

Power Plants

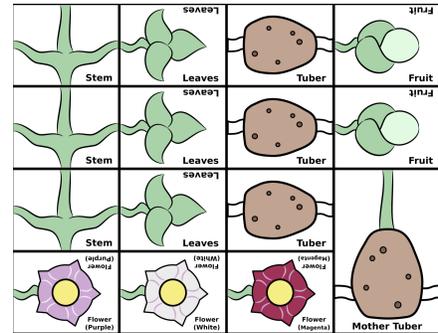
Instructions

Power Plants is a game designed to teach the basics of genetics, inheritance and variation of traits. The object of the game is to breed their potato plant with other player's to create a "power potato plant" with different characteristics and strengths.

Setup

Each player should receive a copy of the card sheet, which contains all of the pieces for the game. The player should cut out the cards to make a deck of 14 feature/trait cards, including:

- 3 stem cards
- 3 leaves cards
- 3 flower cards
- 3 tuber cards
- 2 fruit cards



The "mother tuber" double card is always the core of their plant and should be set aside and not shuffled into the deck.

Background Story

Before the game begins, we suggest reading the following background story in order for students to understand the objective of the game:

Twenty years ago, an earthquake destroyed the world as we knew it, but humans lived on. Your family and neighbors have lived off of potatoes for decades, and now your food supply is strong enough to begin experimenting to make a better potato plant for a better tomorrow. What will your power potato plant look like?

To do this, you have several options for what to prioritize in making your "power potato plant."

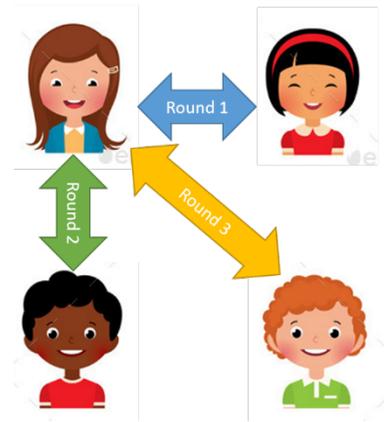
- *Will you aim for the most productive plants that produce the most tubers to feed the people?*
- *Will you aim to produce plants with pretty flowers to decorate and beautify your village?*
- *Or will you aim for tall plants which can be "hilled" with extra soil to protect their tubers from sun, wind, and water exposure?*

Different farmers will prioritize different traits, and you may find crossing/breeding your plants with someone with a conflicting goal could maybe work out for the best.

Gameplay

1. **Get in a Group of Four (4) and Find a Partner** – Players should assemble themselves in groups of four and then break off into pairs. Each player should now have a partner.

Note: There will be three rounds of gameplay and players should change partners after each round so they play against each of the other players in their group of four.



2. **Create Potato Plant** – Each player should shuffle their own deck of cards, and place the deck face down in front of them. Without looking, each player should draw 7 cards from their own deck. Players should then arrange their seven drawn cards around their “mother tuber” card to create their plant. The bottom of the plant will always have the mother tuber.

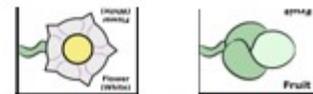
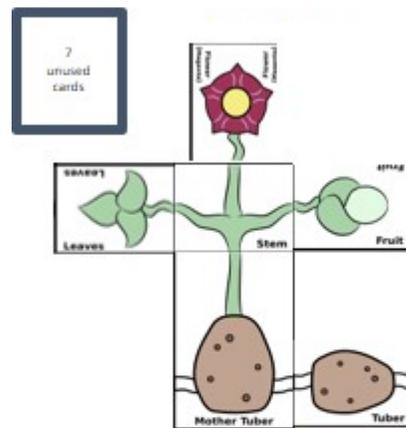
A. “Stem” cards should be attached to the top of the green stem on the mother tuber with additional “stem” cards attached to the previous “stem” card’s upwards facing branch.

B. Next, attach any “tuber” cards to the side of the “mother tuber” or other “tuber” cards by linking their stolons (the white stems extending from the tubers underground).

C. Leaves, fruit, and flower cards should be attached to any open slots on the “stem” cards or to the single green slot on the “mother tuber” if the player put no “stem” cards into play.

D. Any unused cards (perhaps because the player drew too many flowers, leaves, and fruit and not enough “stem” cards to use them) should be placed face up to the side of the plant.

