NSF HBCU-UP TIP EVALUATION REPORT

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AGSC 4630/5630
Pre/Post Survey Findings

TENNESSEE STATE UNIVERSITY

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INTRODUCTION

This report presents a summary of key findings from a pre/post survey administered to students enrolled in the AGSC 4630/5630: Introduction to Gene Editing with CRISPR-Cas9 course during Spring 2025. This document provides an overview of the collated responses, highlighting dominant themes and notable patterns observed with the data. The findings are intended to support an understanding of participant perspectives and experiences related to the course.

Visual tools are used throughout the report to summarize and illuminate key patterns emerging from the collected survey data. Images include:

- **Bar charts**. Bar charts are used to compare response frequencies across categories.
- **Treemaps.** Treemaps are used to compare response frequencies by focusing on the proportional significance of different segments.
- **Dumbbell plots.** Dumbbell plots (also known as barbell charts) are used to visualize changes in average student agreement on statements about gene editing.
- **Word Clouds.** Word clouds are used to visually capture the most frequent textual responses across qualitative feedback.
- **Mosaic Plots.** Mosaic plots are used to explore the complex interrelationships and conditional distributions between multiple categorical variables. These plots are used to visualize beliefs at the start of the course (pre) and at the end of the course (post) to understand how opinions across different aspects of gene editing remained stable or shifted. Key features of Mosaic plots include:
    - The total area of the plot is proportional to the total number of observations.
    - The width of each column is proportional to the number of observations in each level of the variable plotted on the horizontal axis.
    - The vertical length of the bars within each column is proportional to the number of observations in the second variable within each level of the first variable.
    - Color can be used to highlight the relationships between variables.

Insights provided for the major thematic elements in open-ended responses were generated using an iterative refinement process that leveraged GEMINI AI, a large language model developed by Google. The tool was used to generate preliminary sets of codes to capture main themes emerging from the data which were then reviewed by the evaluator to determine the appropriateness and alignment of the codes based on her interpretation of the responses. GEMINI was leveraged a second time by using the platform to summarize the major thematic elements across students' responses into a single paragraph. The final output was then reviewed and edited into the report. These insights should be verified by those with subject matter expertise to validate the statements.

SURVEY FINDINGS

Student Characteristics

A total of 14 graduate students were enrolled in the AGSC 4630/5630: Introduction to Gene Editing with CRISPR-Cas9 course during Spring 2024. The breakdown for student reported identification for gender, ethnicity and race includes:

- Sex/Gender: Female (7), Male (5), and Not reported (2)
- Ethnicity: Not Hispanic (8) and Not reported (6)
- Race: Asian (7), Black (3), White (1), and Not reported (2)
- Academic Majors: Agricultural Sciences (11/7 with Biotechnology concentration), Food & Animal Science (1), and Not reported (2)
- Career Interests (Post, interest at pre- is used for students who did not complete a post-survey): Research Scientist (10), Academia / Professor (2), Both Research Scientist/Academia (1), Not reported (1)

Students' self-reported characteristics

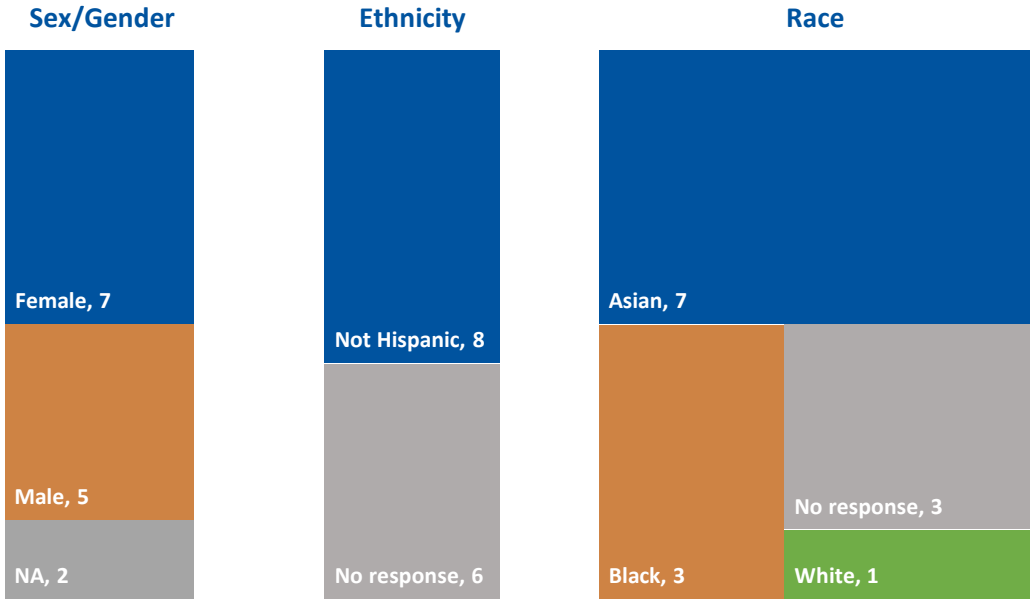

Figure 1. Composition of students by Sex/Gender, Ethnicity and Race.

Students' Academic Majors

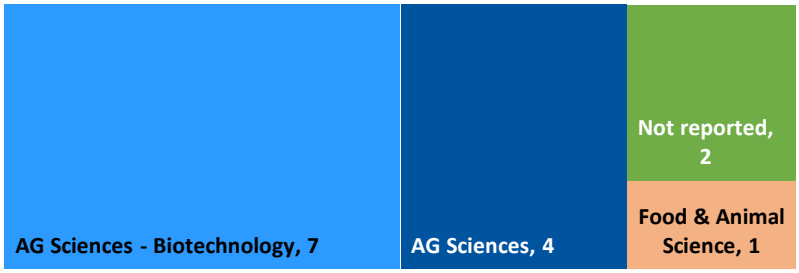

Figure 2. Distribution of academic major for students enrolled in AGSC 4630/5630 during Spring 2025.

Pre and post surveys were administered to all students enrolled in the course. A total of 12 students completed the pre-survey and 10 completed the post. This resulted in a total of 9 (64%) matched surveys across time periods as three students who completed the pre-survey did not complete a post, and 1 student who completed a post-survey did not complete a pre. For the purposes of this report, all students' data are included in analyses unless otherwise noted.

Students' Career Interests

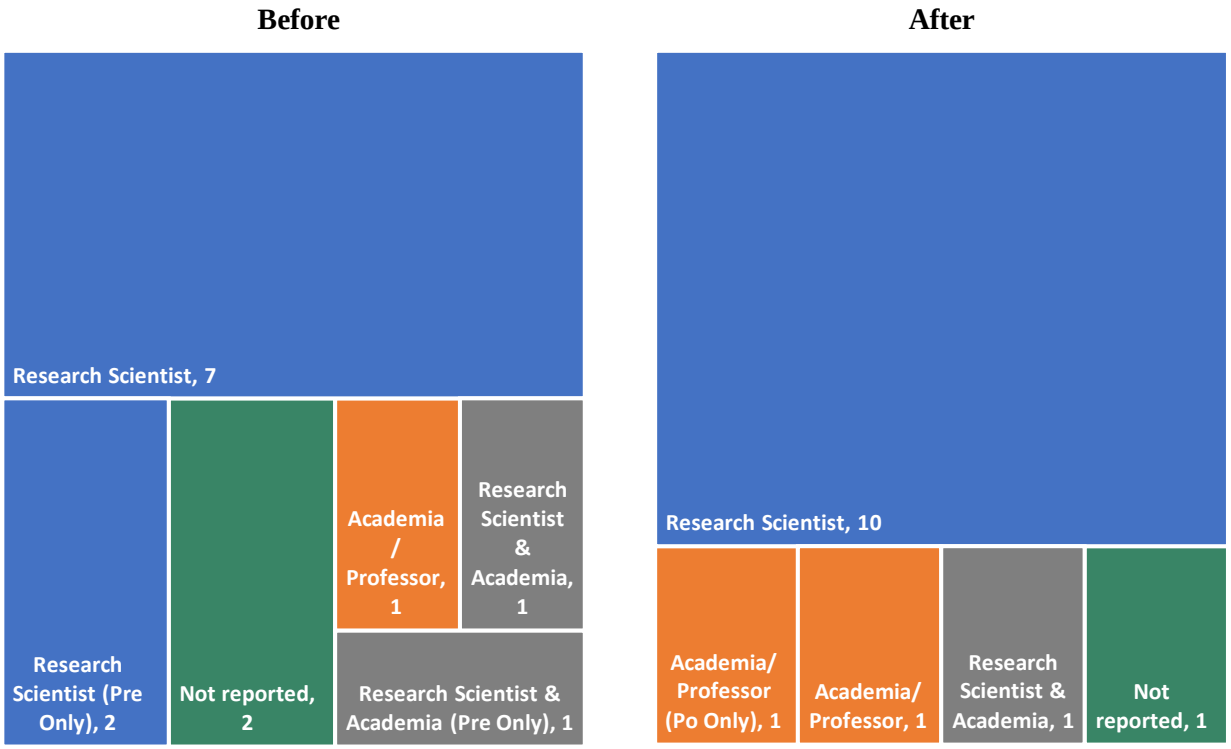

Figure 3. Career interests for students enrolled in AGSC 4630/5630 during Spring 2025 at Pre and Post.
Note. Pre-responses were carried over for students who did not complete a post-survey.

