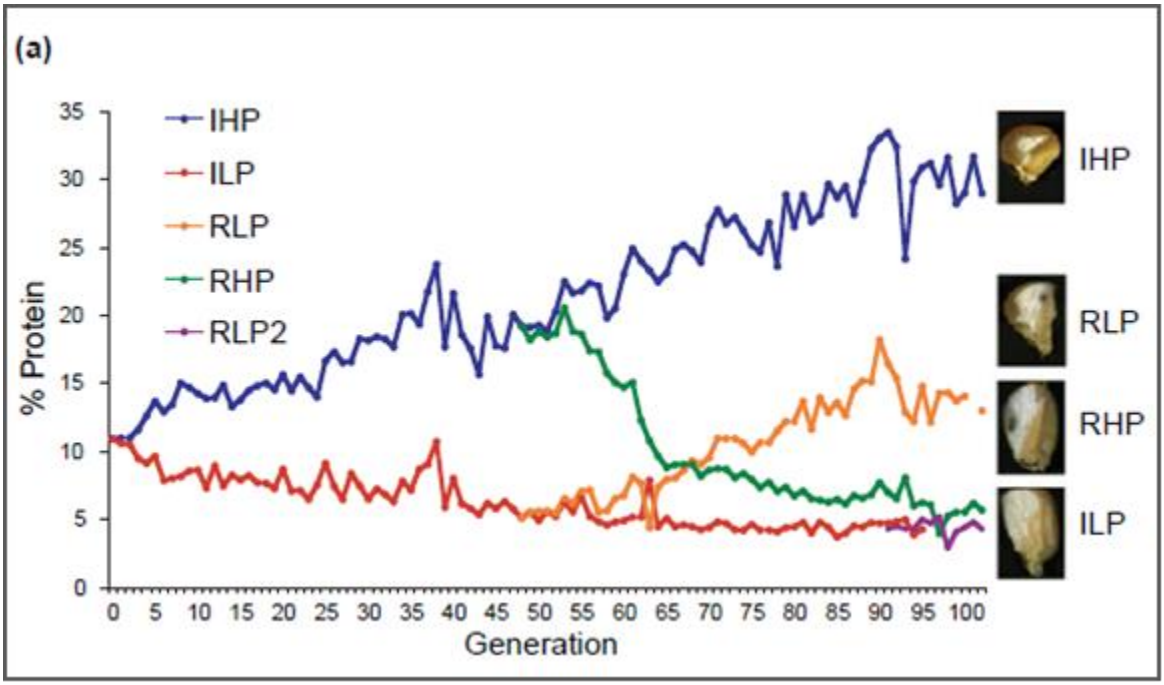
HOW TO USE THIS RESOURCE

Show the figure below to your students along with the caption and background information. The "Interpreting the Graph" and "Discussion Questions" sections provide additional information and suggested questions that you can use to guide a class discussion about the characteristics of the graph and what it shows.



Caption: The graph shows the effect of artificial selection on the protein content of maize kernels. Starting at generation 0, plants were selected for either high or low protein content to produce two strains: Illinois High Protein (IHP, shown in blue) and Illinois Low Protein (ILP, shown in red). At generation 48, researchers reversed the selection on some of the IHP and ILP plants, leading to two new strains: Reverse High Protein (RHP in green) and Reverse Low Protein (RLP in orange). At 90 generations, selection on some of the ILP plants was again reversed to produce a fifth strain, RLP2, shown in purple. Cross sections of the kernels of four of the strains are shown on the right side.

BACKGROUND INFORMATION

In 1896, researchers in Illinois began an experiment to study whether they could increase the protein concentration of maize (corn) by selective breeding. Each year, researchers planted seeds from the most protein-rich and protein-deficient plants from the previous generation. Running for over 100 generations, this is now the longest-running controlled artificial selection experiment in the world. From a single strain of corn, the selection process resulted in two new strains: one with increased protein, called Illinois High Protein (IHP), and one with decreased protein, called Illinois Low Protein (ILP). After 48 generations, researchers then reversed the selection pressures on some of the IHP and ILP plants. They planted the seeds from the most protein-deficient IHP plants and the most protein-rich ILP plants to produce reverse high protein (RHP) and reverse low protein (RLP) plants, respectively. As a result, after 48 generations from the start of the experiment there were four strains of maize plants: IHP, ILP, RHP, and RLP. After 90 generations from the start of the experiment, researchers reversed the selection pressure on the ILP strain a second time to produce a fifth strain: RLP2 plants. Cross-sections of mature kernels from generation 100 show the phenotypic differences among the different strains. In addition to the

impacts on nutrition and quality of the corn grain, the selection for grain protein changed other traits such as grain yield and nutrient uptake. The results of the study, as summarized by Moose, Dudley, and Rocheford, are shown in the graph above.

INTERPRETING THE GRAPH

The graph shows the percent protein content of different maize strains over 103 generations of artificial selection. The blue and red lines represent the maize populations that were selected for high and low protein content (respectively) for the duration of the study. The green and orange lines represent the maize populations that were selected for high and low protein content (respectively) for the first 48 generations; then the selective pressure was reversed for the remaining 55 generations. The purple line represents the maize population that was selected for low protein for the first 90 generations, then the selective pressure was reversed for the remaining 13 generations. The trends in this graph show that protein levels in corn increase or decrease based on the direction of selection and that the change in protein levels can be reversed when selection is reversed. For strains in which protein level decreases (red and green lines), the rate of change begins to level out as the minimum protein threshold is reached, which represents the minimum amount of protein needed to support effective seed germination. The yearly fluctuations in each line represent the degree of genetic variation still left in each population, as well as the environmental instability of maize protein measures.

Teacher Tip: Prompt your students to explain the parts of the graph as applicable:

- Graph Type: Line Graph
- *X*-Axis: Generations of maize
- *Y*-Axis: % of the maize kernel that is protein
- Multiple Lines: Lines indicate maize populations that received different selection treatments over the course of the study.

DISCUSSION QUESTIONS

- Describe the trends and calculate the slopes of the high-protein (IHP) and low-protein (ILP) lines in the figure.
- Based on the change in slope of the IHP and ILP lines, what can you infer about the lower limit of protein content in a corn kernel? Does there appear to be an upper limit?
- The reverse low protein (RLP) lineage began at generation 48 and stopped at the end of the experiment. Describe the trend and calculate the slope of the RLP line from generations 48 to 103 and compare it to the trend of the IHP line from generations 0 to 48. Explain what this means about how maize responds to selection.
- If the RLP lineage had been allowed to continue, **predict** what would happen to the slope of the line representing protein content in the kernels. **Justify** your prediction.
- How does the slope of RLP and RLP2 differ? Why? **Predict** what the slope of RLP2 might be if the experiment continued. **Justify** your prediction.

SOURCE

Figure 1 from:
Moose SP, Dudley JW, and Rocheford TR. Maize selection passes the century mark: a unique resource for 21st century genomics. Trends in Plant Science 2004; 9(7):358-64.
View article: http://www.sciencedirect.com/science/article/pii/s1360138504001323

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