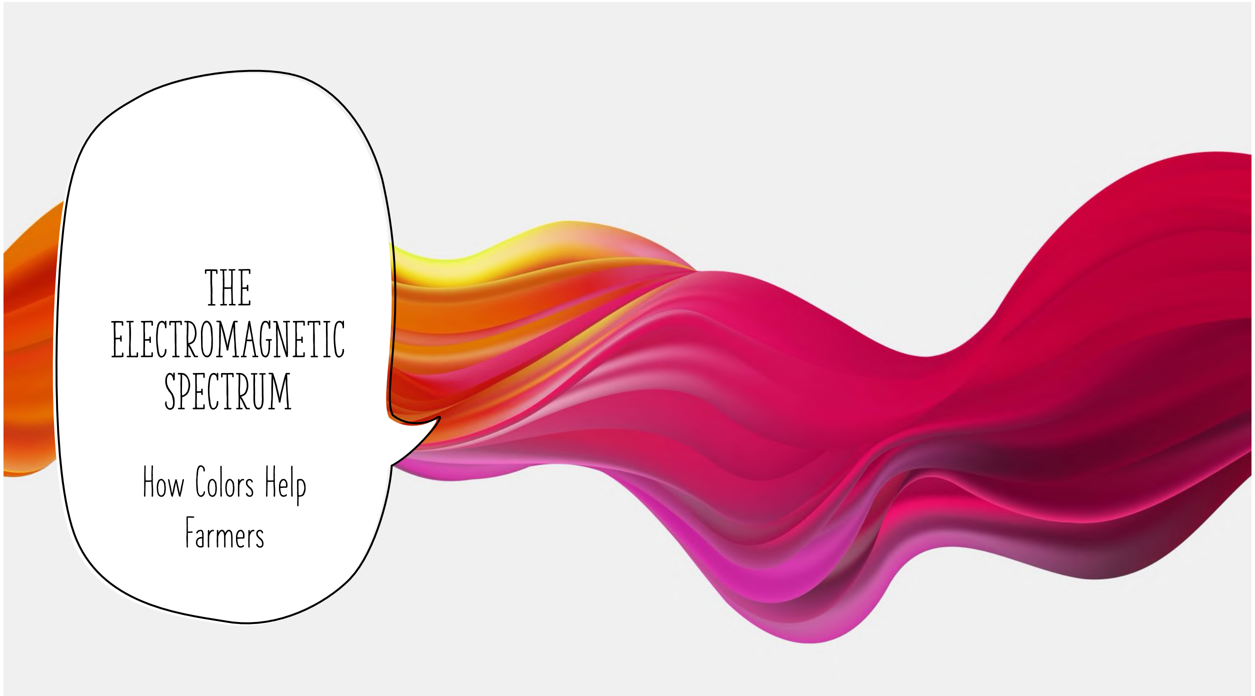
2. How can multispectral or thermal sensors support decision-making in agriculture?

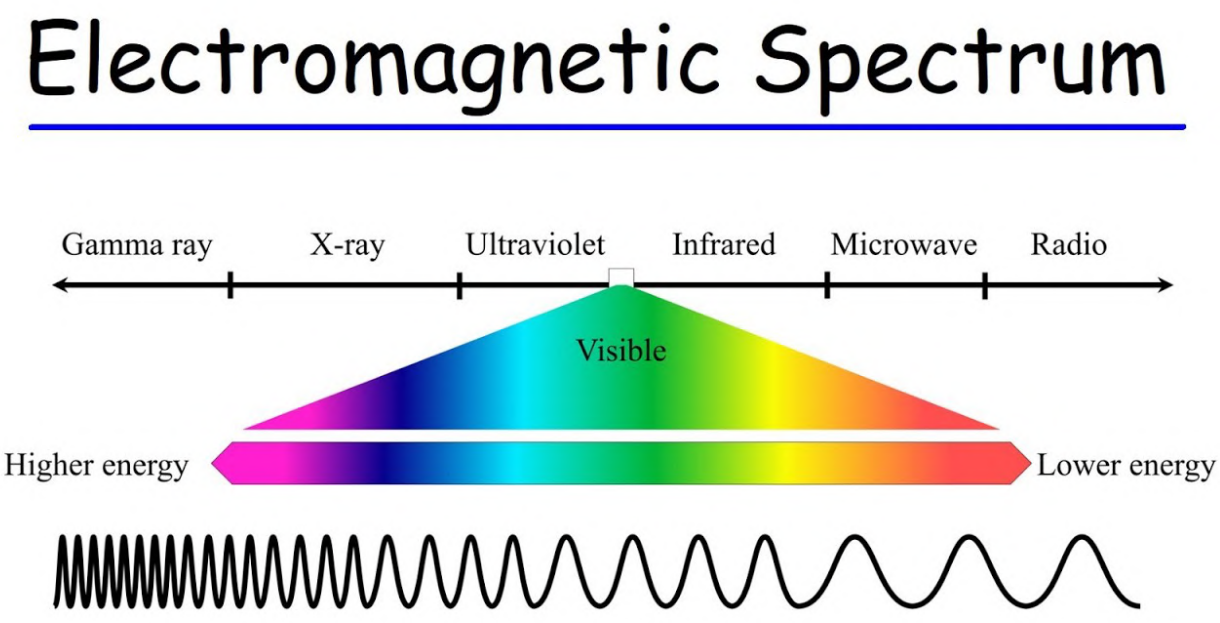
3. How has your understanding of wavelength and frequency changed after this presentation?

4. Do you see yourself using or working with sensor-based agricultural technologies in your career?

☐ Yes
☐ Maybe
☐ No

Presentation 2nd–3rd Grade





NOTES: The electromagnetic spectrum is like a big rainbow of different types of light energy. Some of this light we can see, and some we can't!

<u>The Color Spectrum</u>

The part of the spectrum we can see is called the color spectrum.
It includes all the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet.

NOTES: Plants need light to grow. They use a process called photosynthesis.
Different colors of light help plants in different ways!

NOTES: Red light helps plants grow tall and strong.
Farmers use red lights in greenhouses to help their plants grow better.

NOTES: Blue light helps plants grow more leaves.
It makes plants bushy and healthy.

NOTES: Infrared light is a type of light we can't see.
Farmers use special cameras to see infrared light to check if plants are healthy.

NOTES: Coaling College uses the Amiga robot with an infrared camera to take pictures of the plants we grow.

NOTES: Farmers use different types of light to help their plants grow better. This helps us get more food from the farms!

Careers in Energy, Sensors, & Agriculture

Engineer

Builds new farm machines.

Remote Sensing Specialist

Uses computers to figure out what farms need.

Data Scientist

Checks farm temperatures to help plants grow.

Environmental Scientist

Helps farmers keep plants healthy.

Drone Operator

Uses flying robots to look at farms.

SUMMARY

Light is very important for plants.

Different colors of light help plants in different ways.

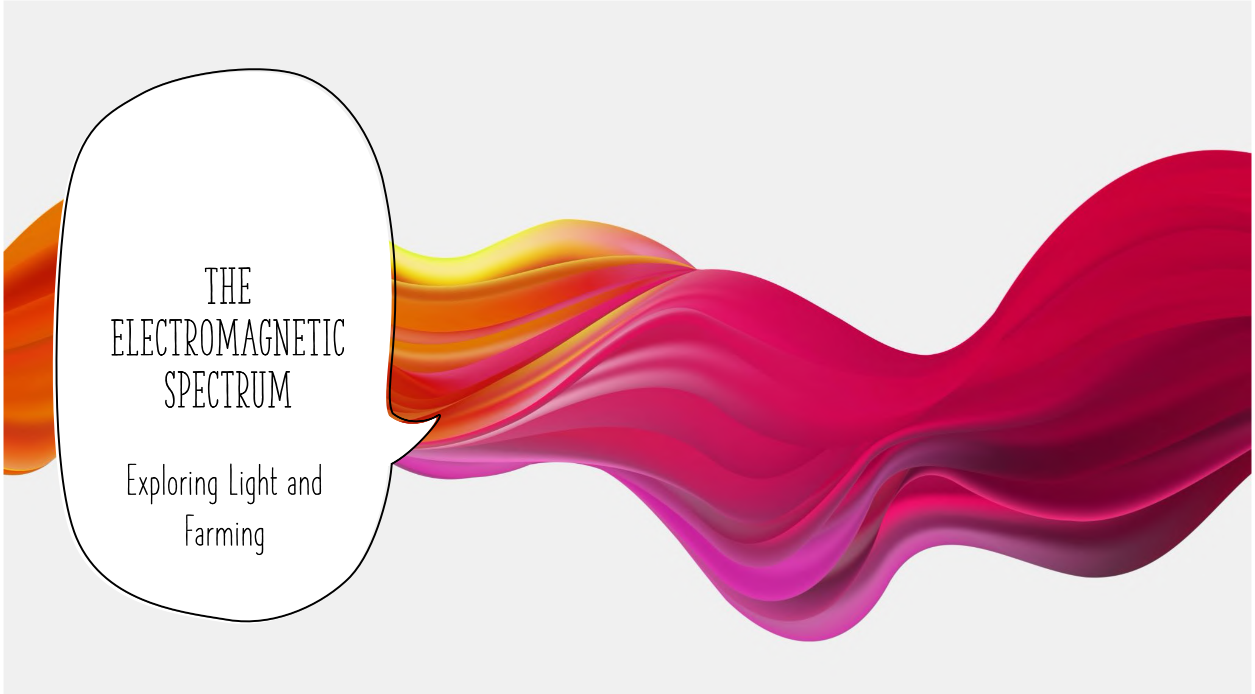
Farmers use light technology to grow healthy plants and get more food.

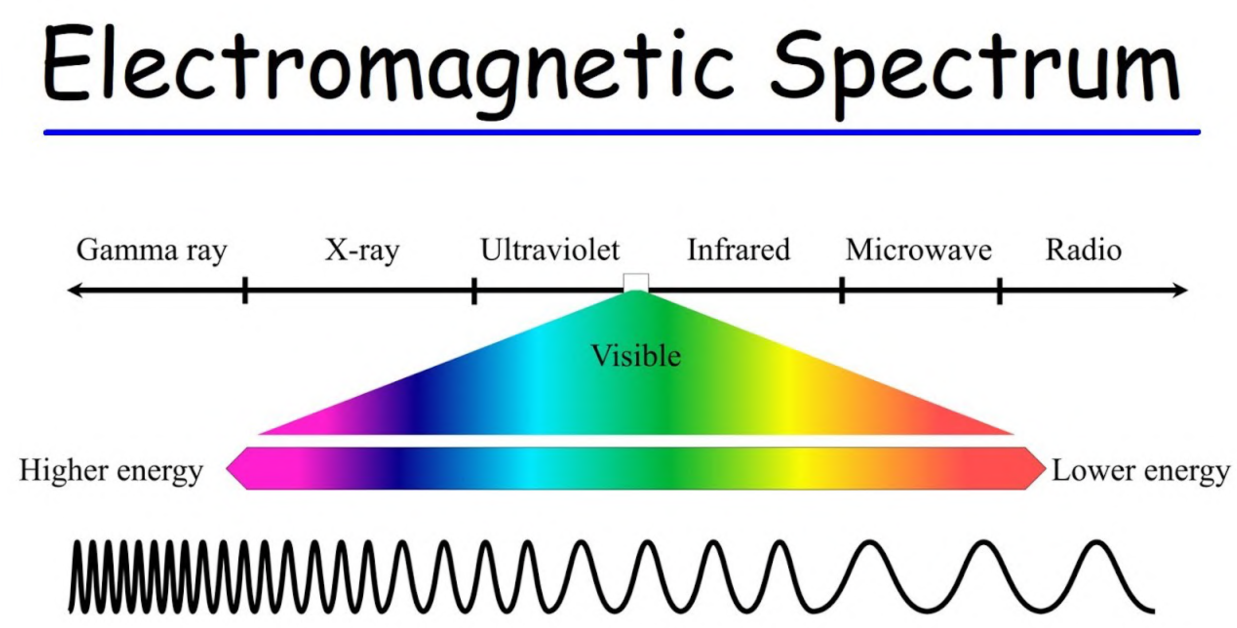
THANK YOU!