12 out of **12** students indicated that **attending TSU has influenced or shaped their career aspirations.**

In their own words:

- Attending Tennessee State University has advanced my career goals by providing a platform for research in Agricultural Biotechnology. Building on my background in Microbiology from my bachelor's and master's, my PhD program has deepened my knowledge and skills in addressing agricultural challenges, such as plant disease management and sustainable crop production, aligning with my aspirations to contribute to global food security.

- Considering the courses I am pursuing this semester, though the academic semester just started, I anticipate the courses will shape my knowledge in my field of research and furthermore, increase my knowledge in this area of science.

- I became familiar with several research ideas and technology and learning several techniques that motivated me towards agriculture research.

- The academic standard in a developing country and in a first world country can be explicitly prominent in making a lifelong impression in career building goals. In a country like Bangladesh, we have limited opportunities to gain hands-on experience and knowledge. To bridge the gap between the practical skillsets and theoretical experience, the Tennessee State University will surely make an immense role in shaping my career aspirations in prospective fields with definite professional confidence.

  The excellent academic curriculum, course alignments, combination of multi-disciplinary research fields, respectable professors and fellow classmates and officials, these are all contributing factor for a long and lasting opportunities to navigate as an international student in the USA. TSU will definitely help me shape my promising future in foreseeable future.

- Attending Tennessee State University (TSU) has played a role in shaping my career aspirations. The university provides access to quality programs in agricultural sciences, hands-on lab experiences, and opportunities for research in plant and soil science. Also, the university's collaborations with industry leaders like Bayers and Syngenta may offer insights into real-world applications of biotechnology. These partnerships might expose me to cutting-edge innovations and research opportunities, reinforcing my passion for plant science and my goal of pursuing a career in research or industry to advance sustainable agricultural solutions.

- It has helped shape my career aspirations by providing valuable research experience and connections in plant pathology.

- Attending TSU has indeed significantly influenced my career aspirations. I am currently working on genome wide association analysis in chickpea for protein using NIRS with Dr. Wallace. Further, there are several courses that provides practical assessments that are significant for my career development. The university also provides opportunities to participate in seminars, conference, along with community engagement programs, so in a nutshell, TSU is providing the right path for my success.

- After attending TSU, I was introduced to the broader aspects of genetics, which makes me realized various fields where I could build a fulfilling and impactful career. The exposure to different areas of research and practical applications in genetics has shaped and inspired my career aspirations. TSU has not only broadened my knowledge but also guided me in identifying the paths that align with my passions and long-term goals, influencing my professional journey in a profound way.

Course Preparedness

Prior experience or coursework related to bioinformatics, cloning or transformation techniques

Prior Experience included:

- DNA sequencing analysis
- I studied Several courses like genetics, Plant breeding, Animal breeding, Population genetics, Biochemistry, and Biotechnology in My Undergraduate. I have very surface Experience in DNA extraction, PCR, and Gel electrophoresis.
- Bioinformatics, Plant Tissue Culture
- Primer design, Data Wrangling, Use of relevant websites for gene prediction and analysis
- Plant breeding and genetics, Biotechnology, Population genetics
- Design primer, amplifying gene, preparing vector, amplifying vector, extracting of that and then transfer to the yeast (cloning).

Hands-on experience with genetic engineering techniques prior to enrolling in this course

Prior Experience included:

- PCR-based cloning, restriction enzyme digestion, and ligase-mediated ligation, Agrobacterium-mediated transformation, RNA extraction, cDNA synthesis, and quantitative PCR (qPCR)

Concerns about ability to perform well within the course

In their own words:

- I am ready to learn and apply the concepts.
- I feel confident in my ability to perform well in this course.
- I think I can performed my best and will try to give my best within this course.
- While I am excited to take the course, I have a few concerns about ensuring I perform well. This course involves advanced molecular biology concepts and hands-on applications, which can be challenging to master. Understanding the intricate mechanisms of CRISPR technology and its applications in gene editing requires consistent effort and focus. However, I am confident in my ability to work hard, actively participate, and seek guidance from my professors or peers when needed. I see this course as an excellent opportunity to deepen my knowledge and strengthen my skills in cutting-edge biotechnology.

Attitudes toward gene-editing

Figure 4 demonstrates the scores from students who provided both pre- and post-intervention responses (n = 9 matched data responses). Agreement was measured on a 5-point scale, where 1 indicated "*Strongly disagree*" and 5 indicated "*Strongly agree*." On these plots, pre-intervention averages are shown in a lighter blue, while post-intervention averages are in a darker blue. Overall, there does appear to be negligible change or slight decreases in student agreement across gene-editing aspects from pre-to-post, with one exception ('*Gene editing is necessary for long-term food security*').

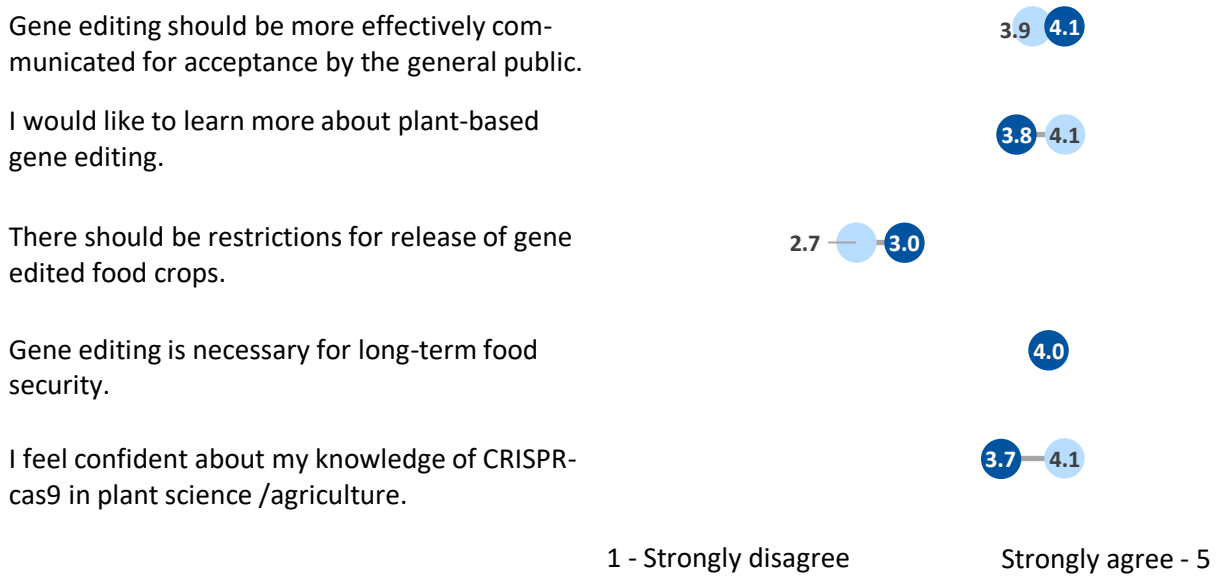

Figure 4. Using a scale of 1 (Strongly disagree) and 5 (Strongly agree), average student agreement towards statements on gene-editing at pre (●) and post (●).

Overall, there was a positive shift in perceptions of the importance of gene editing for enhancing nutritional content, disease resistance, and improving crop yield (see Figure 5). Agreement was measured on a 5-point scale, where 0 indicated "*Not important*" and 4 indicated "*Extremely important*".

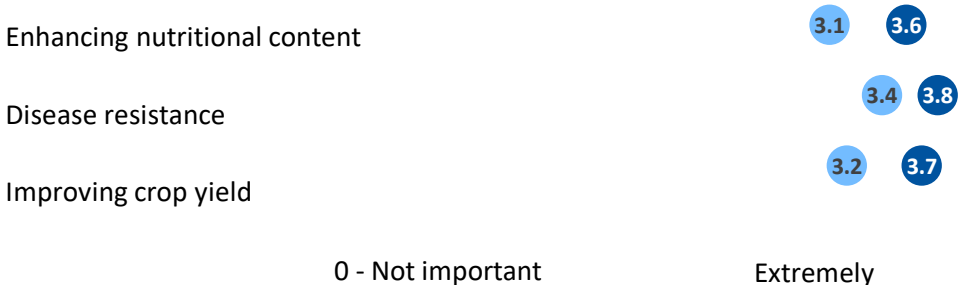

Figure 5. Using a scale of 0 (*Not important*) to 4 (*Extremely Important*), average student rating of importance for gene editing in addressing the following challenges in agriculture at pre (●) and post (●) for matched data.

Students were asked to indicate their comfort across learning objectives of the AGSC 4630/5630 course using a scale of 0 "*No Comfort*" to 4 "*Extremely comfortable*" across three assessment points: actual ratings of comfort at pre (●), students' reflection after the course on what their comfort was before the course (●), and ratings of comfort at post/after completing the course (●) – Figure 6. Students generally increased their comfort across all gene-editing learning objectives, as evidenced by the higher average comfort levels at post compared to pre- or retrospective ratings. Overall, students' retrospective assessment of their initial comfort was notably lower than their actual initial ratings of comfort at pre.

