

Investigate poultry challenges

How can poultry farmers keep up with consumer demand in the food industry?

What challenges have we faced in growing food throughout human history?

How might farmers use genetics to solve these on-farm challenges?

Standards

B.H.5: Modern genetics

Introduction

Poultry farmers face a multifaceted set of challenges that require a combination of good management practices, technological adoption, effective disease control, and adaptability to market and environmental changes. These challenges can impact productivity, profitability, and the overall sustainability of poultry farming operations. Addressing these challenges requires continuous learning, investment, and strategic planning to ensure sustainable and profitable poultry farming operations. By 2050, it is estimated that there will be over 10 billion people on the planet. We do not have additional land on which to grow or produce more food. Modern chicken breeding practices utilize a combination of traditional techniques and cutting-edge technologies to enhance productivity, health, and adaptability. Selective breeding and hybridization remain foundational, but should genetic selection, gene editing, and other advanced methods be used to meet the growing demand for poultry production? These practices could address challenges related to disease, feed efficiency, and environmental sustainability.

Student prior knowledge

- Students should have completed an introductory lesson on inheritance and basic Mendelian genetics. Students need to understand that an organism's inheritance pertains to alleles being passed from parent to offspring during sexual reproduction.
- Students should have a basic understanding of spontaneous changes in an organism's DNA that may or may not pass from parent to offspring due to Mendelian genetics and basic genetic law assumptions.
- Human technology has an impact on an organism's genotype and phenotype.
- Selective breeding involves choosing parent chickens with desirable traits to produce offspring that inherit those traits. This practice has been foundational in developing specialized breeds for meat (broilers) and egg production (layers). Hybridization involves crossing different breeds or lines of chickens to produce hybrids that exhibit hybrid vigor (heterosis). This practice is common in commercial operations to achieve superior performance.

Suggested Timeline

1–3 class periods (50–150 minutes)

Materials

- Poultry challenge cards
- Chicken breed cards
- Student KWL chart
- Computers for research

Teacher preparation

Print out handouts or upload digital copies.

Procedure

DAY 1

1. Pose the question: What challenges or problems have we faced in growing food throughout human history? Give some examples: not enough rain, too much rain, harvesting crops by hand took a long time, using horses to pull plows was hard work. Give students two minutes to brainstorm on their own, then group brainstorm for three minutes with their table. Give each group a chance to share what they believe is the biggest challenge on their list.
2. Ask: What are the current challenges in agriculture or food production? (i.e. food may have lower nutrient content; soil may not be able to grow enough food) Have them again brainstorm on their own for two minutes, then group brainstorm for another three minutes. Collect their challenges on a document, parking lot, or Jamboard to revisit.
3. Briefly discuss different ways that scientists have selectively bred chickens. Use the chicken cards to discuss how students would selectively breed chickens for problems they discussed if possible.
4. Have students take out the KWL chart before assigning each type of genetic technology. Students will take note of what they know, what they want to know (questions), what they learn, and ethical issues after researching.
5. The teacher will assign various technologies for altering the genetics of plants/animals to student groups.
6. Students will use research materials to gather information on each type of genetic technology: selective breeding/artificial selection, hybrids, induced mutation/mutagenesis, genetic engineering (use of rDNA), and genome editing (TALENs, ZFNs, CRISPR).

DAY 2

7. Print off or assign poultry challenges to each group.
8. Upon entering the classroom, students will divide into groups to discuss their research from the previous day with others, so one student who investigated each technology is represented in each group (i.e., one person from each– selective breeding/artificial selection, hybrids, induced mutation/mutagenesis, genetic engineering (use of rDNA), and genome editing (TALENs, ZFNs, CRISPR– will meet together to share information).
9. After sharing information, students (remaining in the same groups) will receive a “poultry challenge card” with a problem that a farmer would like to solve using biotechnology. Provide students with the chicken breed cards to help them determine traits and genetics they might want to use to solve the challenge card.
10. Encourage student creativity in addressing the problems! Using research information from day 1, students will determine the best genetic technology method to produce the desired results in order to help the farmer.
11. Students will continue online research to produce a CER (Claim–Evidence–Reasoning) in order to answer their challenge question.

DAY 3

12. Students may need additional time for evidence and CER production. If so, provide time; however, limit this time to bell work.
13. Students will create a poster (using a white board, poster board, or online program) to display their information in a persuasive format.
14. Upon completion, students will communicate their evidence to peers through class presentation or an online format such as FlipGrid.