THANK YOU FOR LEARNING ABOUT THE ELECTROMAGNETIC SPECTRUM AND HOW IT HELPS FARMERS!

DO YOU HAVE ANY QUESTIONS?

Presentation 4th–5th Grade



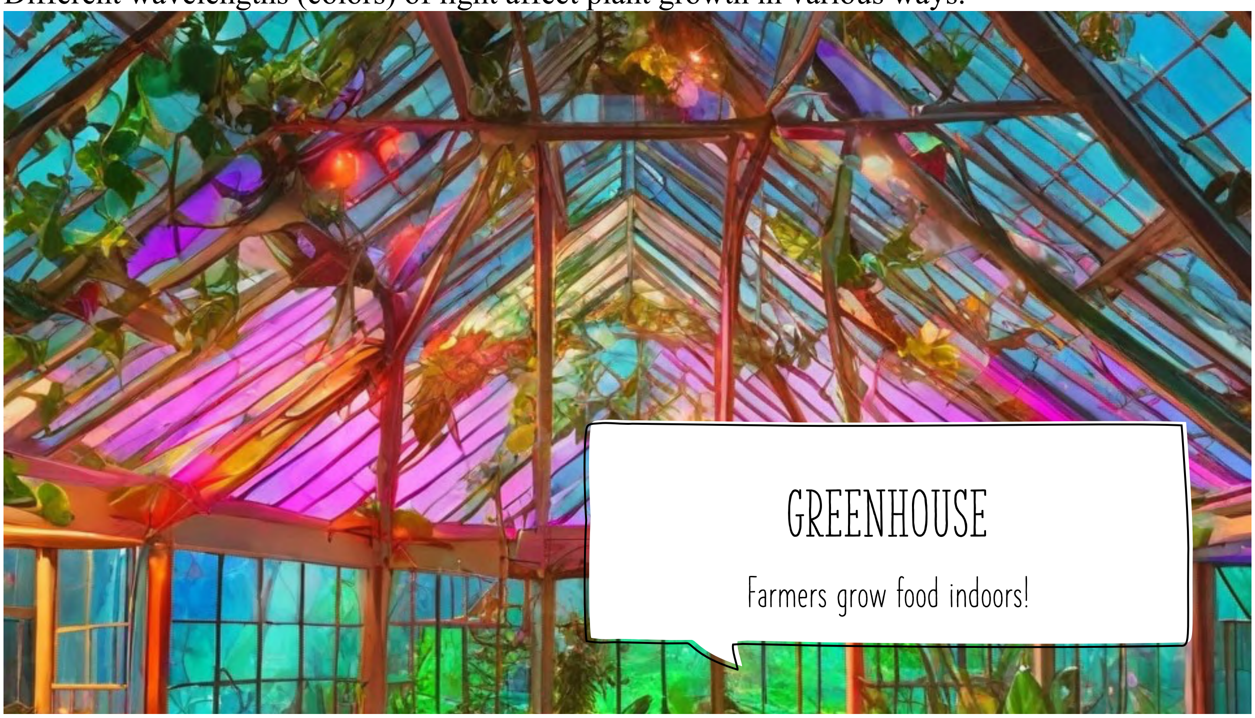


NOTES: The electromagnetic spectrum includes all kinds of electromagnetic waves.
It goes from very short gamma rays to very long radio waves.
Visible light is a small part of this spectrum.

The Visible Light Spectrum

The visible light spectrum is the part of the electromagnetic spectrum that humans can see.
It includes all the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet (ROYGBIV).

NOTES: Plants use light for photosynthesis to create food by turning light into sugar for energy. Different wavelengths (colors) of light affect plant growth in various ways.



NOTES: Red light (620-750 nm) helps plants make flowers and fruit.
It is used in places like greenhouses to help plants grow better.

NOTES: Blue light (450-495 nm) helps plants grow strong and healthy leaves.
It is very important for young plants and seedlings.

NOTES: Ultraviolet light (10 nm - 400 nm) is also invisible to us.
UV light can help get rid of plant diseases and pests.
It can also make plants stronger against these problems.

NOTES: Infrared light (700 nm - 1 mm) can't be seen by our eyes but can be felt as heat. Farmers use infrared cameras to check plant health by seeing heat patterns. These patterns show if plants need water or are sick.

NOTES: Coaling College uses the Amiga robot with an infrared camera to take pictures of the plants we grow.

NOTES: Farmers use light sensors and drones to collect information about how healthy and how much their crops are growing.
This information helps them water, fertilize, and harvest the crops better.

NOTES: Plants grow bigger and produce more food.
Better control of pests and diseases.
Using resources like water and fertilizers more efficiently.

Careers in Energy, Sensors, & Agriculture

Agriculture Engineer

Makes smart machines for farms.

Remote Sensing Specialist

Uses computers to figure out what farms need.

Plant Scientist

Studies how plants grow with light and water.

Environmental Scientist

Checks if the soil has what plants need.

Drone Operator

Flies drones to take pictures of plants and soil.

SUMMARY

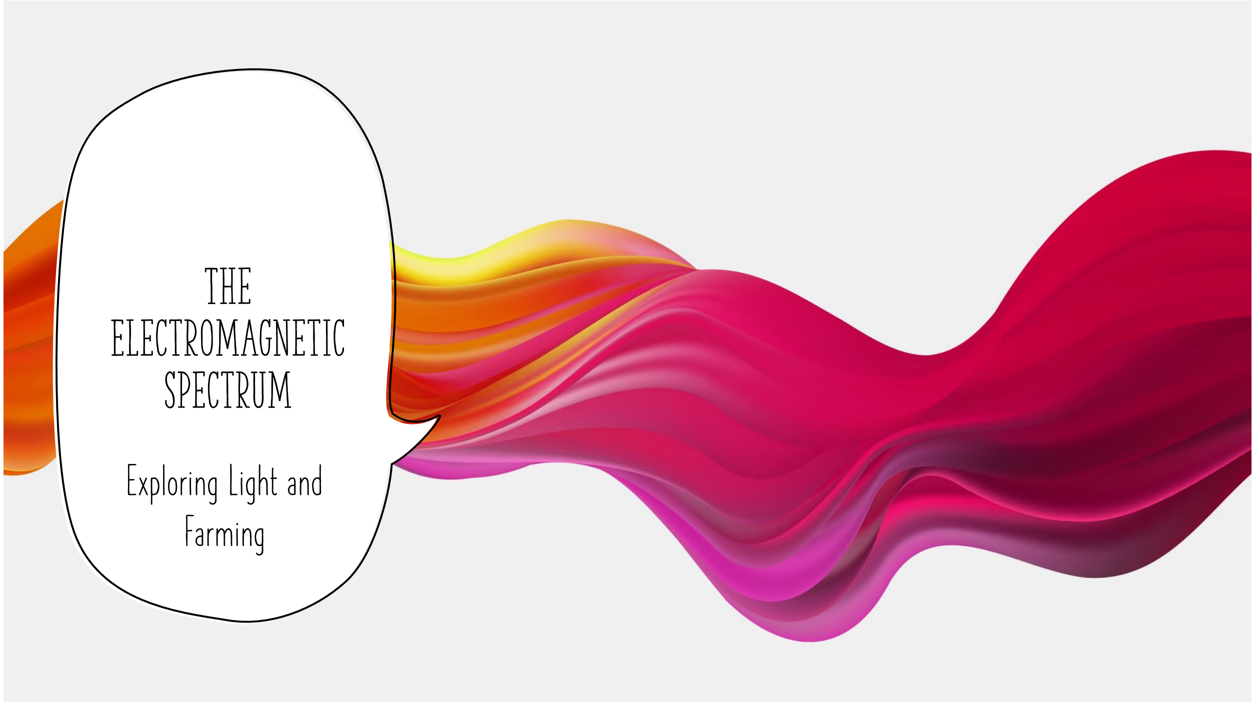
- The electromagnetic spectrum includes many types of light, some of which are visible.
- Different colors of light affect plant growth differently.
- Farmers use light technology to improve crop production and sustainability.

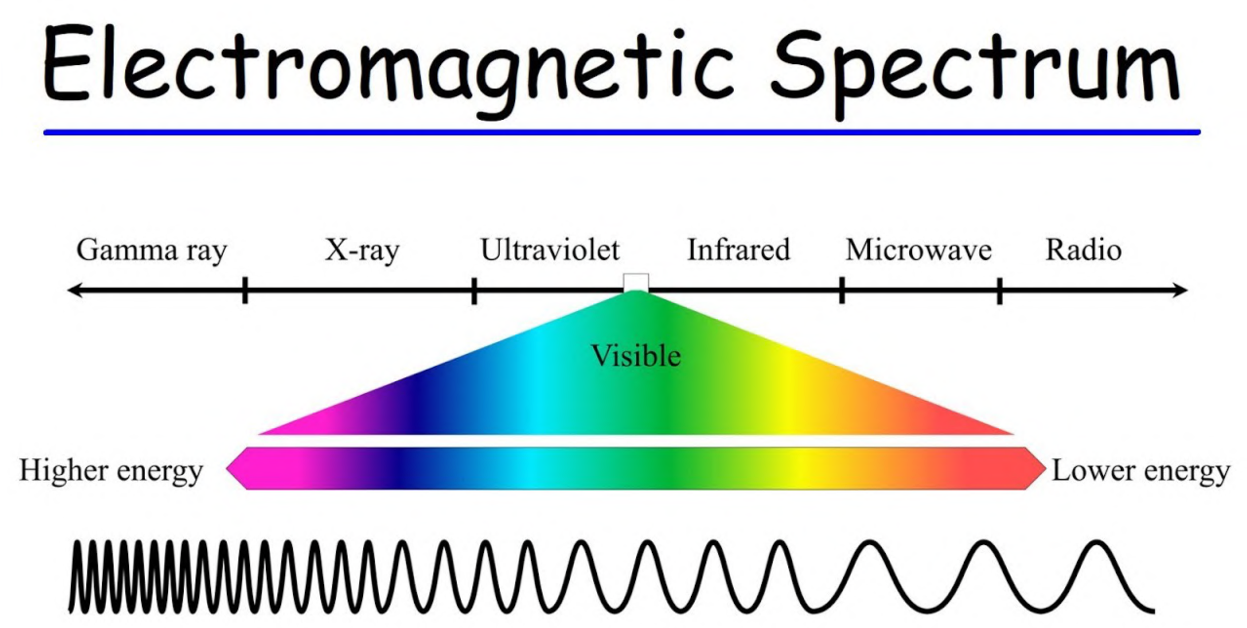
THANK YOU!