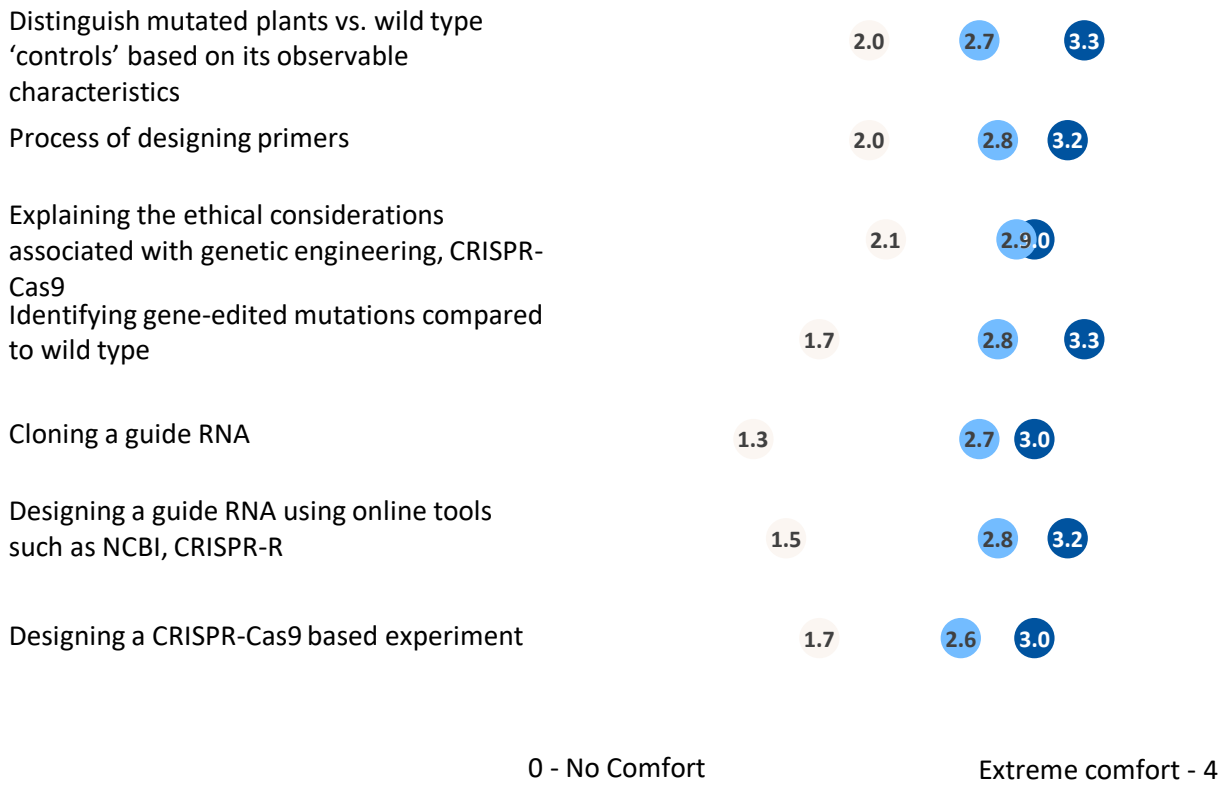

Figure 6. Average student rating for level of comfort across learning areas at pre (●) and post (●) using a scale of 0 (*No Comfort*) to 4 (*Extreme Comfort*). Light orange (●) represents retrospective ratings where students reflected on their initial comfort level after completing the course.

Students' definition for a "Scientist"

Students in the course were asked to define 'scientist' at pre- and post-survey. Figure 7 shows the word clouds created based on the definitions students provided at pre- and at post. Word clouds were used to show frequency of word used in the text by increasing the font size of words that were most prominently used throughout the text. In both the pre- and post-survey responses, students consistently defined a scientist by their engagement in a systematic process of inquiry, emphasizing experimentation, data collection and analysis, hypothesis testing, and evidence-based reasoning. This core understanding of scientific methodology remained a central theme.

Figure 7. Word clouds for defining a 'scientist' at pre- and post-survey.

Students' Identification as a Scientist

Nine out of 10 students indicated they identified as a scientist at post with one student indicating "*I am not sure*" which represents a change from indicating "*No*" at pre. The follow-up explanation *"All I can say I have a lot to learn and know before calling myself a scientist*". This change in response and accompanying explanation suggests a developing, but still uncertain, self-perception as a scientist.

Explanations from participants' responses suggest participants overwhelmingly view themselves as scientists due to their active engagement in the scientific process and their alignment with the core tenets of scientific inquiry. This is exemplified by statements like:

> *'doing research to have some meaningful conclusion'*
>
> *'actively engaged in genomic studies, fieldwork, and data analysis',*
>
> *'conduct well thought experiments, collect data and present my findings'.*

Another prominent theme is the application of scientific methodology and systematic approaches, as seen in phrases such as:

> *'apply scientific methods to answer research questions',*
>
> *'conduct my experiment systematically',*
>
> *'by methods and mindset I am a scientist.'*

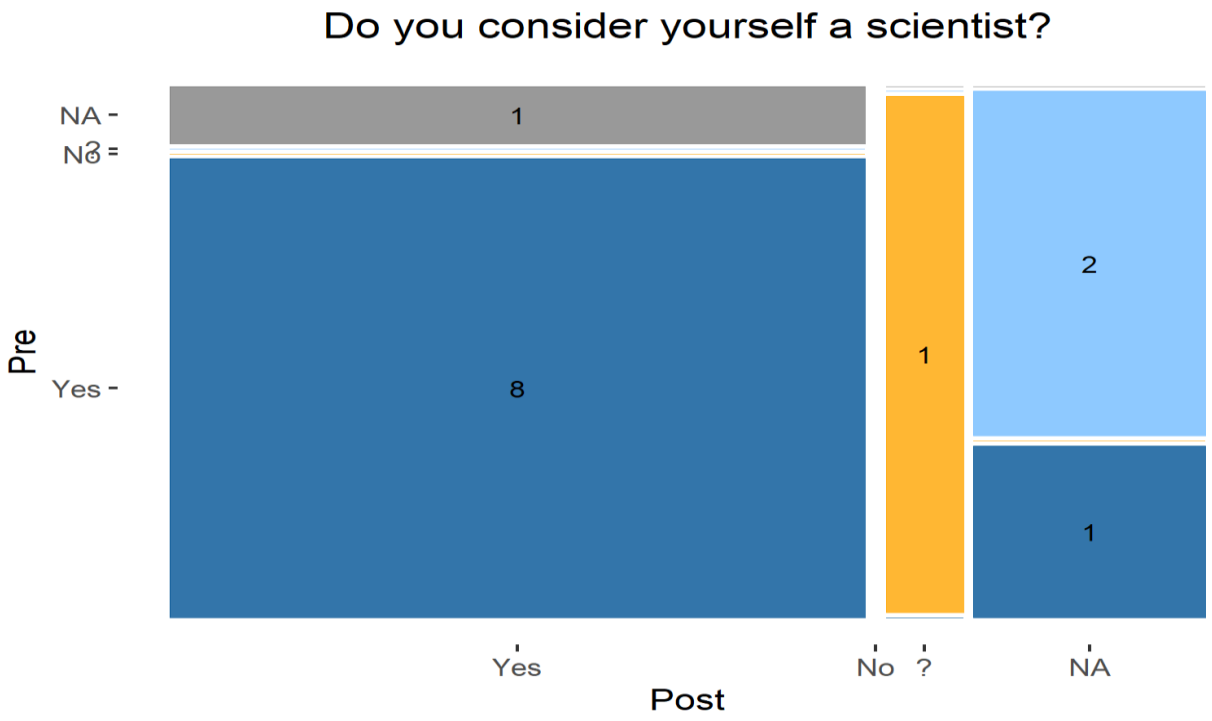

Figure 8. Mosaic plot illustrating the distribution of responses to the question, "Do you consider gene edited plants to be genetically modified organisms (living things)?" The x-axis categorizes the post-survey responses, while tile color represents the pre-survey responses –dark blue (■) for *yes*, light blue for ? = *I am not sure* (■), orange for No (■), and missing (*NA*) color coded grey (■).

Students' definition for "Biotechnology"

Students in the course were asked to define 'biotechnology' at pre- and post-survey. Figure 9 shows the word clouds created based on the definitions students provided at pre- and at post. Pre-intervention, students defined biotechnology as applying technology to biological systems for products or problem-solving, focusing on benefits in human life, agriculture, health, and environment, often noting the use of living organisms or molecular biology. Post-intervention, while the core definition held, there was a shift towards explicitly mentioning modifying/re-engineering organisms and a greater emphasis on problem-solving and cellular-level activities, with CRISPR cited as an example.