Suggested wrap-up activity

- Have the students create a flipgrid about one poultry chicken challenge to share with another student group.
- Hold a debate about the ethical issues different forms of genetic technology could create.

Differentiation

- Heterogeneous student grouping works best for this activity.
- Provide specific content articles at the appropriate reading level for heterogeneous student groups.
- The jigsaw practice can be eliminated and student groups complete all research together as one group.

More challenges

- Expand the research into other organisms and other global or local problems.
- Interview a local farmer and provide them with a solution to a problem their farm is facing.
- **Home Connection:** If you are interested in cross breeding or selectively breeding at home, consider using the chicken cards to create your own breeds based on the desired traits you want, such as feather color, egg production, etc.

Support information

- **Mutagenesis:** introduces random genetic changes using external agents.
- **CRISPR:** precise and targeted genome editing with minimal off-target effects.
- **Genetics:** the study of genes and inheritance in living organisms.
- **Heredity:** the passing on of physical or mental characteristics genetically from one generation to another.
- **Inheritance:** the way genetic information is passed from a parent to a child.
- **Cross breeding:** animal breeding with crosses within a single species (but of a different breed).
- **Genetic modification:** any change to an organism's DNA through any method from selective breeding to genome editing.
- **Selective breeding/artificial selection:** the process of choosing an organism with a particular genotype to cross with another of the same species in order to produce offspring with a specific trait(s).
- **Hybridization:** the practice of crossing two pure varieties of an organism to create a more hardy offspring. Many different hybrids have been created in many different organisms.
- **Induced mutation/mutagenesis:** the use of radiation or chemicals to create a change in the DNA of an organism.
- **Genetic engineering:** a method of changing the DNA of an organism by inserting a piece of DNA from another organism using recombinant DNA technology—this is how a GMO might be created; also referred to as “bioengineered”.
- **Genome editing:** a targeted method to cut, paste, or replace portions of DNA in an organism. Types include Transcription Activator-Like Effector Nucleases (TALENs), Zinc-Finger Nucleases (ZFNs), or Clustered Regularly Interspaced Short Palindromic Repeats (CRISPR).
- Humans have modified the genetics of plants and animals since 7000 BC when humans began to selectively breed for advantageous traits in grains.
- For additional history of genetic modification in agriculture, please visit “The Progress of Science Timeline” developed by HudsonAlpha Institute for Biotechnology (timeline.hudsonalpha.org). Altering an organism at the genetic level requires careful considerations about the future of the species. This lesson specifically focuses on five common techniques that scientists use for genetic modification: selective breeding/artificial selection, hybridization, induced mutation/mutagenesis, genetic engineering (use of rDNA), and genome editing (TALENs, ZFNs or CRISPR).

- Teach.genetics.utah.edu is a great resource for both middle and high school teachers looking to provide a more solid background for students to avoid misconceptions.
- Hybridization method of crop improvement
biologydiscussion.com/crops/improvement/hybridization-method-of-crop-improvement/17701
- Plant breeding: Induced mutation technology for crop improvement article
iaea.org/sites/default/files/34405682533.pdf
- Genetic Literacy Project website
geneticliteracyproject.org/gmo-faqs
- Plant breeding techniques, including CRISPR, elearning
elearning.grownnextgen.org/plant-breeding-crispr/
- CRISPR-Cas9 Mechanism & Applications interactive website
biointeractive.org/classroom-resources/crispr-cas-9-mechanism-applications

Teaching suggestions

- Additional support should be offered for students who lack prior knowledge of genetic modification techniques.
- Students generally have a variety of misconceptions about this topic since many associate genetic modification with science fiction and pop culture. The teacher must be clear and concise with teaching materials in order to clear up misconceptions associated with incorrect ideas that students might have regarding genetic modifications.

Career connections

- **Geneticist:** investigates how traits are inherited, how they manifest in individuals and populations, and how genetic variations contribute to animal health, diseases, and evolution.
- **Veterinarian:** specializes in the diagnosis, treatment, and prevention of illnesses and injuries in animals. Veterinarians provide medical care to a wide range of animals, including pets, livestock, zoo animals, and wildlife.
- **Animal scientist:** helps with monitoring flocks for their health and well-being and ensuring they have constant access to fresh food and water and a safe living environment.
- **Poultry production manager:** leads teams in various areas of farm operations, including animal care, food processing/packaging, feed production, shipping, etc.