THANK YOU FOR LEARNING ABOUT THE ELECTROMAGNETIC SPECTRUM AND AGRICULTURE

DO YOU HAVE ANY QUESTIONS?

Presentation 6th–8th Grade





NOTES: The electromagnetic spectrum includes all types of electromagnetic radiation.
It ranges from very short gamma rays to very long radio waves.
Visible light is a small part of this spectrum.

<u>The Visible Light Spectrum</u>

The part of The visible light spectrum is the part of the electromagnetic spectrum that humans can see.

It includes all the colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet (ROYGBIV).

NOTES: Plants use light for photosynthesis to create food by turning light into sugar for energy. Different wavelengths (colors) of light affect plant growth in various ways.

NOTES: Red light (620-750 nm) promotes flowering and fruit production in plants.
It is used in controlled environments like greenhouses to enhance plant growth.

NOTES: Blue light (450-495 nm) encourages vegetative growth and strong, healthy leaves.
It is crucial for young plants and seedlings.

NOTES: Ultraviolet light (10 nm - 400 nm) is also invisible to us.
UV light can help control plant pathogens and pests.
It can also stimulate plant defense mechanisms.

NOTES: Infrared light (700 nm - 1 mm) is not visible to the human eye but can be felt as heat. Infrared cameras help farmers monitor plant health by detecting heat patterns, which indicate water stress and disease.

NOTES: Coaling College uses the Amiga robot with an infrared camera to take pictures of the plants we grow.

NOTES: Farmers use light sensors and drones to gather data on crop health and growth. This information helps optimize irrigation, fertilization, and harvesting.

NOTES: Enhanced plant growth and yield.
Better pest and disease control.
More efficient use of resources like water and fertilizers.

Careers in Energy, Sensors, & Agriculture

Agricultural Engineer

Designs innovative farming technology including sensor systems and irrigation solutions. Requires strong problem-solving skills and understanding of both engineering principles and agricultural needs.

Remote Sensing Specialist

Collects and interprets data from satellites and drones to create actionable insights for farmers. Combines knowledge of geospatial technology with agricultural science.

Data Scientist

Transforms raw sensor data into meaningful insights through advanced analytics and machine learning algorithms that help farmers make better decisions.

Environmental Scientist

Studies how electromagnetic energy interacts with ecosystems and helps develop sustainable farming practices based on sensor data.

Drone Operator/Technician

Pilots agricultural drones and maintains sensor equipment, requiring technical skills and knowledge of aviation regulations.

SUMMARY

- The electromagnetic spectrum includes many types of light, some of which are visible.
- Different colors of light affect plant growth differently.
- Farmers use light technology to improve crop production and sustainability.

THANK YOU!

THANK YOU FOR LEARNING ABOUT THE ELECTROMAGNETIC SPECTRUM AND AGRICULTURE

DO YOU HAVE ANY QUESTIONS?

Presentation 9th–12th Grade

Exploring Energy: The Electromagnetic Spectrum & Agriculture

How Light and Sensors Help Farmers

Welcome to an exciting journey through the invisible forces that power our world and how modern farmers are harnessing these energies to revolutionize agriculture. Together, we'll discover how the same electromagnetic energy that powers our devices also helps grow our food more efficiently.

Learning Objectives

1. **Understand the Electromagnetic Spectrum**

   Explore the different types of energy waves that surround us every day and how they influence our world.

2. **Learn the Relationship Between Wavelength and Frequency**

   Discover how these two properties of electromagnetic waves are connected and why this matters.

3. **Explore How Sensors Use Energy to Help Farmers**

   Investigate the practical applications of electromagnetic energy in modern precision agriculture.

How Do We Use Energy Every Day?

Powering Our Lives

Electricity flows through our homes and schools, providing light, heat, and power for countless devices.

Cooking and Communication

Microwaves use electromagnetic waves to cook food, while cell phones use radio waves to connect us globally.

Natural Growth

Plants harness the sun's energy through photosynthesis—converting light into the food energy they need to grow!

What is the Electromagnetic Spectrum?

The electromagnetic spectrum encompasses the complete range of all types of electromagnetic radiation—energy that travels in waves.

High Energy, Short Wavelength

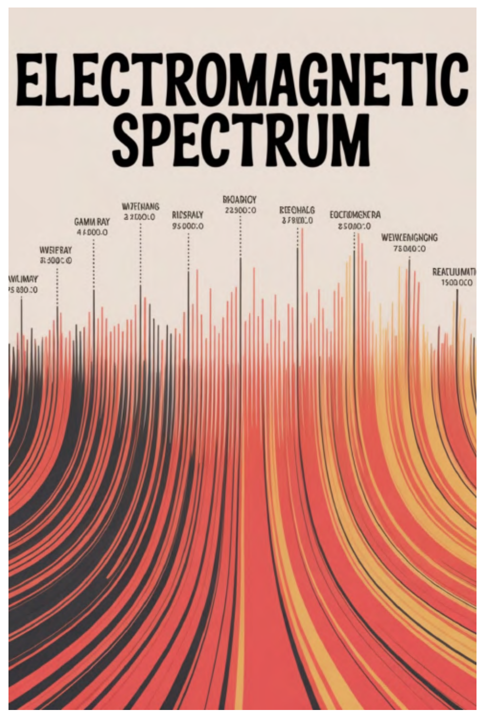
- Gamma rays
- X-rays
- Ultraviolet (UV)

Visible Light

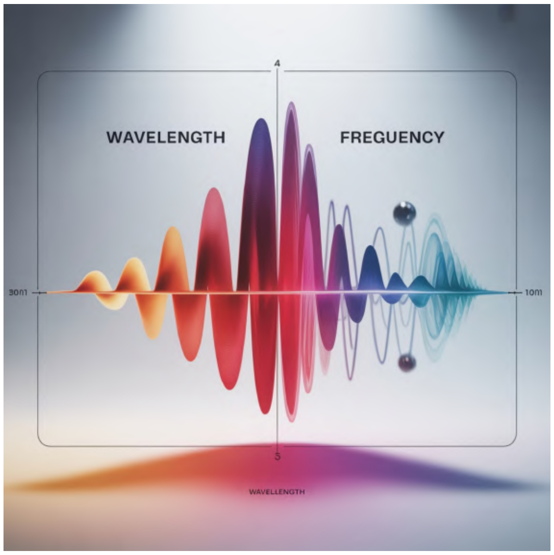
The tiny portion of the spectrum we can see with our eyes.

Low Energy, Long Wavelength

- Infrared (IR)
- Microwaves
- Radio waves



Wavelength & Frequency



Key Concepts

Wavelength

The distance between consecutive crests or troughs in a wave, measured in meters.

Frequency

The number of complete wave cycles passing a point per second, measured in Hertz (Hz).

Inverse Relationship

As wavelength **increases**, frequency **decreases** and vice versa. This relationship is described by the equation:

$$c = \lambda \times f$$

where c is the speed of light, **λ** (lambda) is wavelength, and f is frequency.

The Visible Light Spectrum

Red Longest visible wavelength (700nm)	Orange Wavelength ~620nm	Yellow Wavelength ~580nm
Green Wavelength ~530nm	Blue Wavelength ~470nm	Indigo Wavelength ~450nm

Violet
Shortest visible wavelength (400nm)

Plants primarily absorb red and blue light for photosynthesis, reflecting green light—that's why most plants appear green to our eyes!

Energy and Agriculture

Visible Light

- Drives photosynthesis in plants
- Different wavelengths affect plant growth differently
- Enables visual inspection of crops

Infrared Light

- Reveals plant health before visible symptoms appear
- Helps calculate vegetation indices like NDVI
- Shows water stress in crops

Thermal Energy

- Detects temperature variations across fields
- Identifies irrigation issues
- Helps monitor soil health

By capturing and analyzing different types of energy, farmers can make more informed decisions about their crops.

Introduction to Multispectral Sensors

What Are They?

Multispectral sensors capture data from several specific bands of the electromagnetic spectrum simultaneously, beyond what human eyes can see.

How They Work

These sensors use special filters to isolate different wavelengths, creating separate images for each spectral band. When combined, they reveal information invisible to the naked eye.

Agriculture Applications

Mounted on drones, planes, or satellites, these sensors help farmers monitor large areas efficiently, detecting subtle changes in plant health and field conditions.

A drone equipped with a multispectral camera can capture visible light, near-infrared, and

How Sensors Help Farmers

Early Stress Detection

Sensors can identify plant stress up to 10 days before symptoms become visible to the human eye, allowing for prompt intervention before crop damage occurs.

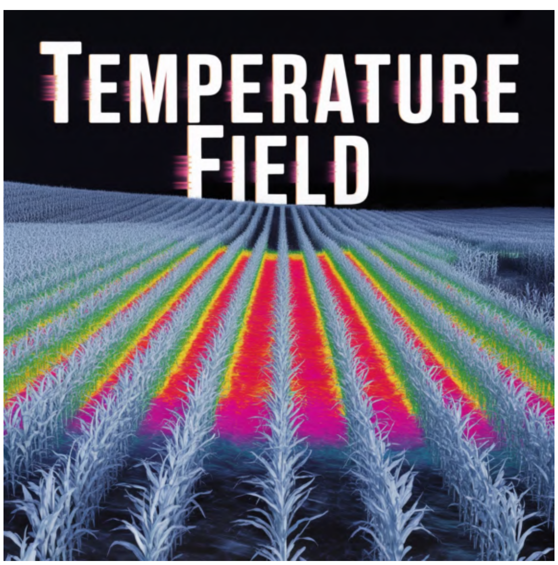
Water Management

By monitoring soil moisture levels across fields, sensors help farmers optimize irrigation, reducing water usage by up to 30% while maintaining or improving crop yields.

Pest and Disease Mapping

Sensors detect the subtle signatures of pest damage or disease spread, enabling targeted treatment instead of blanket application of pesticides, saving money and reducing environmental impact.

Thermal Sensors in Agriculture



The Power of Heat Mapping

Thermal sensors detect infrared radiation emitted by objects, creating detailed temperature maps of agricultural fields.

Irrigation Management

Cooler areas (blue in thermal images) often indicate excess moisture, while warmer areas (red) may show drought stress, helping farmers target irrigation precisely.

Equipment Monitoring

Thermal sensors can detect overheating in farm equipment before mechanical failures occur, preventing costly breakdowns during critical harvest periods.

Livestock Monitoring

These sensors can identify changes in animal body temperatures, potentially detecting illness before visible symptoms appear.

Real-World Applications

Precision Agriculture in Action

1. Data Collection

   Drones equipped with multispectral sensors fly over fields, collecting data across different wavelengths. Satellites provide additional broad-scale monitoring.