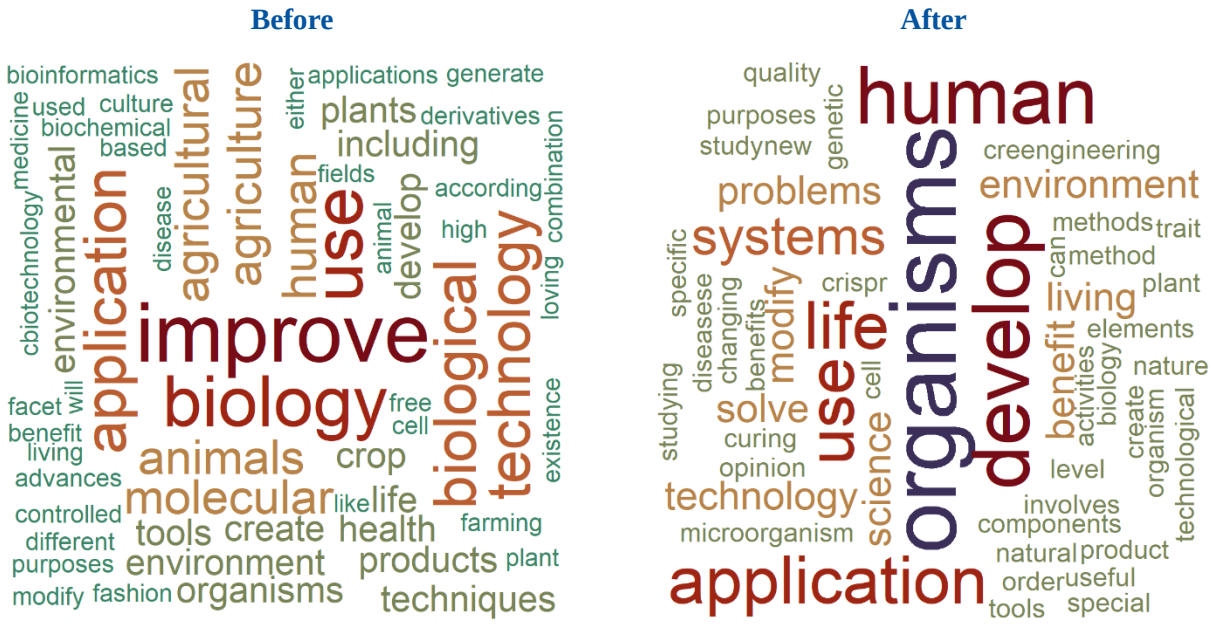

Figure 9. Word clouds for defining a 'biotechnology at pre- and post-survey.

Student Beliefs

Students enrolled in the course were asked to indicate their beliefs using '*yes/no*' responses on the potential and implications of gene editing in agriculture. For each question, students were encouraged to explain their answers. Results from their beliefs from the start of the course and at the end of the course are summarized using mosaic plots to demonstrate how opinions across these aspects of gene editing either remained stable or shifted, highlighting areas of strong agreement, growing disagreement, and emerging uncertainty.

Positive Impact AG/Food Production

All 12 initial responses indicated "*Yes, Plant Biotechnology has potential to positively impact agriculture and food production*" and was held stable in post-survey responses (Figure 10). Thus, there were no changes in beliefs in the positive potential impacts of biotechnology.

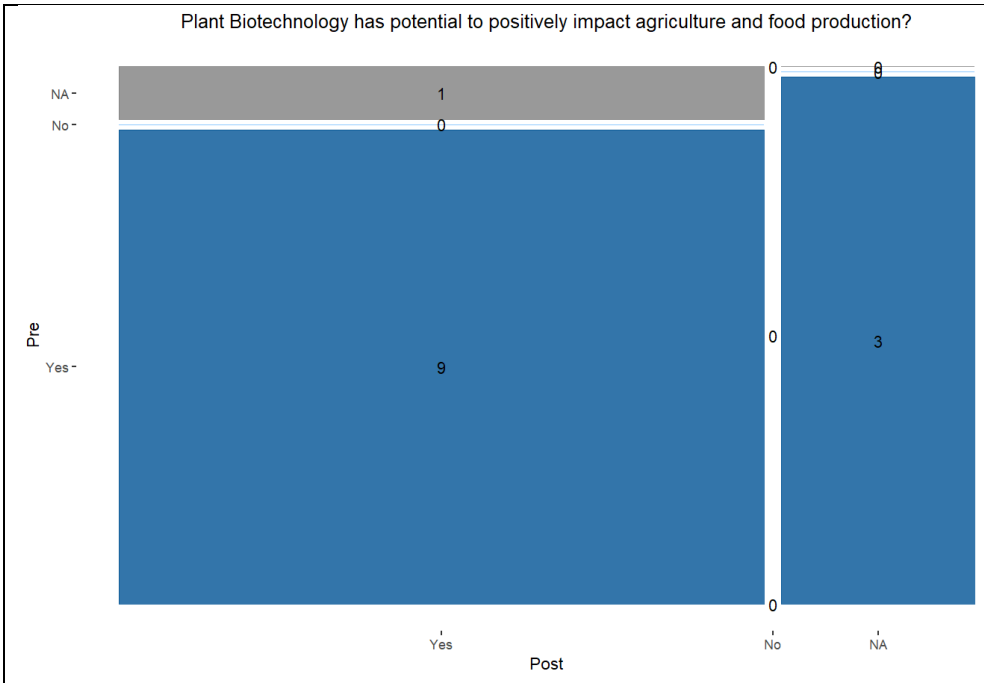

Figure 10. Mosaic plot illustrating the distribution of responses to the question, "Do you believe plant biotechnology has the potential to positively impact agriculture and food production?" The x-axis categorizes the post-survey responses, while tile color represents the pre-survey responses color coded as dark blue (■) for *yes*, light blue for *no* (■), and missing (*NA*) color coded grey (■).

Summary of supported explanations using GEMINI:[1]

Supporting explanations of '*Yes'* primarily related to enhanced crop traits, which includes developing disease and pest resistance, improving stress tolerance for climate resilience, increasing crop yield, and boosting nutritional value. Ultimately, these efforts contribute to the overarching goal of food security and global impact by addressing world hunger and strengthening food production systems. An emergent, though less prominent, theme also points to the necessity of considering the ethical and regulatory implications of these biotechnologies.

[1] To assist understanding of the major thematic elements across responses at pre- and post, GEMINI was used to compare explanations. The resulting summaries were cleaned based on the evaluator's interpretation of accuracy within the summaries; however, additional review would be necessary by subject matter experts to support the interpretations.

Ownership Rights of Scientists/Countries

Nine out of 10 students who completed the post-survey indicated *No* to the question "Do you think scientists or countries developing gene edited crops should 'own' the rights for commercial use of these plants?" – Figure 11. For these students, 5 out of the 10 had also indicated *No* at pre, one changed their response from *Yes* to *No*, and one student did not complete the pre-survey. The single *Yes* at post remained constant from their pre-response. Additionally, three students who completed a pre-survey did not complete a post-survey, with a mix of *No* (2) and *Yes* (1).

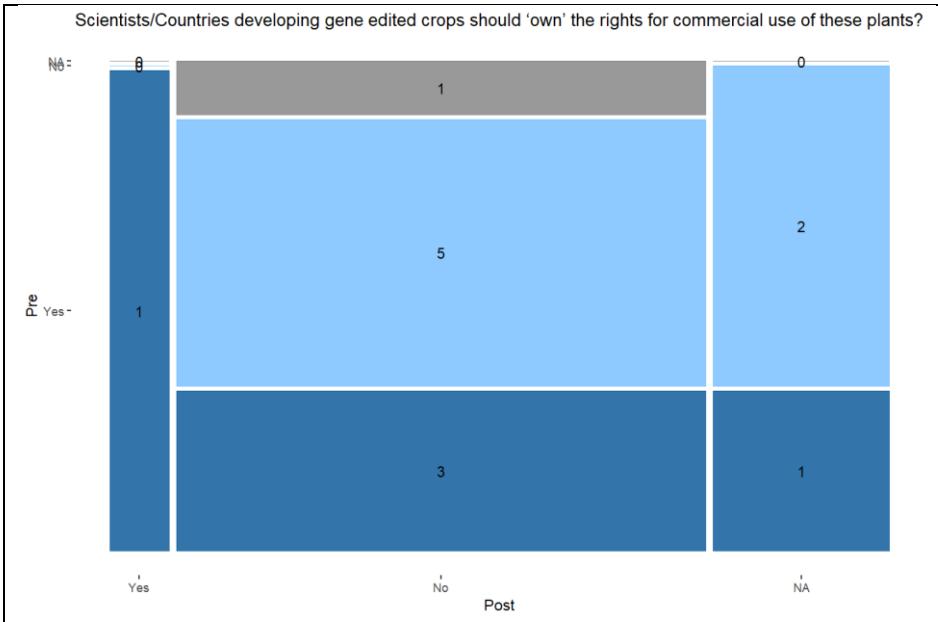

Figure 11. Mosaic plot illustrating the distribution of responses to the question, "Do you think scientists or countries developing gene edited crops should 'own' the rights for commercial use of these plants?" The x-axis categorizes the post-survey responses, while tile color represents the pre-survey responses color coded as dark blue (■) for *yes*, light blue for *no* (■), and missing (*NA*) color coded grey (■).

Summary of supported explanations using GEMINI:[1]

The major thematic elements across all responses highlight a central tension between rewarding innovation and ensuring the public good and widespread benefit from gene-edited crops. Significant concerns revolve around access and equity, particularly the fear that ownership by a few (scientists, countries, or large companies) could lead to monopolies, control, and prohibitive costs, thereby restricting availability for farmers in developing countries and small-scale operations. Counterbalancing this is the acknowledgment that developers deserve recognition and reward for their investment. However, there's a strong push for these technologies, especially those addressing global challenges like hunger and climate change, to be considered for the "benefit of living beings," fostering collaboration and further development through open or shared access. This leads to suggestions for mechanisms to balance these interests, such as collaborative licensing, while underlying ethical considerations question whether prioritizing profit over societal benefit might exacerbate existing inequalities.

GMO Classification of Gene-Edited Plants

Six out of 10 students who completed the post-survey indicated *Yes* to the question "*Do you consider gene edited plants to be genetically modified organisms (living things)?*", see Figure 12. For these students, five had also indicated *Yes* at pre and one did not have a pre-response. Of the four students indicating *No* at post, three of the students changed their response from *Yes* at pre. Additionally, three students who completed a pre-survey did not complete a post-survey, with a mix of *No* (2) and *Yes* (1).