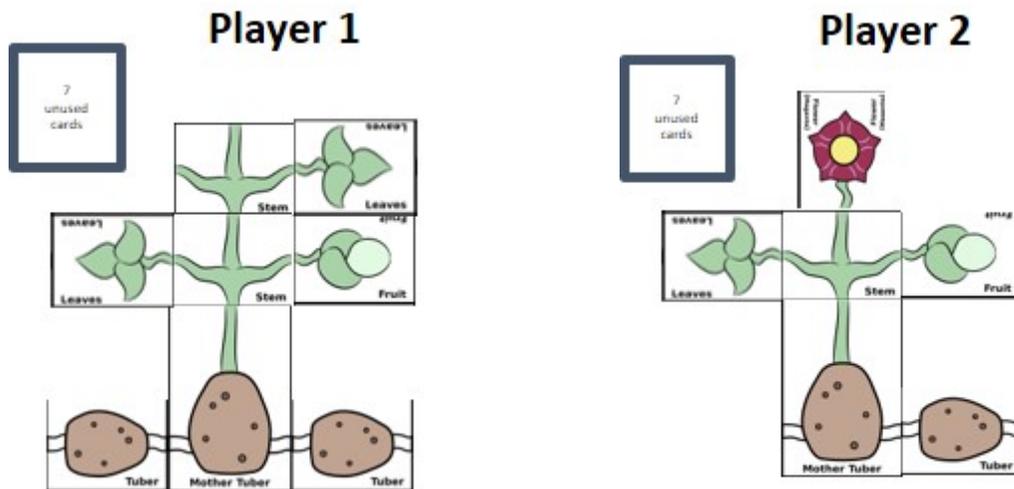
Note: If a player **can** attach a card, they **must** do so. If a player cannot put all of their cards in play, they must put as many as they can in play but may choose which ones are put to the side.



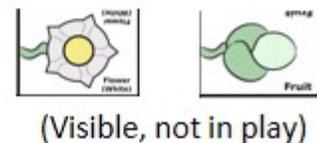
(Visible, not in play)

3. **Choose Winner of Round 1** – Partners look at each other’s plants and decide which plant is healthiest. The player who has the **highest number of unique parts** attached to their mother tuber card (stem, leaves, fruit, tuber, flower) has a more robust plant and wins the round.

Note: The mother tuber is not counted and all three flower colors count as a single card type (if you have white and purple flowers, you don’t count “flower” twice). It is possible for two players to have equally healthy plants.

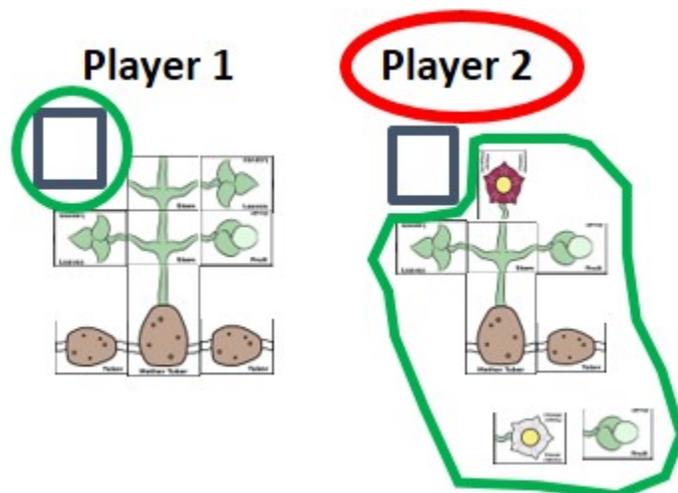


In the example above, Player 1 has four unique parts, but Player 2 has five unique parts. Player 2 wins this round, even though she has two visible cards that are not in play.



4. **Winner of Round 1 Chooses Plant Traits for Breeding** - The player with the healthier plant chooses one of her decks to keep and one of her opponent’s decks to take. She can choose to keep either the visible deck of 7 cards in play or the undrawn/invisible deck of 7 cards. Her opponent takes the remaining two decks. Players should then mix their two new decks together.

In the example shown, Player 2 (winner) chooses to keep her visible cards and take her opponents undrawn/invisible cards (both circled in green). Her opponent keeps his visible deck and receives her invisible/undrawn deck.



At the end of the round, all players should have a new combined deck of 14 cards representing the combined genetic information from both parents in the offspring.

Note: If both players are tied for healthiest plant, they keep their visible plant cards and take their opponent's undrawn deck. Both players should end up with 14 cards and their original mother tuber.

5. Repeat with 2 Additional Rounds - Both players should find new partners within their group of four, shuffle their decks, and repeat steps #2-4 for two more rounds.