2. Data Analysis

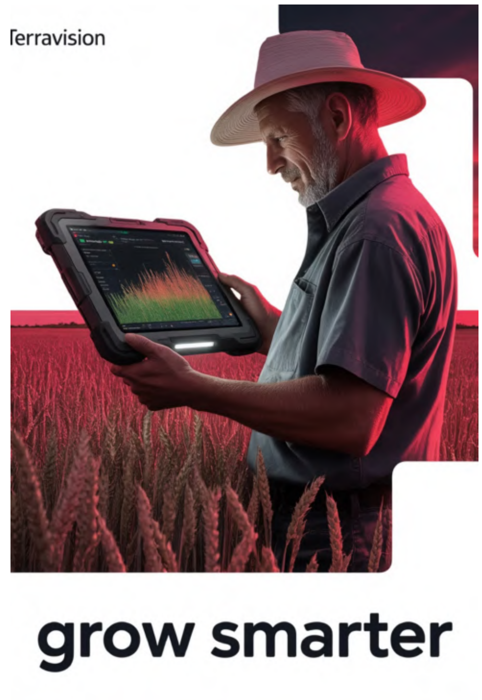
   Software processes sensor data to create detailed maps of crop health, soil moisture, and other variables, highlighting areas that need attention.

3. Targeted Action

   Farmers apply water, fertilizer, or pest control precisely where needed, using variable-rate technology guided by sensor data.

4. Results

   Studies show precision agriculture can increase yields by 10-15% while reducing water usage by 20-30% and fertilizer application by up to 40%.



Careers in Energy, Sensors, & Agriculture

Agricultural Engineer

Designs innovative farming technology including sensor systems and irrigation solutions. Requires strong problem-solving skills and understanding of both engineering principles and agricultural needs.

Remote Sensing Specialist

Collects and interprets data from satellites and drones to create actionable insights for farmers. Combines knowledge of geospatial technology with agricultural science.

Data Scientist

Transforms raw sensor data into meaningful insights through advanced analytics and machine learning algorithms that help farmers make better decisions.

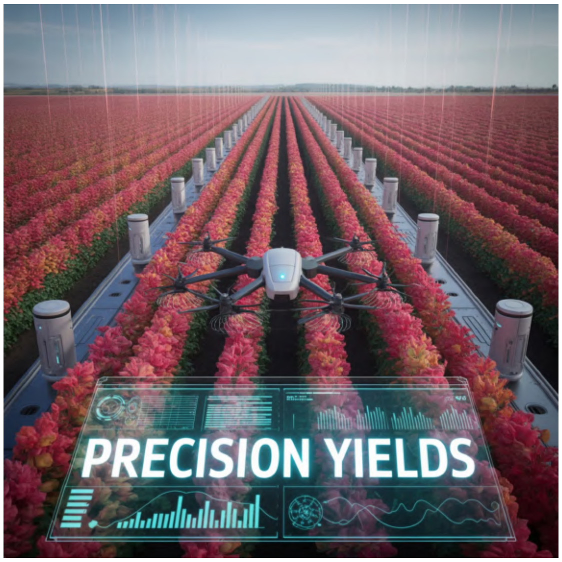
Environmental Scientist

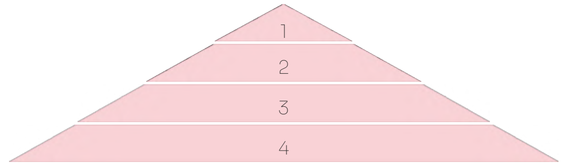
Studies how electromagnetic energy interacts with ecosystems and helps develop sustainable farming practices based on sensor data.

Drone Operator/Technician

Pilots agricultural drones and maintains sensor equipment, requiring technical skills and knowledge of aviation regulations.

Conclusion & Key Takeaways





1. Energy Is Everywhere
2. Wavelength & Frequency
3. Sensor Technology
4. Agricultural Applications

The electromagnetic spectrum powers our everyday lives in countless ways, from the visible light we see to the invisible waves that fuel modern technology.

Understanding the relationship between wavelength and frequency helps explain how different types of energy interact with our world.

By harnessing multiple parts of the spectrum through advanced sensors, we're revolutionizing agriculture—making farming more efficient, sustainable, and productive than ever before.

Discussion & Reflection

1 — Future of Farming

How might farming change with more advanced energy sensors? What new possibilities could emerge as sensor technology continues to improve?

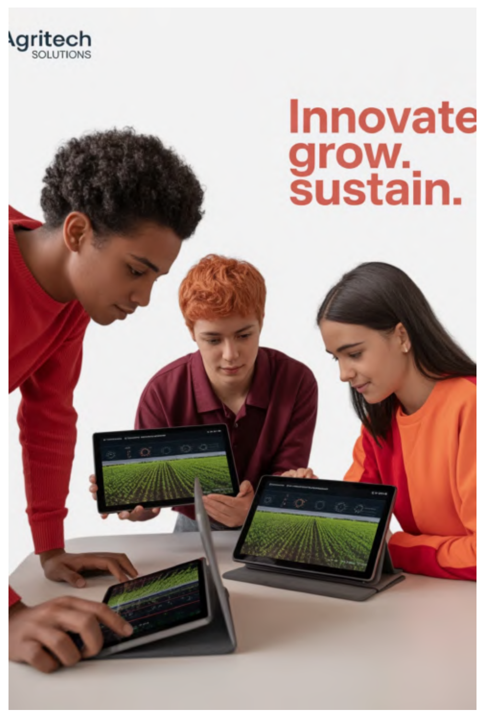
2 — Cross-Industry Applications

What other industries might benefit from the same types of sensors used in agriculture? How might the technology be adapted for different purposes?

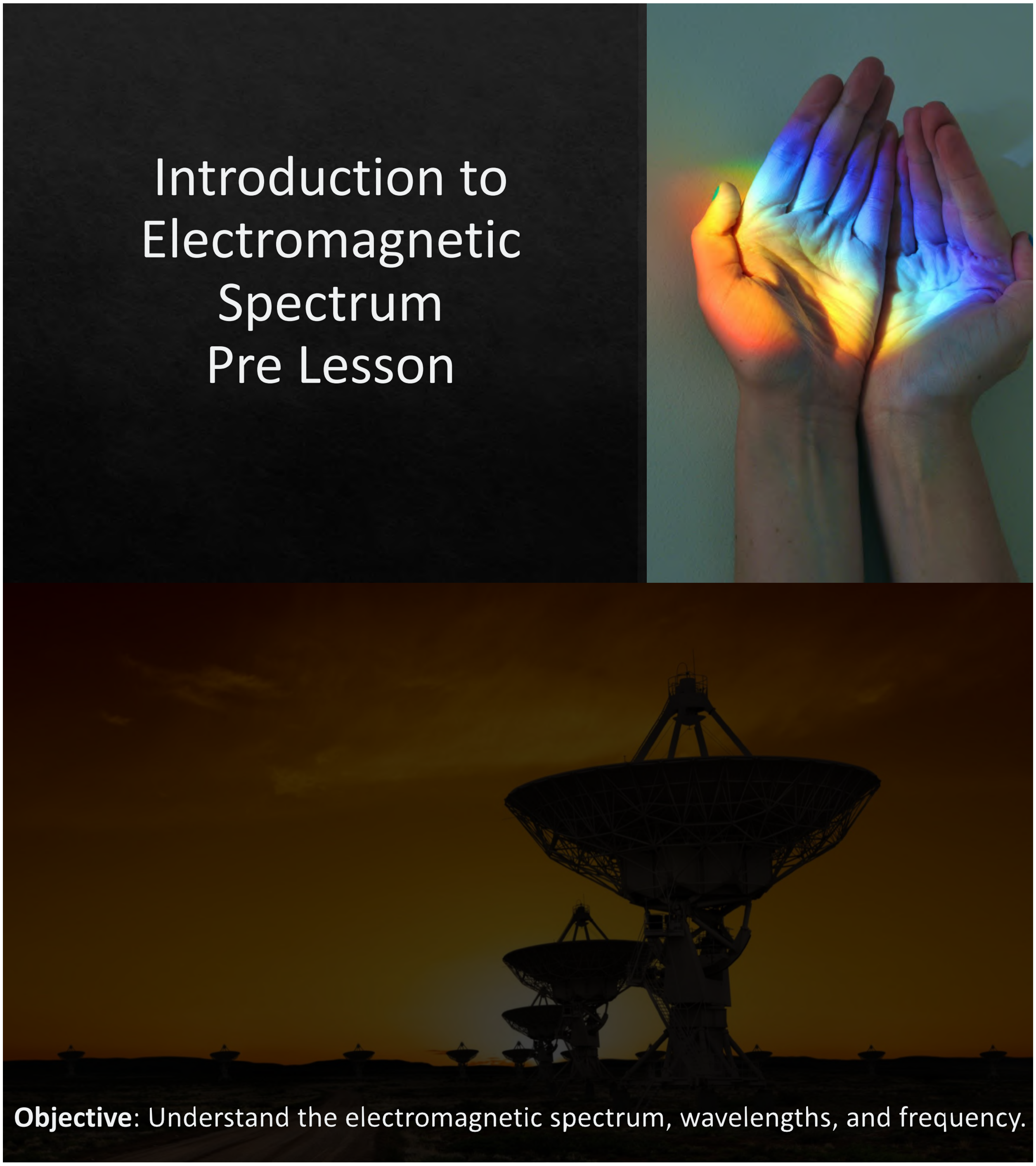
3 — Personal Connection

How does the food on your plate connect to the electromagnetic spectrum and sensor technology we've discussed today?

Take a few minutes to discuss these questions in small groups, then we'll share ideas as a class. Consider how these technologies might influence your own future career possibilities.