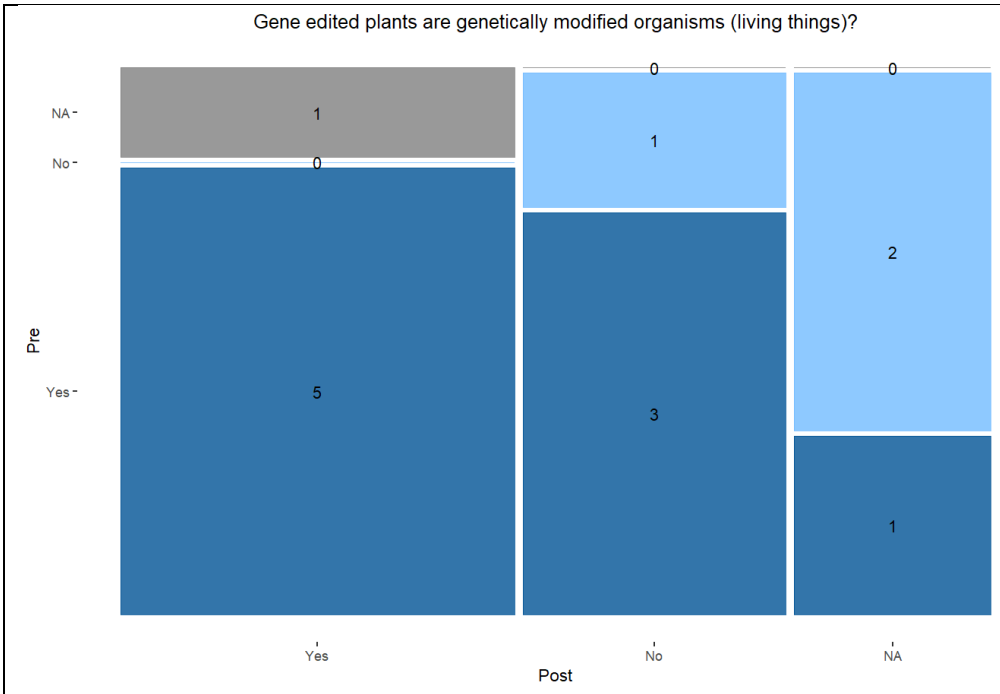

Figure 12. Mosaic plot illustrating the distribution of responses to the question, "Do you consider gene edited plants to be genetically modified organisms (living things)?" The x-axis categorizes the post-survey responses, while tile color represents the pre-survey responses color coded as dark blue (■) for *yes*, light blue for *no* (■), and missing (*NA*) color coded grey (■).

Summary of supported explanations using GEMINI:[1]

Based on students' explanations, the major thematic elements revolve around the definition and classification of genetically modified organisms, particularly in light of newer gene editing technologies. A core understanding is that any human-induced change to an organism's genetic material constitutes a genetic modification, a viewpoint often linked to the intentionality of human intervention. However, a significant differentiating factor is the presence or absence of "foreign DNA" (transgenesis), with many arguing that gene editing techniques like CRISPR, which offer high precision and can result in changes similar to natural mutations without introducing foreign genes, should be distinguished from traditional GMOs. This leads to a noticeable regulatory and definitional ambiguity, reflecting the ongoing debate and differing perspectives on how to categorize organisms modified by these advanced, precise techniques.

Environmental Threat of Gene-Edited Plants

Nine out of 10 students who completed the post-survey indicated *No* to the question "In your opinion, are gene edited plants a threat to the environment?" – Figure 13. For these students, six out of the nine had also indicated *No* at pre and three students changed their response from *Yes* to *No*. The one *Yes* response at post did not have a pre-response, and all three students who completed a pre-survey but did not complete a post-survey indicated *Yes* at pre.

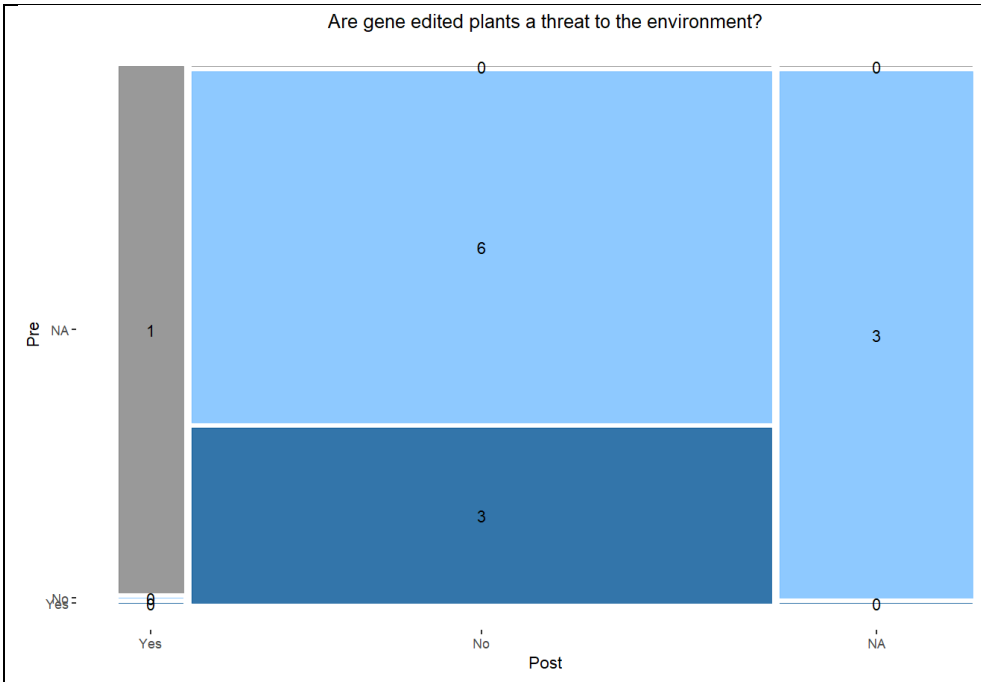

Figure 13. Mosaic plot illustrating the distribution of responses to the question, "In your opinion, are gene edited plants a threat to the environment?" The x-axis categorizes the post-survey responses, while tile color represents the pre-survey responses color coded as dark blue (■) for *yes*, light blue for *no* (■), and missing (*NA*) color coded grey (■).

Summary of supported explanations using GEMINI:[1]

The major thematic consensus is that gene-edited plants are not inherently a threat, but their safety is conditional, primarily hinging on robust regulation, thorough testing, and ongoing oversight. While potential risks—such as gene flow to wild relatives creating "superweeds," plants becoming invasive, unforeseen ecological impacts, and harm to non-target organisms—are clearly acknowledged, these are often weighed against significant potential benefits. These benefits include reduced reliance on chemical inputs, enhanced crop resilience and adaptability (e.g., to climate change), improved resource efficiency, contributions to sustainable farming, and even biodiversity preservation by lessening the need for agricultural expansion. The source of threat is often attributed more to the potential for misuse of the technology than the technology itself, with some comparing gene editing to natural processes, suggesting a lower intrinsic risk. Ultimately, a benefit-versus-risk assessment is deemed crucial, with a general sentiment that benefits can outweigh potential threats if risks are properly managed, though a distinct concern for occupational hazards to researchers was also noted separately from environmental impacts.

Interest, Career, and Knowledge Impact

10 out of 10 students indicated the course **increased their interest in the field of genetic engineering**.

Students' explanations indicate the course successfully fueled their interest by making genetic engineering both understandable and relevant.

Comments included:

- *Yes, this course definitely increased my interest in the field of genetic engineering. Learning about the science behind gene editing and its real-world applications—especially in agriculture —was exciting and eye-opening.*
- *Learning about the precision and real-world applications of CRISPR deepened my curiosity and inspired me to explore more about its potential in agriculture and plant science research.*

9 out of 10 students indicated that completing the AGSC 4630/5630 course **influenced their major or career interests.**

Students' explanations indicate that the exposure to CRISPR technology and its applicability to real-world issues helped shaped their academic and professional aspirations.

Comments included:

- *The course deepened my understanding of applied agricultural biotechnology and inspired me to integrate genome editing and data-driven tools into my research. It affirmed my interest in pursuing advanced plant breeding and genetics.*
- *It deepened my understanding of molecular biology and the potential of genome editing in agriculture and medicine. The hands-on experience with CRISPR technology not only strengthened my interest in genetic engineering but also inspired me to consider a career in biotechnology research or crop improvement. The course showed me how cutting-edge science can be applied to solve real-world problems, which was both motivating and enlightening.*

10 out of 10 students indicated they **could explain gene editing concepts** to their family and friends.

Students' explanations indicate that they feel equipped to discuss gene editing due to a solid grasp of core concepts provided through their academic experiences.

Comments included:

- *I have gained a good understanding of gene editing, especially CRISPR-Cas9, through academic courses and research exposure. I feel confident explaining the basics, how it works, its benefits, and ethical considerations, in a simple and relatable way.*
- *I feel I have a basic understanding of gene editing and could explain the main ideas—like how scientists can change parts of a plant's DNA to improve traits such as yield, nutrition, or disease resistance.*

10 out of 10 students indicated they **would recommend this course** to another student.

Students' explanations indicate they would recommend the course because of the content material, engaging and practical teaching methods, positive learning environment, and overall experience as valuable and relevant.