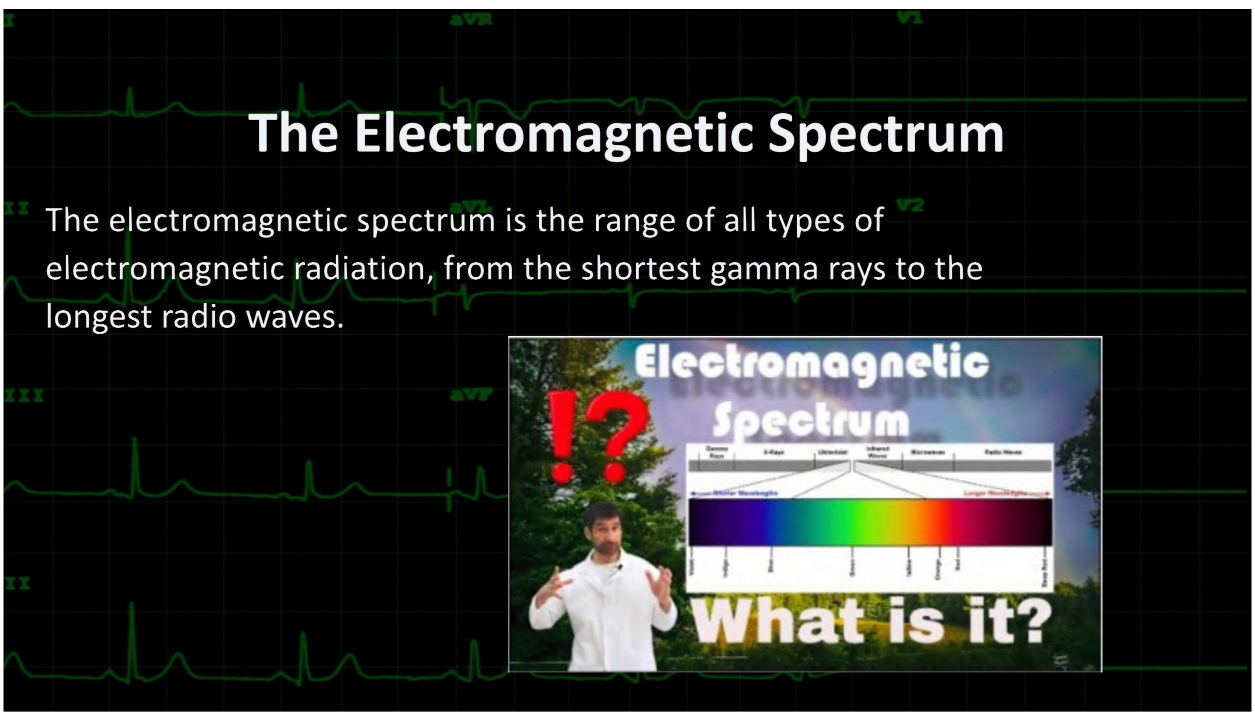


Presentation Community College

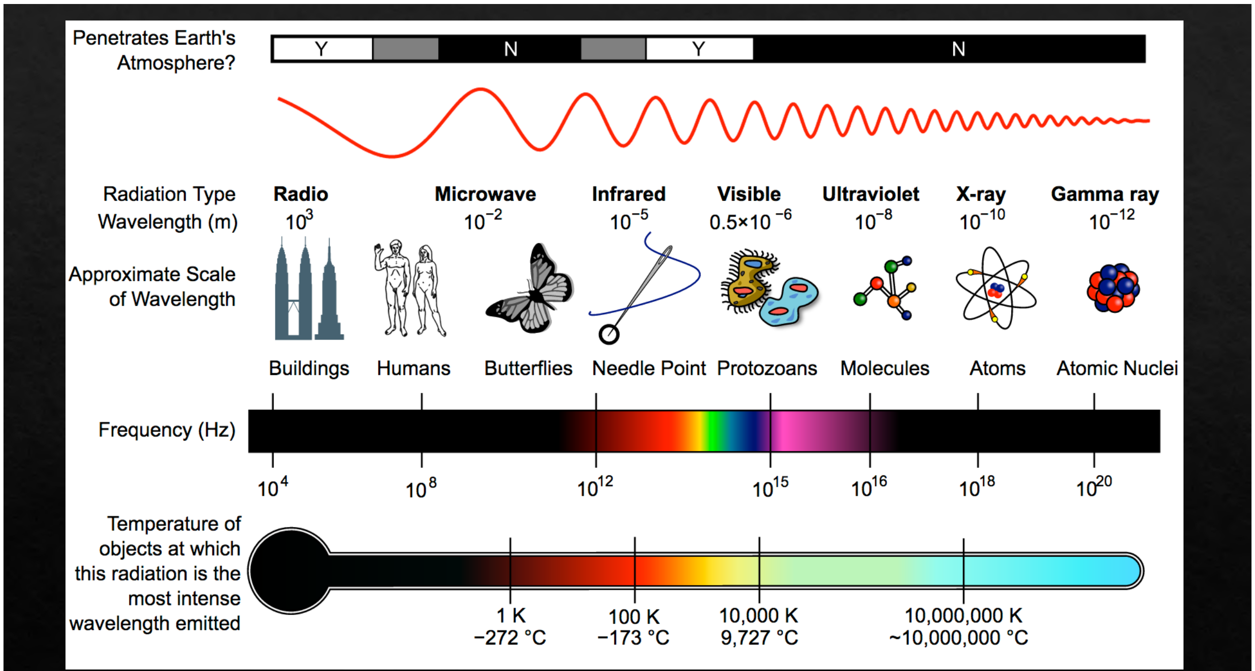


NOTES: Provide a brief overview of the lesson's objectives and outline the topics that will be addressed by both the home campus instructor and the instructors from West Hills College.

NOTES: Ask students to brainstorm ways they use energy daily.



NOTES: Play video full screen for a discussion on the different waves in the electromagnetic spectrum.



Electromagnetic spectrum. (2023, September 7). In *Wikipedia*. https://en.wikipedia.org/wiki/Electromagnetic_spectrum

NOTES: Discuss wavelength and frequency:

Wavelength:

- **Definition**: Wavelength (λ) is the distance between two consecutive points that are in phase (typically peaks or troughs) on a wave. In other words, it's the length of one complete cycle of the wave.
- **Units**: Wavelength is typically measured in meters (m) or other units of length, depending on the scale of the wave.
- **Relation to Wave Shape**: In a sine wave, which is a simple, periodic waveform, the wavelength is the distance between two consecutive peaks or troughs.

Role in Wave Characteristics: Wavelength is crucial in determining the type of wave and how it interacts with its environment. For example, in electromagnetic waves, different wavelengths correspond to different colors of light, and in sound waves, different wavelengths correspond to different pitches (frequencies) of sound.

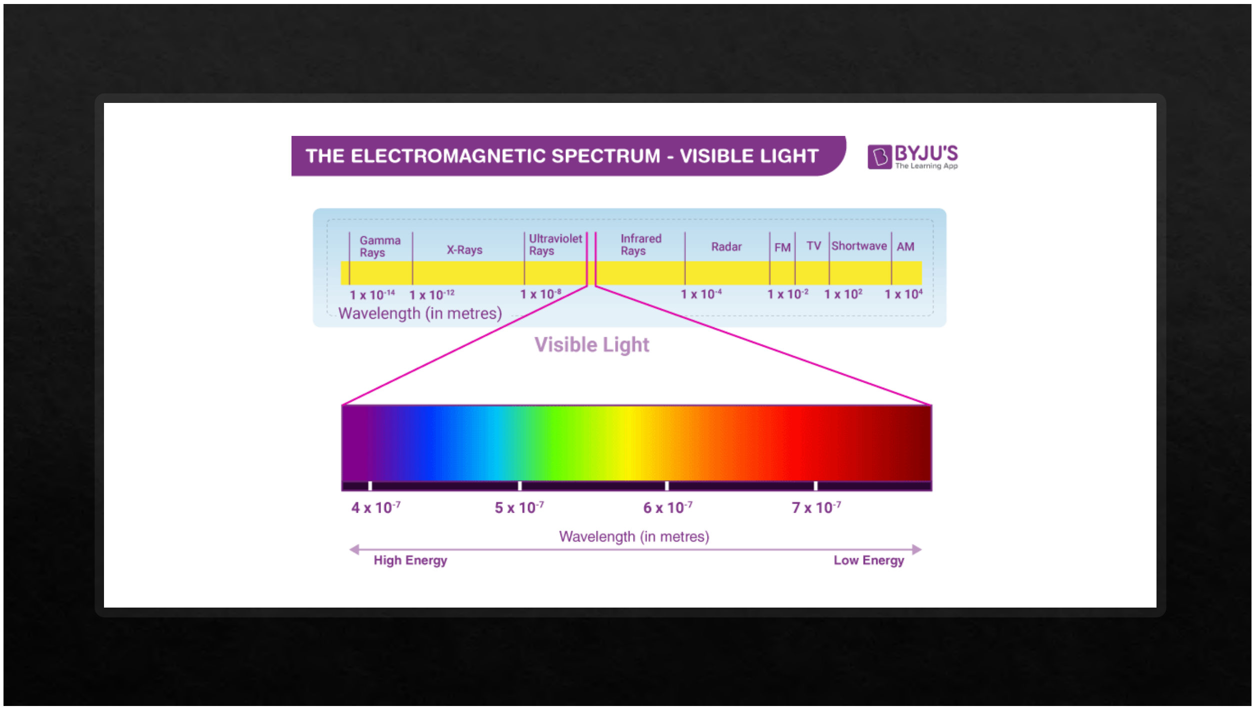
Frequency:

- **Definition**: Frequency (f) is the number of complete cycles (oscillations or vibrations) of a wave that occur in one second. It represents how many waves pass a fixed point in a given amount of time.
- **Units**: Frequency is measured in Hertz (Hz), where 1 Hz equals one cycle per second.
- **Relation to Wave Shape**: In a sine wave, frequency is related to the number of cycles that occur in one second. The higher the frequency, the more cycles occur in the same time frame.
- **Role in Wave Characteristics**: Frequency determines the pitch of sound waves and the color of light waves. In general, higher frequencies are associated with higher-pitched sounds and bluer colors in the electromagnetic spectrum.

Key points to remember:

- Shorter wavelengths are associated with higher frequencies.
- Longer wavelengths are associated with lower frequencies.

- The speed of a wave is usually constant for a given medium, so changes in frequency are accompanied by changes in wavelength to maintain this relationship.



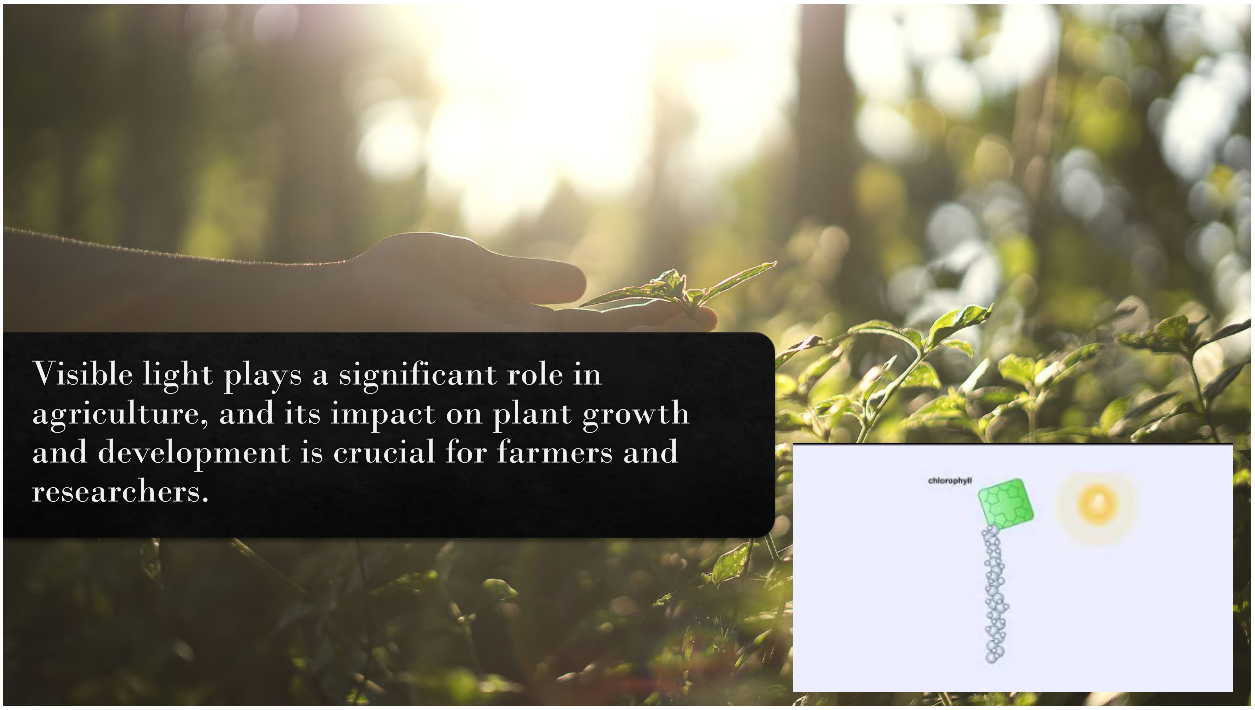
NOTES: Discuss visible light:

Wavelength Range: Visible light occupies a relatively small portion of the electromagnetic spectrum. It has wavelengths ranging from approximately 380 nanometers (nm) to 750 nm. The range is often divided into different colors based on their wavelengths, with red having the longest wavelengths and violet having the shortest.

Colors of Visible Light:

Red: Longest visible wavelengths, typically around 620-750 nm.
Orange: Wavelengths around 590-620 nm.
Yellow: Wavelengths around 570-590 nm.
Green: Wavelengths around 495-570 nm.
Blue: Wavelengths around 450-495 nm.
Violet: Shortest visible wavelengths, typically around 380-450 nm.

Perception of Color: The perception of different colors is a result of our eyes' sensitivity to specific wavelengths of light. When light of a certain wavelength enters our eyes and interacts with the cells in the retina (specifically, cones), it generates electrical signals that our brain interprets as colors.



NOTES: **Play Video!**

Discussion:

Photosynthesis: Visible light is essential for photosynthesis, the process by which plants convert light energy into chemical energy (in the form of glucose) and oxygen. Chlorophyll, the green pigment in plant cells, absorbs light in the blue and red parts of the visible spectrum most efficiently. This process is critical for plant growth, as it provides the energy needed for plant functions and the production of fruits, vegetables, and grains.

Light Quality: The quality (color or wavelength) of light can have a significant impact on plant growth and development. Different wavelengths of light affect various aspects of plant physiology. For instance:

Blue light is important for vegetative growth, leaf expansion, and the regulation of photomorphogenesis (how plants respond to light).

Red light promotes flowering and fruiting.

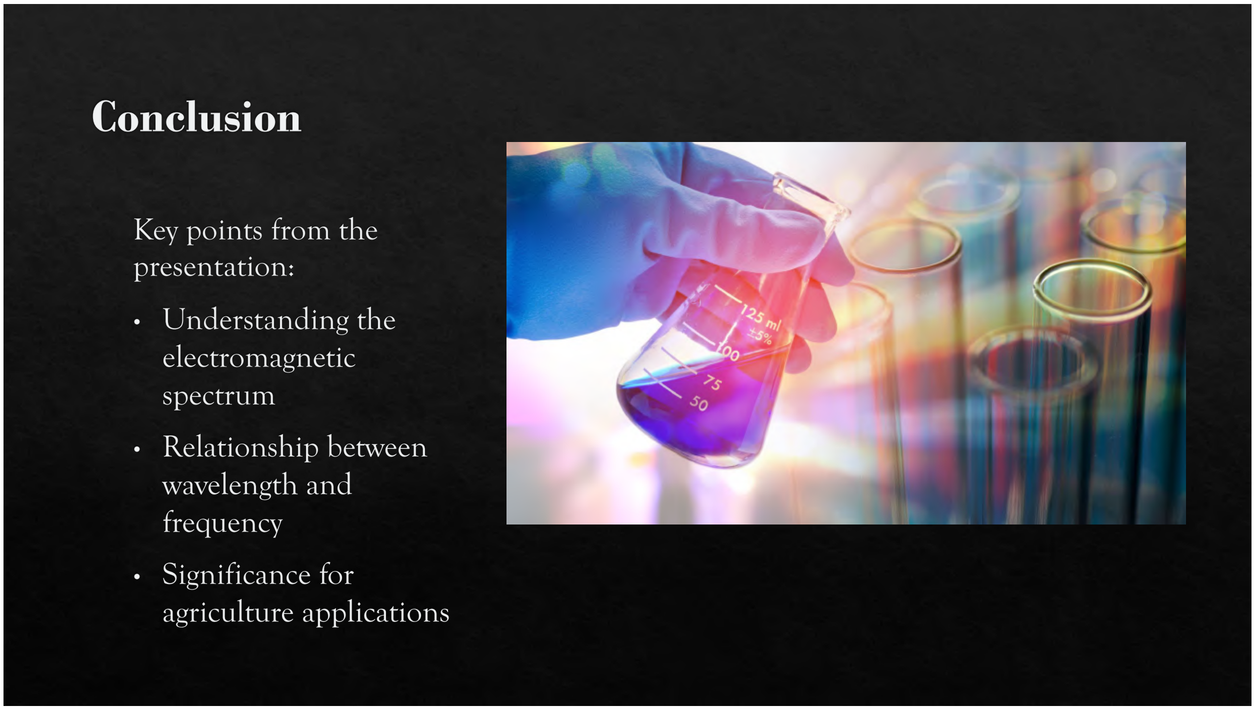
Far-red light is involved in germination and the regulation of the plant's light-sensing mechanisms.

Light Quantity (Intensity): The intensity of light, often measured in terms of photosynthetically active radiation (PAR), affects the rate of photosynthesis and overall plant growth. Light quantity varies depending on factors such as location, season, and weather conditions. Growers often use artificial lighting, like high-intensity discharge (HID) lamps and light-emitting diodes (LEDs), to supplement natural light and optimize plant growth indoors or in greenhouses.

Photoperiodism: Many plants have specific photoperiodic requirements, meaning they require a certain amount of light and darkness during a 24-hour cycle to trigger flowering or other developmental stages. Farmers can manipulate photoperiods using techniques like light deprivation or supplemental lighting to control when their crops flower and fruit.

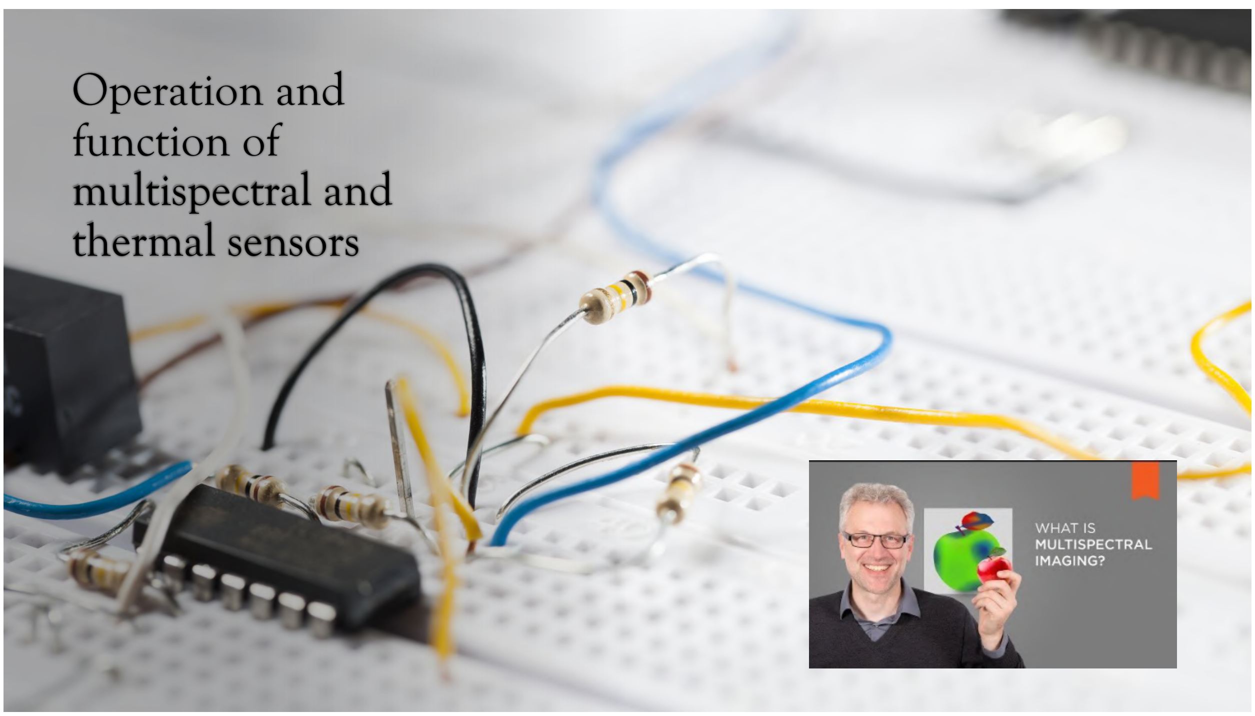
Light Stress and Damage: While plants need light for photosynthesis, excessive light exposure or certain light wavelengths can lead to light stress or photodamage. This can cause issues such as sunburn on leaves and reduced yields. Farmers may use shading or netting to protect plants from excessive sunlight in high-light environments.

Precision Agriculture: Advances in technology and remote sensing have allowed farmers to monitor and manage crop health and growth by analyzing reflected light. Satellite and drone-based remote sensing can capture information about plant health and stress, helping farmers make informed decisions about irrigation, pest control, and nutrient management.



NOTES:
Emphasize the importance of this knowledge.
Encourage questions and discussions from the audience.

NOTES: Coalinga College uses the Amiga robot with an infrared camera to take pictures of the plants we grow.



NOTES: **Play the video** for a definition of multispectral sensors and an explanation of how they capture data!

Discussion:

<u>Introduction</u>

Discuss the technical specifications of multispectral sensors.

Discuss the specifications of multispectral sensors, including:
Wavelength bands they capture
Spectral resolution (accuracy of wavelength measurement)

Key points:
Wavelength bands
Spectral resolution's importance

NOTES: **Play Video!**

Definition of Multispectral Sensors:
Multispectral sensors are specialized instruments capable of capturing data across multiple wavelengths or spectral bands of the electromagnetic spectrum. These bands can range from visible light to infrared and thermal radiation.

How They Capture Data:
Multispectral sensors operate by using various detectors or filters to capture specific wavelengths or bands of light. These detectors can be tuned to target the spectral regions most relevant to the agricultural application at hand.
These sensors can be mounted on different platforms such as drones, satellites, or handheld devices, allowing for versatility in data collection.

Purpose in Agriculture:
Multispectral sensors find extensive use in agriculture due to their ability to provide valuable insights into crop health, environmental conditions, and other critical factors. Some key purposes in agriculture include:

<u>Crop Monitoring:</u> By capturing data in various spectral bands, these sensors help assess the health of crops. This is often done by calculating indices like NDVI (Normalized Difference Vegetation Index) to determine plant health and identify stressed areas.

<u>Disease Detection:</u> Multispectral sensors can identify signs of diseases or infestations in crops before they become visible to the naked eye. Early detection enables timely intervention and minimizes crop loss.