Comments included:

- *The course provides a strong foundation in gene editing, particularly CRISPR-Cas9, combining theoretical knowledge with hands-on experience. It's highly relevant, well-structured, and valuable for students interested in modern biotechnology.*
- *Yes, it is a great learning experience.*

Course/Lab Suggestions

Four of the five responses to "*Do you have any suggestions for improving the CRISPR-Cas9 gene-editing learning materials?*", were positive feedback indicating satisfaction with the current technical content and teaching approach. The only suggestion offered related to enhancing learning materials by incorporating more real-world case studies and recent scientific breakthroughs to improve the connection between theoretical concepts and current applications.

> *Include more real-world case studies and recent breakthroughs to help students connect concepts with current applications.*

Three of the five responses to "*Do you have any suggestions for improving the CRISPR-Cas9 lab practical?*", were positive feedback affirming that the lab practical is sufficient and valuable. The other two responses included 1) Providing lab protocols to students in advance to allow for prior study and better preparation and 2) incorporating a basic data analysis component into the lab practical to help students connect experimental outcomes with scientific interpretation.

> *Lab protocols should be sent to us in advance for study.*

> *If possible, incorporate a simple data analysis section to link lab outcomes with scientific interpretation.*

APPENDIX

Open-ended responses for Pre and Post Surveys

How do you define a scientist?

Pre	Post
A person learned in science and especially natural science	Someone who is curious and strives to solve mysteries of universe.
A scientist is someone who systematically gathers and uses research and evidence, to make hypotheses and test them, to gain and share understanding and knowledge.	A scientist is an individual who systematically investigates and explores the natural world through observation, experimentation, and analysis.
A person who investigates in solving issues systematically and provides evidence-based reasoning.	A scientist is someone who asks questions and looks for answers about how things work.
A scientist is a person who experiments, collects data, analyzes the data, and draws conclusions based on the outcome of analyzed data.	Scientist is a person who conducts well planned experiment, collect data, analyze the data and present it to the world.
Scientist is someone who systematically gathers and uses research and evidence, to make hypotheses and test them, to gain and share understanding and knowledge	In my opinion A scientist is more persistence, think of every aspect why it happened like that why didn't happen like that also always think about public benefit.
A scientist is someone who has a knowledge of science and harnesses this knowledge to solve world challenges based on his/her chosen specialization.	A Scientist is someone who studies science and finds ways to improve it through research.
A scientist is a person who researches to advance their knowledge in an area of the natural or physical sciences.	A scientist is a person who systematically investigates the natural world to develop knowledge, explain phenomena, and test hypotheses using empirical methods, such as observation, experimentation, and data analysis.
A scientist is someone who seeks to comprehend natural world utilizing a systematic approaches and critical thinking to solve or minimize the real-world issues.	A scientist is someone who systematically investigates natural phenomena through observation, experimentation, and analysis to develop knowledge, solve problems, or create new technologies.
To me, scientists are individuals who dedicate their time and efforts to researching and studying topics especially the noble one that aim to improve the well-being of the environment and all living creatures, including plants and animals. They are driven by a passion for discovery and knowledge, constantly seeking solutions to the challenges faced by the world. Scientists work across various fields, from ecology to medicine, with the ultimate goal of advancing human understanding and promoting sustainability. Their discoveries have the power to make a lasting, positive impact on the planet, ensuring a better future for all life forms.	Scientist are the one who innovate new idea, perform research on it to have meaningful conclusion.

Pre

- A scientist is an individual who is curious, sincere and optimistic professional individual. In my own opinion, a scientist must have the ability to comprehend the importance of thinking outside of the box scenario. For instance, Wright Brothers for making this possible to be called the first human being to fly in the open sky. Nowadays, it is so amazing to think about travelling from one country to another within hours. How far a human brain can function and can compromise the restriction of our social barriers! To answer this question, it is only possible if a curious and honest mindset can work equivalently. In modern plant breeding, we consider Gregor Johann Mendel as the founder of modern Genetics. He relentlessly worked on identifying the phenotypic and genotypic combinations of peas. It is a daunting and persistent work to conduct. In professional definition, a scientist will be described as an individual who will conduct an experimentation, analyze the data, evaluate the data, reconstruct the experimentation, drawing conclusion for the result showed. However, a scientist has the x-factor that can only be a curious and sincere individual can bring into world for the benefit of human kind. From the famous Albert Einstein to a hard-working person, the factor we all looking for is to be honest about the elemental combination of finding an absolute truth for bigger and brighter future that will sustain for generation after generation.
- Scientist are the person who systematically conducts experiments or research and gathers and analyze data to test hypothesis.
- A scientist is someone who explores the world through observation and experimentation, using evidence to answer questions and solve problems.

Post

- Someone who systematically gathers and uses evidence to study special area of question in the world. Who can design experiment, conduct experiment by using scientific method, analyzing data, and drawing conclusions.

Do you see yourself as a scientist? Please explain.

Pre - YES	Post - YES
Yes, I am a scientist. I am an agricultural graduate, and I am working continuously to advance my knowledge in the field of plant science so that I can contribute to the broader agricultural community.	I am a scientist. I am deeply involved in soil health analysis, statistical analysis, agricultural research, manuscript writing. So, by methods and mindset I am a scientist.
I do consider myself as a scientist because my work is involved with research, experimentation, observation and data analysis, and somewhat tends to solve real world issues. However, let take me put it this way, I would say I am on my way to becoming a scientist.	As a graduate research assistant actively engaged in genomic studies, fieldwork, and data analysis, I apply scientific methods to answer research questions and contribute to agricultural science, which aligns with the role of a scientist.
Anyone who contributes, even in small ways, to improving the well-being of living creatures or the environment, or who is consistently striving to make new discoveries, can be considered a scientist. Since I, too, am conducting research on topics that aim to benefit humans, animals, and the environment, I believe we can all be regarded as scientists.	Yes, I am also a part of scientist as I am doing research to have some meaningful conclusion
Yes, I consider myself a scientist because I conduct experiments, analyze data, and work to understand biological processes.	
I consider myself a scientist as i apply my knowledge of science to contribute to solutions in my field of animal science	
	I am someone with complete patience and determination to uncover answers in a world full of mysteries. I am driven by a deep curiosity to explore the unknown, ask meaningful questions, and seek understanding through careful observation and study.
	I conduct well thought experiments, collect data and present my findings to the world.

Pre - NO	Post – I AM NOT SURE
	All I can say I have a lot to learn and know before calling myself a scientist.

Pre - I AM NOT SURE

- I am working in the field of agriculture research and completed few researches in the past.
- I consider myself as a hard working as well as smart working individual. I try to find out solution towards a problem. The relentless commitment and persistent mental aptitude is required for bringing out the best in possible outcome in every field of study-Agriculture, food, disease, health, medicine so on. I believe to address myself as the a potential professional person who knows how to conduct an experimentation and finding out the probable solution towards a problem in my field of study.

Post - YES

- I have specific knowledge in tomato proteomics study, I already done protein extraction et.al things. I can conduct my experiment systematically.

How would you define biotechnology?

Pre	Post
According to my understanding, Biotechnology is the use of different technology on improving the performance (either qualitative or quantitative) of biological thing including plant, animals.	Biotechnology is the use of technology on biological organism to have some useful product
Agricultural biotechnology is the application of scientific techniques and tools, including genetic engineering, molecular markers, tissue culture, and bioinformatics, to improve plants, animals, and microorganisms for agricultural purposes.	The use of living organisms, or their derivatives to develop products, improve processes, or solve problems.
Application of biology in human, plants, animals	In my opinion, biotechnology is the application of technology to modify living organisms in order to develop new products, processes, or technologies.
Biotechnology is technology based on biology	Re-engineering natural elements for human benefits.
Biotechnology is the application of molecular biology studies and techniques to improve human's existence in several facet of life.	Biotechnology is the study of activities of an organism's cell and its application to solve problems.
Biotechnology is the application of technology to improve biology or agriculture.	Biotechnology involves the application of technological tools or methods to biology or life science
Biotechnology is the use of biological systems, organisms, or their derivatives to develop products and technologies that improve human life, agriculture, health, and the environment.	Biotechnology is the application of biological systems, organisms, or derivatives to develop or create products and technologies that benefit human life and the environment.
Biotechnology is the utilization of the biological components to improve or develop innovative tools to improve the agricultural, healthcare and environmental fields.	Biotechnology is the use of biological systems, organisms, or derivatives to develop or modify products and processes for specific human purposes.
The use of advances in molecular biology for applications in human and animal health, agriculture, environment, and specialty biochemical manufacturing.	Biotechnology is a science that can improve the quality of life by studying at the microorganism level, and changing their genetic nature for benefit of human.

Pre

- Biotechnology is the use of living things or their parts to create products and solve problems, like in medicine or farming.
- Biotechnology is the use of loving organisms, cell or biological procedures to create product and modify organism in human, social, and environmental benefit.
- It is a combination of technology that will be used in a controlled fashion to generate multi-production for the humankind, for instance- high yielding crop, disease free crop and so on in short period of time.

Post

- The use of biological systems, organisms, or their components to develop products and technologies that improve human life and the environment. CRISPR should be a special method to improve plant trait, curing diseases

What do you think are the main social and ethical implications of biotech research?