<u>Yield Estimation:</u> They contribute to yield estimation by monitoring crop growth and providing data on plant density and size. This information aids in predicting harvest yields accurately.
<u>Discussion:</u>

<u>Introduction</u>

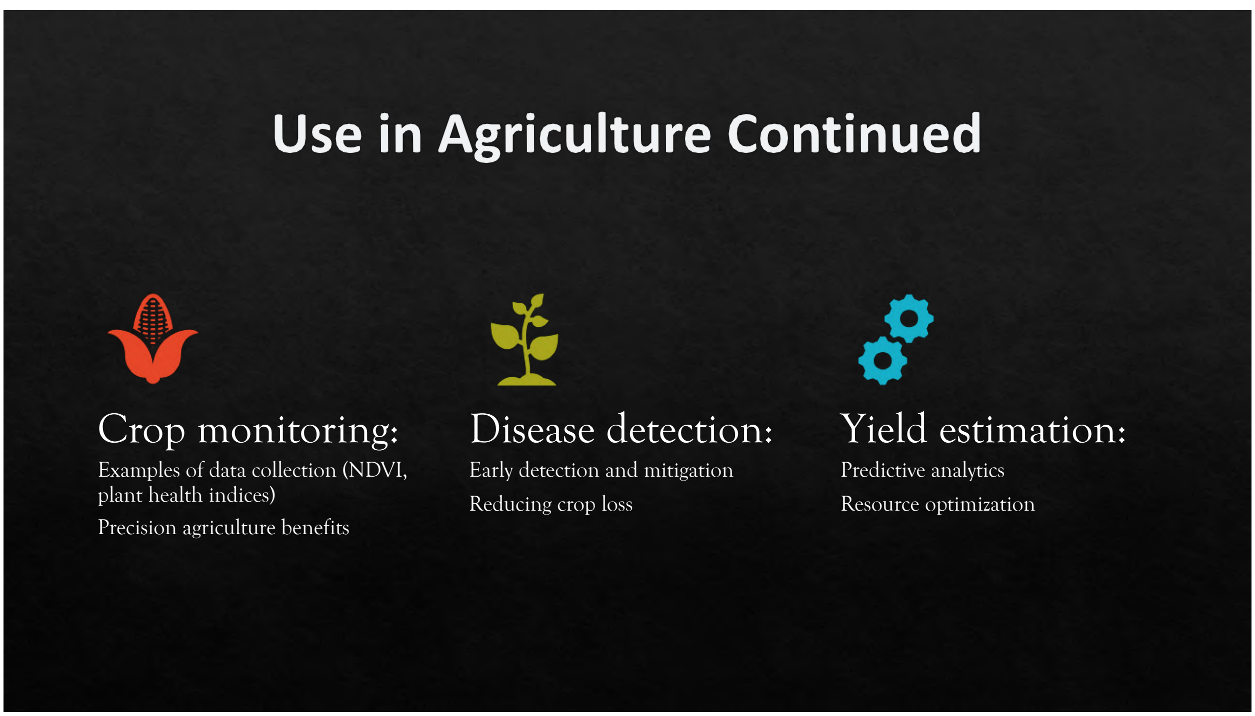
Highlight the practical applications of multispectral sensors in agriculture.

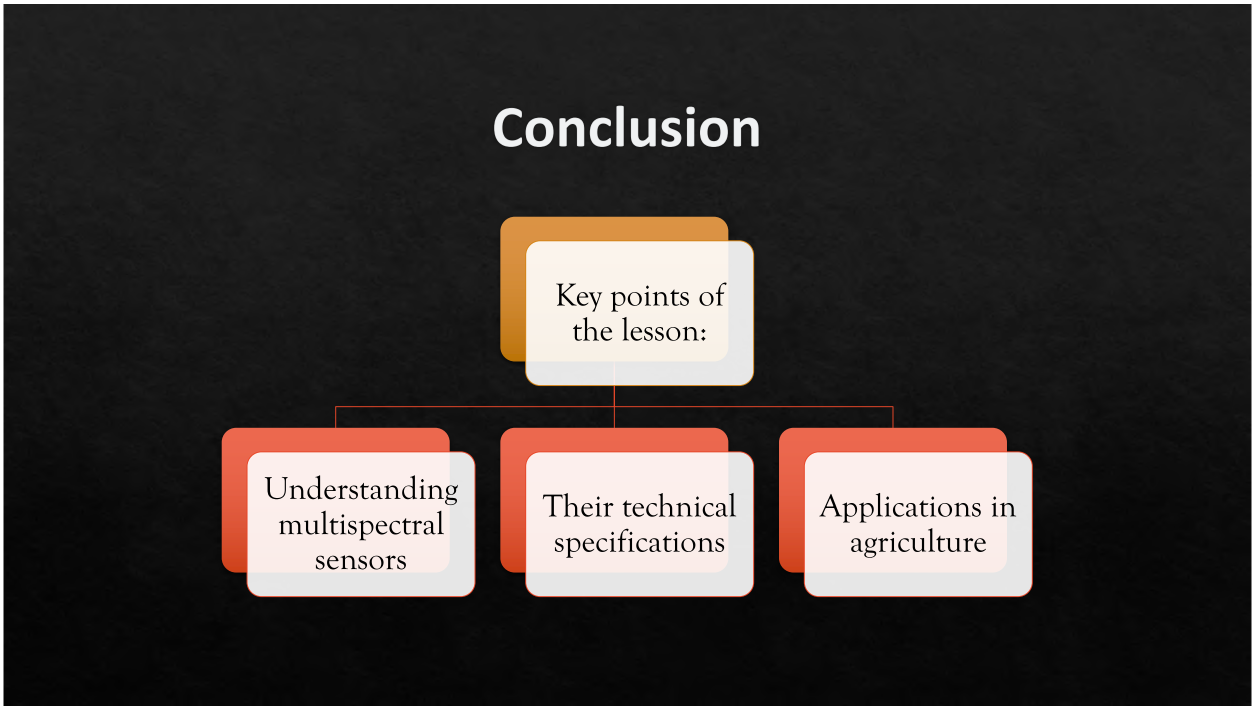
<u>Describe how multispectral and thermal sensors are used in agriculture for:</u>

Crop monitoring
Disease detection
Yield estimation

<u>Key points:</u>

Crop health assessment
Identifying diseases
Predicting crop yield





NOTES:
Encourage students to discuss and interpret their lab results in terms of wavelength differences.
Open the floor for discussions, questions, and interpretations.
Emphasize the real-world importance of multispectral sensors in modern agriculture.

Hands-On Activity Grades 2–3: Hot or Not?

**Objective: Introduce students to thermal sensing by comparing the temperature of everyday objects.

Materials:

- - Thermal sensor or camera
- - Water bottles (cold and room temperature)
- - Classroom objects (lamps, books, hands, etc.)
- - Student log sheet

Procedure:

- - Explain what a thermal sensor does (detects heat).
- - Demonstrate how to use the thermal sensor to view warm vs. cool areas.
- - Have students scan different objects and identify if they are hot, cold, or neutral.
- - Students record findings on their log sheet.

Student Log Sheet:

Student Name: _______________________ Date: _____________

Object Scanned	Temperature (Hot/Warm/Cool)	Notes

1. What object was the warmest? ________________________

2. What object was the coolest? ________________________

3. Why might heat be important to farmers?

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Hands-On Activity Grades 4–5: Plant Temperature Detectives

**Objective: Use thermal imaging to identify plant temperature differences under various conditions.

Materials:

- - Thermal sensor or camera
- - Two plants (one in sunlight, one in shade or watered vs. dry)
- - Thermal imaging log sheet

Procedure:

- - Introduce the concept of how plants release heat when under stress.
- - Students scan each plant and compare temperatures.
- - Have students draw or describe temperature differences on the log.
- - Discuss how a farmer might use this to check plant health.

Student Log Sheet:

Student Name: _______________________ Date: ____________

Plant Location | Temperature Observed | Notes

Sunny Plant | ______________________ | ____

Shaded Plant | ______________________ | ____

Watered Plant | ______________________ | ____

Dry Plant | ______________________ | ____

1. Which plant was coolest? ____

2. Which one seemed most stressed? ____

3. What could a farmer do to help a hot plant?

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Hands-On Activity Grades 6–8: Spectral Scouting

**Objective: Explore light reflectance using a spectrometer to compare healthy and stressed leaves.

Materials:

- - Multi-spectrometer device or phone with spectral app
- - Healthy and unhealthy plant leaves
- - Light color cards or reflectance charts
- - Student observation log

Procedure:

- - Review the concept of light reflection and how leaves reflect different colors based on health.
- - Demonstrate how to use the spectrometer to scan leaves.
- - Have students collect data on red, green, and NIR reflectance.
- - Students compare healthy vs. stressed samples and record observations.

Student Log Sheet:

Student Name: ______________________ Date: ____________

Leaf Type	Green (%)	Red (%)	NIR (%)	Notes
Healthy Leaf	_________	________	_______	___________________________________
Unhealthy Leaf	_________	________	_______	___________________________________

1. Which leaf reflected more red light? ___________________________________

2. Which leaf reflected more green light? ________________________________

3. What might this tell a farmer about the plant's health?

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Hands-On Activity Grades 9–10: Thermal & Spectral Field Lab

**Objective: Collect and analyze thermal and spectral data from field samples.

Materials:

- - Thermal sensor
- - Multi-spectrometer
- - Plant samples from different environments
- - Clipboards and student logs

Procedure:

- - Students work in small groups to collect both thermal and spectral data.
- - Measure plants from shaded, sunlit, dry, and wet conditions.
- - Record reflectance and temperature values.
- - Teams analyze and draw conclusions.

Student Log Sheet:

Student Name: ________________________ Group: _____________

Sample Type	Temp (°C)	Red (%)	NIR (%)	Notes
Sunlit Plant	__________	_________	________	______________________________________
Shaded Plant	__________	_________	________	______________________________________
Dry Soil Plant	__________	_________	________	______________________________________
Wet Soil Plant	__________	_________	________	______________________________________

1. Which plant appeared the healthiest? Why?

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2. What environmental factors influenced the results?

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Hands-On Activity Grades 11–12: Stress Detection Trial

**Objective: Simulate plant stress detection using thermal and spectral data and introduce NDVI concepts.

Materials:

- - Thermal sensor or infrared camera
- - Multi-spectrometer
- - Plant samples (varied health conditions)
- - Graph paper or NDVI worksheet
- - Student log sheet

Procedure:

- - Review how thermal and spectral imaging is used in agriculture to detect stress.
- - Introduce the NDVI formula and what it indicates about plant health.
- - Have students collect thermal and spectral readings from healthy and stressed plants.
- - Calculate NDVI values and compare results.
- - Discuss findings and relate them to field management decisions.

Student Log Sheet:

Student Name: ______________________ Date: ____________

Sample	Temp (°C)	Red (%)	NIR (%)	NDVI Value	Notes
Healthy Plant	_________	________	_______	___________	________________________
Stressed Plant	_________	________	_______	___________	________________________
Other Sample	_________	________	_______	___________	________________________

1. What NDVI value indicates the healthiest plant?

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2. How do the temperature and NDVI results compare?

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3. What action would you recommend to the farmer?

Hands-On Activity Community College: Sensor-Driven Decision Making

**Objective: Use sensors to collect field data, calculate vegetation indexes, and make agronomic recommendations.

Materials:

- - Thermal sensor and multi-spectrometer
- - Field samples or real-world plot (optional)
- - NDVI calculation sheet or software
- - Student analysis sheet

Procedure:

- - Assign students roles (data collector, analyst, technician).
- - Students gather thermal and spectral data across multiple samples or field sections.
- - Calculate NDVI and identify stress zones or management priorities.
- - Draft a written recommendation with supporting evidence for irrigation or crop planning.
- - Present findings in a short technical briefing or slide deck.

Student Log Sheet:

Student Name: ______________________ Team: ____________

Plot ID | Temp Avg (°C) | Red (%) | NIR (%) | NDVI | Priority (Low/Med/High) | Notes

A | ______________ | ________ | _______ | ____ | __________ | _____________________

B | ______________ | ________ | _______ | ____ | __________ | _____________________

C | ______________ | ________ | _______ | ____ | __________ | _____________________

1. Which zones require the most attention?

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2. What recommendations can you make based on this data?

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3. How might this data affect future planting or irrigation?