Pre	Post
Biotech innovations like the genetically modified organisms (GMOs) can disrupt ecosystems or lead to biodiversity loss.	Genetic Privacy, Access and Equity, Environmental Risks, ethical use of gene editing, Animal Welfare, Public Trust and Misinformation Mistrust
concerns about the privacy of genetic information, equitable access to biotech advancements	Environmental impact and completer disclosure are important.
Cultural and religion concern	One important social and ethical concern of biotechnology is whether new medical treatments or agricultural technologies will be available to everyone or only to those who can afford them.
Lack of trust in scientist and fear of agro-terrorism	Preference, Lack of education/awareness, Misinformation on biotechnology tools
Manipulation of God's creatures	Concealing scientific findings
Misuse of this technology	Biotechnology has the power to solve major problems, it must be guided by strong ethical standards, public engagement, and thoughtful regulation to avoid harm and ensure it benefits everyone fairly.
The main social and ethical implications of biotech research include concerns about food safety and impact of genetically modified organisms (GMO). The main social and ethical implications of biotech research include equitable access to innovations, privacy concerns in genetic data, environmental impact, ethical debates on genetic manipulation, and the risk of exacerbating global inequalities. The main social or ethical implication which i think is prevalent in biotech research is manipulation of gene which influences the overall performances of the individual whose gene is being manipulated.	Biotech research raises concerns about food safety, environmental impact, intellectual property rights, and equitable access. Ethical issues also involve informed consent, potential misuse, and public trust in new technologies. Environmental Impact: GMOs could disrupt ecosystems and biodiversity. Health and Safety: Long-term effects of biotech products on health need careful assessment. Inequality: Expensive biotech innovations may limit access for lower-income populations. Main social and ethical implication is if the edited crop disturb the natural ecosystem and perceived health and environmental risk that may be associated with edited crops unintentionally.

Pre

- The social adaptability and mentality to opt for genetically modified crop or biotech crop restricted with social awareness, religious concerns, superstitious belief, preservation of the original stature of species
- Misuse of Biological/ genetic information. Production of GMO have impact on biodiversity and environment. Misuse of or Privacy issue with human genetic information.
- Biotech research raises concerns about genetic privacy, misuse of modifications, environmental impact, and fair access to its benefits.

Post

- Genetic privacy and consent – As genetic data becomes more accessible, concerns arise about how it's used, who owns it, and whether individuals have given informed consent.

Do you believe plant biotechnology has the potential to positively impact agriculture and food production? [Please explain your answer.]

Pre - YES	Post - YES
Genetic manipulation including editing gene of plants has the potential to positively impact agriculture and food production since, gene editing can precisely and accurately manipulate the plant gene without any changes in the gene that are needed to be conserved. In other words, unwanted traits which are inherited conventional breeding practices like hybridization, crossing can be eliminated in gene editing techniques. hence, i think genetic manipulation has potential to positively impact agriculture and food production	Yes, I believe it will help in sustainable agriculture
I do believe plant biotechnology has immense potential to address global problems related to agriculture by improving disease and pest resistance and tolerance, also adapting plants to changing climates.	Biotechnology can improve crop yield, stress tolerance, disease resistance, and nutritional content, offering sustainable solutions to global food security and climate challenges.
Improve plant resistant to insect pest and diseases to reduces pre and post-harvest losses.	It helps to produce plants resistant to abiotic and biotic stress with improved nutrient and yield.
Increased Crop Yields: Genetic manipulation can enhance crop productivity, helping to meet the food demands of a growing global population. Pest and Disease Resistance: Gene editing enables plants to develop resistance to pests and diseases, reducing reliance on chemical pesticides and improving sustainability. Climate Resilience: Crops can be engineered to tolerate extreme weather conditions, such as drought or salinity, ensuring stable food supplies in the face of climate change. Nutritional Enhancement: Biotechnology can fortify crops with essential nutrients, addressing malnutrition in vulnerable populations. Sustainability: Reducing the need for chemical inputs and increasing efficiency in land and water use contributes to environmentally sustainable farming practices.	By enabling precise modifications to plant genomes, gene editing technologies like CRISPR can enhance crop traits, such as resistance to diseases, pests, and environmental stresses (e.g., drought or salinity). This can lead to higher crop yields and more sustainable farming practices. Gene editing can also improve the nutritional content of crops, increase shelf life, and reduce reliance on chemical pesticides or fertilizers, which benefits both the environment and human health. Additionally, by developing crops that are more resilient to climate change, plant biotechnology can help ensure food security in the face of growing global populations and changing environmental conditions.
Yes, plant biotechnology has significant potential to positively impact agriculture and food production. Gene editing can enhance traits such as drought resistance, pest resistance, and nutrient utilization efficiency, leading to higher crop yields and improved food security, especially in areas vulnerable to climate change. Biotechnology can be used to enhance the nutritional profile of crops. By making plants more resistant to pests, diseases, and environmental stresses, gene editing could reduce the need for harmful pesticides and chemical fertilizers. However, it's important to approach these advances with caution, ensuring proper regulations and safety protocols are in place to address environmental, ethical, and social considerations.	
	For a rather quick and long-lasting impact gene editing tech can play key role in battle against global hunger and ensuring food security.

Pre - YES

- Plant biotechnology, including gene editing, has the potential to improve crop yields, enhance resistance to pests and diseases, and contribute to more sustainable food production.
- Gene editing helps to create crop variety with desirable traits (high yielding, stress tolerant) within very short period of time in comparison with traditional plant breeding.
- We need more food than before as the population is increasing than before. To feed the whole world we cannot choose and pick. However, the social class and economic standard will always play a crucial part in our life. The over arching path of feeding the population a quality food in a short period of time is crucial human nature. The environmental and climate change has unsurmountable impact on our food production and survival. Every pollution and degradation of our planet earth creating threat to our own existence.
  We need more genetically modified with quality assured food for every human being. Food and diet can be a regulatory medicine for our wellbeing. A science to food only be our own medicine.

Post - YES

- Yes, it will Increase crop yields to feed a growing population, improve resistance to pests, diseases, and harsh climates, reducing the need for chemical pesticides. Enhance nutritional value of crops, helping to fight malnutrition. Reduce food waste by making crops last longer during storage and transport

Do you think scientists or countries developing gene edited crops should 'own' the rights for commercial use of these plants? [Please explain your answer.]

Pre - YES	Post - YES
	I believe people who have invested their lives on development of such tech or crops should have the greater say in it.

Pre - YES	Post - No
Yes, but should be made available upon a reasonable request and discussion	It will be costly for ordinary farmers to benefit from these technologies.
	Strict ownership can limit access, particularly for farmers in developing countries who might benefit most from improved crops

v - NO	Post – NO
I don't think scientist or countries developing gene edited crops should own the rights for commercial use of these crop. Since these crops are made for the benefit of living beings so natural resources should be available for use to everyone. however, it should be taken care of if they are being misused and the one who developed gene edited crops should always be acknowledged while using those crop.	They should have right to some extent, but it should also be available to other for its research and exploration as well as for commercialization so that every people will have access to it.
The monopoly of the rights to gene edited crops might restrict access for farmers in developing regions, thus collaborative licensing agreements should be applied to ensure equitable accessibility.	While innovation should be rewarded, exclusive ownership can restrict access for farmers and developing countries. Public benefit should take precedence, especially for essential food crops.
scientists or countries developing gene-edited crops should not exclusively "own" the rights for commercial use. Instead, a balanced approach is necessary to promote innovation while ensuring equitable access. Global Food Security: Exclusive ownership could limit access to critical agricultural technologies, especially for low-income farmers and countries. Ethical Concerns: Patenting gene-edited crops may prioritize profit over societal benefit, potentially exacerbating inequalities in global food systems. Encouraging Collaboration: Open or shared licensing models can foster international collaboration, accelerating advancements in agricultural biotechnology. Public Good: Crops designed to address global challenges like hunger or climate change should be treated as public goods, with benefits shared widely.	No, scientists or countries should not have exclusive ownership rights over gene-edited crops for commercial use. Such ownership could limit access, especially in developing countries, and hinder global collaboration. Crops developed for public benefit should be widely available to address food security and environmental challenges. While scientists deserve recognition for their work, the broader impact of these innovations should not be restricted by commercial interests.
If gene-edited crops are patented and controlled by a few large companies, this could limit access to small-scale farmers in developing countries. It could also increase food costs or lead to monopolistic practices. The public good should be considered when addressing food security.	

Pre - YES

- Gene editing is a scientific technique and development of gene editing crops requires creativity of scientists as well. Thus, these are creation of scientists, eligible for Patent and copyright.

Before - NO

- The rights for commercial use of gene-edited crops should be shared to ensure broader access, promote innovation, and prevent monopolies that could limit the benefits of these technologies to all.
- The knowledge of producing and developing new kind of crops can shared with country who are less fortunate. Like for my country Bangladesh. A developed country can only have the generous heart to share the food with less privileged nation. The right can be owned but the sharing and contributing in building a greater nation would surely supports others.

Post - NO

- It can limit access for farmers, especially in developing countries, and create dependence on big corporations. A fair approach might be to balance intellectual property rights with public benefit

Do you consider gene edited plants to be genetically modified organisms (living things)? [Please explain your answer.]

Pre - YES	Post - YES
On genetic level, of course gene edited plants can be considered as GMO since there genetic makeup is altered.	Although gene edited plants may not involve foreign DNA, their genomes are still altered by humans using tools like CRISPR, making them genetically modified.
On genetic level, of course gene edited plants can be considered as GMO since there genetic makeup is altered.	Although gene edited plants may not involve foreign DNA, their genomes are still altered by humans using tools like CRISPR, making them genetically modified.
gene-edited plants are genetically modified organisms (GMOs) because their genetic material has been altered through human intervention. However, they differ from traditional GMOs in significant ways: Precision of Edits: Gene editing techniques like CRISPR make precise changes without introducing foreign DNA, unlike traditional GMO methods that often involve transgenic modifications. Regulatory Perspectives: Some regulatory bodies classify gene-edited plants differently, as the changes can mimic natural mutations. Nature of Modification: While the methods vary, both involve modifying genetic material to achieve desired traits, fitting the definition of genetic modification.	
because their genetic material has been altered through biotechnological methods.	
	I consider gene-edited plants to be genetically modified organisms (GMOs) because their DNA has been intentionally altered by humans. However, gene editing, like CRISPR, often makes very small, precise changes without adding foreign DNA, which is different from traditional genetic modification. So while they are technically modified, gene-edited plants are often closer to natural mutations than to conventional GMOs.
	Well, I wish there was another option. My answer would have been it depends whether there are foreign genes inserted into the plant or not.

Pre - YES	Post - No
Since there is genetic modification or manipulation, so gene edited plants can be considered to be genetically modified.	Until and unless there is no presence of foreign gene i did not consider it genetically modified.
Yes, gene-edited plants are considered genetically modified organisms (GMOs). Gene-edited plants involve precise changes to the plant's genetic material using techniques like genetic engineering, which allow for targeted modifications to existing genes. While gene editing does not introduce new genes from other species like the GMOs but rather edits or removes existing ones within the plant's own genetic code. However, they still classify them as GMOs.	

Pre - NO	Post – NO
	I do not...

Pre - NO

- As per my knowledge, genetically modified organisms are developed by incorporating gene of different genus of organism into target organism. However, gene editing uses single genus of Organism.
- That depends on how we are using and making use of it. We can cross out a gene that is not desired as insect free plant but the crop cannot be altered.

Post - YES

- Yes, gene-edited plants are considered genetically modified organisms (GMOs) because it involves insertion of foreign gene always.

In your opinion, are gene edited plants a threat to the environment? [Please explain your answer.]

Pre - NO	Post – NO
Particularly, gene edit is done for the benefit of environment as whole by conserving beneficial traits and discarding harmful ones. however, if these techniques are misused then it may lead serious threat to the environment.	However, proper study and test should be done before there release to natural environment so that they won't turn into invasive species.
Gene edited plants when carefully studied and regulated are not a threat to environment. In fact, they can contribute to environmental sustainability by minimizing the need of chemical inputs, enhancing tolerance and adaptability.	When properly regulated, gene edited plants can reduce chemical usage, enhance resource efficiency, and support sustainable farming. Risks should be assessed, but overall, benefits outweigh threats.
Gene-edited plants are not inherently a threat to the environment, but they do require careful oversight, testing, and regulation to ensure they are safe and beneficial. For example, if a gene-edited crop becomes invasive or outcompetes native plant species, it could reduce biodiversity. If gene-edited crops have traits such as herbicide resistance, there is a risk that these traits could be transferred to weed species, creating "superweeds" that are harder to control. In my opinion, while gene-edited plants present some potential risks, these can be managed with proper regulatory frameworks, research, and environmental safeguards.	
Gene-edited plants are not inherently a threat to the environment, but their potential impact depends on how they are developed, regulated, and used. Reduced Chemical Inputs: Gene-edited plants can reduce reliance on pesticides and fertilizers, lowering environmental pollution and improving sustainability. Biodiversity Preservation: Crops designed for specific climates or soils can help protect natural ecosystems by reducing the need for agricultural expansion. Potential Risks: Unintended consequences, such as gene flow to wild relatives, could affect ecosystems if not properly managed. Regulation and Monitoring: Robust regulatory frameworks and scientific evaluation can mitigate risks and ensure environmental safety.	
	Gene-edited plants are not inherently a threat to the environment if properly regulated. With careful testing and monitoring, they can offer benefits like improved resilience and reduced pesticide use, minimizing environmental risks.

Pre - YES	Post - No
It is harmful to those who produce then through research in the laboratory due to the chemicals, these researchers are exposed to determine a resistant gene.	
	No, because gene edited crops ultimately are form of mutation introduce in the environment and the world has witnessed existence of naturally mutated crop plants for centuries.
Well, I could choose Yes and No because, in maintaining the hierarchy of life, certain species like insects may loose the ability to benefit from plants that are genetically engineered thus causing a ripple effect on their survival and impacting the environment. On the other hand, the benefits of genetically edited plants may reduce the incidence of pests that are actually harmful to the environment.	

Pre - NO

- Gene-edited plants are not inherently a threat to the environment, as they can be designed to improve crop resilience and reduce the need for harmful pesticides. However, their impact depends on how they are used and regulated.
- I believe the answer is no. However, there are many negative connotation with gene edited plants. Nationwide trial and experimentation is required. A repeated active trial and balance check is needed. Expert professional and quality assurance should be maintained. Environmental factors needs to be in consideration for each nation. How changing environment and climate plays crucial part in modifying genetic make up of an species in concern.

Post - YES

- It will improve some trait of plant, but like CRISPR technique, off target always emerge. It should have some unexpected result to environment.

What type of career(s) are you interested in pursuing after completing your academic major?

Pre	Post
After completing my major, I aim to pursue a career in the industry, with a primary focus on gene editing and research essential for varietal development.	I want to be research scientist
Research scientist	Research scientist
Microbial biotechnology	Researching
R&D	R & D or industry related
I want to pursue a career as a research scientist in the field of agriculture, particularly in fields like plant molecular genetics, plant pathology, and bioinformatics.	I am interested in pursuing a career as a plant scientist, either in research institutes or within the agricultural industry.
A Professor	Professor
Research scientist, Professor of Animal Science, Drug Discovery Expert	Research Scientist(Animal health and Diseases)
Scientist	Scientist
Biotechnology Scientist	I am interested in pursuing a career in the biotechnology industry.

Pre

- Focusing on plant biology, plant-microbe interactions, and sustainable agricultural solutions.
- Academic and Research
- Being an professional at conducting Bioinformatics, programming & DNA sequencing

Post

- To be a professor in one university.

Did taking the AGSC 4630/5630 Course influence your academic major or career interests? [Please explain your response.]

Yes

> After taking this class, I am much more fascinated towards the science behind the CRISPR Cas, and even more interested to learn more about it in near future and pursue my career in this sector

> The course deepened my understanding of applied agricultural biotechnology and inspired me to integrate genome editing and data-driven tools into my research. It affirmed my interest in pursuing advanced plant breeding and genetics.

> It stirred a passion in me, wanting for more

> The course was a unique learning experience empowering my hunger for knowledge and perfection.

> It deepened my understanding of molecular biology and the potential of genome editing in agriculture and medicine. The hands-on experience with CRISPR technology not only strengthened my interest in genetic engineering but also inspired me to consider a career in biotechnology research or crop improvement. The course showed me how cutting-edge science can be applied to solve real-world problems, which was both motivating and enlightening.

> Yes, taking the AGSC 4630/5630 course influenced my academic and career trajectory. I had a deep interest in molecular biology and taking this course further sparked my interest.

Do you feel that you have enough information on gene editing to explain the concepts to your family and friends? [Please explain your answer.]

Yes

- To some extent I believe I have the concept to explain to family and friends.
- I have gained a good understanding of gene editing, especially CRISPR-Cas9, through academic courses and research exposure. I feel confident explaining the basics, how it works, its benefits, and ethical considerations, in a simple and relatable way.
- I can explain this concept to family and friends based on the knowledge I have gained through CRISPR.
- Yes, I do have enough knowledge of fundamentals and dynamics of this tech, thanks to this course.
- I feel I have a basic understanding of gene editing and could explain the main ideas—like how scientists can change parts of a plant's DNA to improve traits such as yield, nutrition, or disease resistance.

Would you recommend this course to another student? [Please explain your answer.]

Yes

- The course provides a strong foundation in gene editing, particularly CRISPR-Cas9, combining theoretical knowledge with hands-on experience. It's highly relevant, well-structured, and valuable for students interested in modern biotechnology.
- Yes, it is a great learning experience.
- It is really interesting. The class atmosphere is so good. We can learn a lot from class.
- Yes, definitely.
- Highly recommended
- A friend with science background

Did this course increase your interest in the field of genetic engineering? [Please explain your answer.]

Yes

- Yes, this course definitely increased my interest in the field of genetic engineering. Learning about the science behind gene editing and its real-world applications—especially in agriculture —was exciting and eye-opening.
- Learning about the precision and real-world applications of CRISPR deepened my curiosity and inspired me to explore more about its potential in agriculture and plant science research.
- To produce plant resistant to microbes.
- It absolutely increases my interest
- Yes, it does.

Do you have any suggestions for improving the CRISPR-Cas9 gene-editing learning materials?

- Include more real-world case studies and recent breakthroughs to help students connect concepts with current applications.

- So, far the course in its technicality and teaching approach looks perfect.
- Overall, I feel this course has been the best platform for me to gain both technical and practical knowledge.
- No, I don't think so. everything we had in class is good to understand the concept very well.
- I preserve all thing good enough

Do you have any suggestions for improving the CRISPR-Cas9 lab practical?

- Lab protocols should be sent to us in advance for study.
- If possible, incorporate a simple data analysis section to link lab outcomes with scientific interpretation.

- Practical are up to the standards of graduate teaching at this level. Enjoyed it all.
- No, it already good enough, we cloned one gene already. At least, we know the whole procedure of clone.
- No, I don't have any.