Grade 3 Worksheet: Understanding the Electromagnetic Spectrum In Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Understanding the Electromagnetic Spectrum

1. How do you think energy is used in everyday life?

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Exploring the Spectrum

2. We learned about something called the electromagnetic spectrum. Can you explain what that is?

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Let's Talk Wavelengths

3. Imagine a wave in the ocean. It has a length, right? We call this length a "wavelength." Can you draw a wave and show its wavelength?

Different Types of Light

4. There are many different types of light waves. Some you can see, like colors in a rainbow. Can you name a color from a rainbow? That's one type. Can you think of any other types of light waves?

Part 2 - Energy in Agriculture and Lab Activity

Light and Plants

5. How do different types of light help or harm plants?

Getting Ready for the Lab

6. We're going to do a cool experiment! We'll use special cameras to take pictures of plants. Can you guess why we want to do that?

Lab Adventure

7. In your groups, take pictures of plants using different types of light. What do you notice?

Looking at the Pictures

8. Now, compare the pictures and see how the plants looked in each one. What do you notice?

Part 3 - Multispectral Sensors in Agriculture

Using Sensors in Farms

9. Farmers use these sensors to help their plants grow better. They check for problems like sickness or drought. Can you think of any other ways these sensors might help?

Grades 4-5 Worksheet: Understanding the Electromagnetic Spectrum In Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Understanding Light and Energy

1. Think about your day. Where do you see or use light and energy?

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What is the Electromagnetic Spectrum?

2. Imagine you're explaining the electromagnetic spectrum to a friend. How would you describe it in simple terms?

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Learning about Wavelengths

3. Do you know what a wavelength is? Try to explain it using something you know, like the waves in the ocean.

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Exploring Different Lights

4. Can you name a color from a rainbow? Great! Now, what about light that we can't see? Can you think of any examples?

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Part 2 - Energy in Agriculture and Lab Activity

Light's Role in Plants

5. How do you think different types of light might affect how plants grow and stay healthy?

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Getting Ready for the Lab

6. We're going to do an exciting experiment today! Why do you think we're using special cameras to take pictures of plants?

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Lab Adventure

7. In your groups, you'll take pictures of plants using different types of light. What do you expect to see in these pictures?

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Analyzing the Pictures

8. After the lab, we'll compare the pictures and see how the plants looked in each one. What kind of differences do you think we'll find?

Part 3 - Multispectral Sensors in Agriculture

Discovering Multispectral Sensors

9. Let's learn about some high-tech cameras called "multispectral sensors." Why do you think they are useful in farming and agriculture?

Exploring Sensor Details

10. These sensors can "see" light in a special way. What do you think makes them different from regular cameras?

Grades 6-7 Worksheet: Understanding the Electromagnetic Spectrum In Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Understanding Light Waves

1. Think about your everyday life. Where do you see or use light waves, even if you can't see them?

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The Electromagnetic Spectrum

2. Can you explain the electromagnetic spectrum in your own words? Try to break it down for someone who knows nothing about it.

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Delving into Wavelengths

3. Wavelengths are like the building blocks of light. Can you give an example of something that has a long wavelength and something with a short wavelength?

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Exploring Light Types

4. We know about visible light, but there are other types of light we can't see. Can you name a few, and what do you think they're used for?

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Part 2 - Energy in Agriculture and Lab Activity

Light and Plant Growth

5. How do you think different types of light affect how plants grow and thrive? What factors might be involved?

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Lab Preparation

6. Today's experiment involves using specialized cameras to photograph plants. Why might we want to do this, and what do you expect to discover?

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Hands-on Lab

7. In your groups, you will use various types of light to capture images of plants. What do you anticipate observing in these images?

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Analyzing Lab Data

8. After the lab, we will analyze the images to understand how different types of light affect plant appearance. What hypotheses do you have about the outcomes?

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Part 3 - Multispectral Sensors in Agriculture

Exploring Multispectral Sensors

9. Let's delve into advanced technology. What do you think multispectral sensors do, and how might they be beneficial in agriculture?

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Grades 8-9 Worksheet: Understanding the Electromagnetic Spectrum In Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Understanding Light Waves

1. Reflect on your daily life. Where do you encounter light waves, and why is it crucial to study them?

Demystifying the Electromagnetic Spectrum

2. Explain the electromagnetic spectrum in your own words, emphasizing its significance. Imagine you're teaching someone who knows nothing about it.

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Exploring Wavelengths

3. Wavelengths are fundamental to understanding light. Provide examples of long and short wavelengths and explain their importance.

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Examining Diverse Light Types

4. Beyond visible light, various types of light exist. Name some, and speculate on their practical applications.

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Part 2 - Energy in Agriculture and Lab Activity

Light's Impact on Plants

5. Analyze how different types of light waves can influence plant growth and health. What factors might come into play?

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Preparing for the Lab

6. Today's experiment involves using advanced cameras to photograph plants. Why might we choose to do this, and what hypotheses do you have about the outcomes?

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Hands-on Lab Experience

7. In your groups, you will use various types of light to capture images of plants. What differences do you anticipate observing in these images?

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Interpreting Lab Data

8. After the lab, we will analyze the images to understand how different types of light affect plant appearance. What do you expect to discover, and how might this knowledge be applied?

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Part 3 - Multispectral Sensors in Agriculture

<u>Exploring Multispectral Sensors</u>

9. Delve into advanced technology. What roles do multispectral sensors play in agriculture, and how do they work?

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Understanding Sensor Specifications

10. Multispectral sensors are not your typical cameras. Discuss their unique features and why farmers might opt for them.

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Sensor Applications in Agriculture

11. Farmers harness the power of multispectral sensors in various ways. Enumerate specific applications and their benefits for farming and agriculture.

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Conclusion and Discussion

12. Reflect on today's lesson. How does mastering the electromagnetic spectrum and employing technology like multispectral sensors transform the field of agriculture? Share your thoughts.

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Grades 10-11 Worksheet: Understanding the Electromagnetic Spectrum In Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Diving Deeper into Light Waves

1. Reflect on technological advancements and modern applications. How does the understanding of light waves impact various fields, including agriculture?

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Mastering the Electromagnetic Spectrum

2. Provide an in-depth explanation of the electromagnetic spectrum, highlighting its critical role. Imagine you're addressing a scientific conference; what key points would you emphasize?

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Analyzing Wavelengths

3. Consider the intricate relationship between wavelength and frequency. How does this understanding drive innovation in fields like agriculture and technology?

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Exploring Advanced Light Types

4. Beyond the basics, there are numerous specialized light types. Share examples and delve into their sophisticated uses in contemporary agriculture.

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Part 2 - Energy in Agriculture and Lab Activity

Light's Impact on Advanced Agriculture

3. Investigate the nuanced ways different light wavelengths can influence plant physiology and crop management in modern, high-tech agriculture.

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Advanced Lab Setup

6. Today's experiment involves using cutting-edge multispectral sensors to capture high-resolution images of plants. Why is this method superior to traditional approaches?

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Advanced Lab Experience

7. In your groups, you will employ multispectral sensors to capture detailed images of plants. What specific parameters will you measure, and how will these measurements advance agricultural knowledge?

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Interpreting and Applying Lab Data

8. After the lab, rigorous data analysis awaits. How will the detailed information acquired through multispectral imaging benefit precision agriculture, and what challenges might arise in handling and interpreting this data?

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Part 3 - Multispectral Sensors in Agriculture

Mastering Multispectral Sensors

9. Explore multispectral sensors in-depth. How do these advanced devices function, and what makes them indispensable in modern agriculture?

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Advanced Sensor Specifications

10. Delve into the technical specifications of multispectral sensors, such as spectral resolution and accuracy. Explain how these factors influence their performance in agricultural applications.

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Advanced Sensor Applications in Agriculture

11. Contemporary agriculture relies heavily on multispectral sensors for tasks like crop monitoring, disease detection, and yield estimation. Provide detailed examples of how these sensors are transforming farming practices.

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Advanced Conclusion and Discussion

12. Conclude today's lesson with a forward-looking perspective. As future scientists and innovators, how can you envision pushing the boundaries of agriculture through the mastery of the electromagnetic spectrum and advanced technology like multispectral sensors?

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Grades 12-Community College Worksheet: Advanced Understanding of the Electromagnetic Spectrum in Agriculture

Part 1 - Introduction to the Electromagnetic Spectrum

Diving Deeper into Light Waves

1. Reflect on technological advancements and modern applications. How does the understanding of light waves impact various fields, including agriculture?

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Mastering the Electromagnetic Spectrum

2. Provide an in-depth explanation of the electromagnetic spectrum, highlighting its critical role. Imagine you're addressing a scientific conference; what key points would you emphasize?

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Analyzing Wavelengths

3. Consider the intricate relationship between wavelength and frequency. How does this understanding drive innovation in fields like agriculture and technology?

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Exploring Advanced Light Types

4. Beyond the basics, there are numerous specialized light types. Share examples and delve into their sophisticated uses in contemporary agriculture.

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Part 2 - Energy in Agriculture and Lab Activity

Light's Impact on Advanced Agriculture

5. Investigate the nuanced ways different light wavelengths can influence plant physiology and crop management in modern, high-tech agriculture.

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Advanced Lab Setup

6. Today's experiment involves using cutting-edge multispectral sensors to capture high-resolution images of plants. Why is this method superior to traditional approaches?

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Advanced Lab Experience

7. In your groups, you will employ multispectral sensors to capture detailed images of plants. What specific parameters will you measure, and how will these measurements advance agricultural knowledge?

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Interpreting and Applying Lab Data

8. After the lab, data analysis awaits. How will the detailed information acquired through multispectral imaging benefit precision agriculture, and what challenges might arise in handling and interpreting this data?

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Part 3 - Multispectral Sensors in Agriculture

Mastering Multispectral Sensors

9. Explore multispectral sensors in-depth. How do these advanced devices function, and what makes them indispensable in modern agriculture?

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Advanced Sensor Specifications

10. Examine the technical specifications of multispectral sensors, such as spectral resolution and accuracy. Explain how these factors influence their performance in agricultural applications.

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Advanced Sensor Applications in Agriculture

11. Contemporary agriculture relies heavily on multispectral sensors for tasks like crop monitoring, disease detection, and yield estimation. Provide detailed examples of how these sensors are transforming farming practices.

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Advanced Conclusion and Discussion

12. Conclude today's lesson with a forward-looking perspective. As future scientists and innovators, how can you envision pushing the boundaries of agriculture through the mastery of the electromagnetic spectrum and advanced technology like multispectral sensors?

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Video Demonstration

In this demonstration, a farmer operates the Amiga field robotic device equipped with an infrared (IR) camera attachment to scan rows of crops for moisture levels. As the Amiga moves through the field, the infrared camera captures detailed thermal imagery that reveals differences in plant canopy temperature.

The data provided by the infrared camera highlights areas where plants are experiencing water stress- hotter signatures indicate reduced moisture availability, while cooler areas suggest adequate irrigation. This allows the farmer to identify uneven watering, pinpoint sections of the field needing attention, and make data-driven irrigation decisions.

Beyond immediate insights, the IR camera data can be archived and compared over time, helping the farmer track crop health trends, evaluate the efficiency of irrigation systems, and even anticipate potential yield impacts. By combining precision robotics with infrared imaging, the Amiga supports more sustainable water use, lowers costs, and promotes healthier crop growth.

https://www.youtube.com/watch?v=dRzesJgh2nY