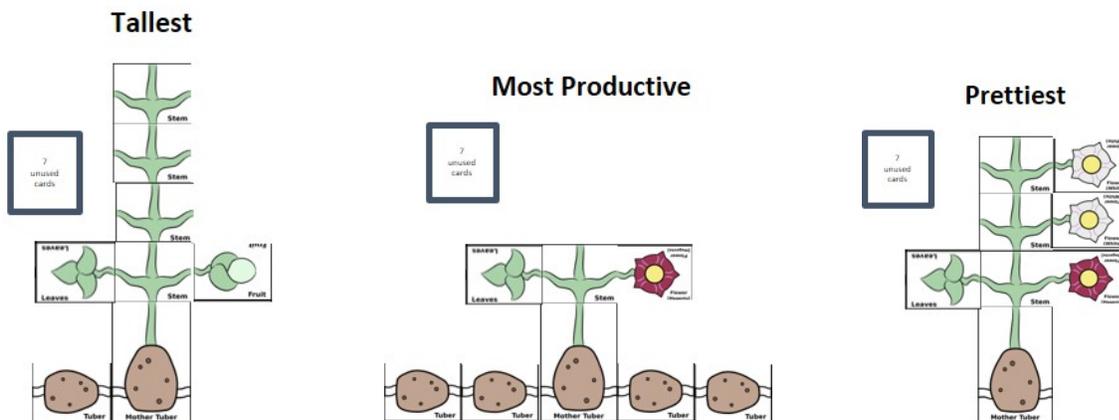
Winning the Game

By the end of the game, players should have bred their plant with a total of three other partners. At this point, they draw a final set of 7 cards, arrange their final plant from them, and judge their plant against all their peers to see who has created a "power potato plant" in one of the categories below.

There are three categories of "power potato plant" to judge from:

- tallest plant (most "stem" cards in play),
- most productive plant (most "tuber" cards in play)
- prettiest plant (most "flower" cards in play).

Each category should be recognized separately and the mother tuber is never counted as a stem or tuber card.



Variants

Teachers can add in external pressures to select for certain features when determining the healthiest plan. For example, in a time of drought, it is disadvantageous to have a lot of leaves because a plant will lose more water due to transpiration. Under drought conditions, the healthiest plant (or, more precisely, the fittest plant) is the one with the fewest leaves, followed by the one with the most diverse parts.

Below are some possible scenarios:

- **Drought** - The plant with the fewest “leaves” cards wins (minimize transpiration).
- **Famine** - The plant with the most “tuber” cards wins (maximize nutritional value).
- **Storm** - The player with the fewest “stem” cards wins (taller plants are more vulnerable to wind).
- **Pollination** - Players don’t partner up before they assemble their plant for the round, instead they draw their seven cards and assemble their plant first. Once they do, only players who attached “flower” cards to their plant partner up and trade cards. Players who did not reveal any flowers simply shuffle their plant back into their decks since they lack the ability to swap pollen with a neighbor.
- **Gene Therapy** - The player with the healthier plant can search her opponent’s deck and plant for any seven cards she wants and combines them with either her own deck or her own plant. Her opponent takes the remaining 14 cards to make his new deck.
- **Tomato Plant** - Tomatoes and potatoes are members of the same family (nightshade) but one was bred for its tubers and the other for its fruit. In this case, the plant with the most fruit is the healthiest.

Helpful Tips

- A powerpoint slide deck is available for use in explaining the game instructions here: <https://goo.gl/uiL3DM> - please feel free to download and change it to meet your needs.
- Cards can be cut out ahead of time, but if using a paper cutter be careful that you do not accidentally cut the mother tuber card which is twice the size of the others!
- Normal paper is slightly transparent and can give extra information about the undrawn deck to a player. You should consider printing the game deck on a thicker cardstock which will also make shuffling the deck easier.

Lesson Content

- For younger students (grades K-5): There is a strong similarity between parents and offspring. A potato plant will not spontaneously produce a pumpkin offspring.
- Traits are passed down from parents to children. A plant's deck represents its DNA, half of which it inherited from each parent.
- A plant can have the genes for a trait in its code without necessarily expressing that trait. Likewise, children can inherit and express traits that neither of their parents express. 'Hidden' traits can disappear and reappear in later generations.
- Pressure can affect the rate at which traits are expressed over multiple generations. In this game, pressure is artificial in the form of selective breeding but it can also be natural in the form of natural selection explored in the "variants" section above.
- Wildly different plants can emerge from the same genome. Every plant in the room started with an identical genome but drifted over time. The differences among a species are differences in degree, not differences in kind.
 - An interesting example of this is [*Brassica oleracea*](#) or wild cabbage plant, which has been bred to produce cabbage, broccoli, cauliflower, kale, Brussels sprouts, collard greens, savoy, kohlrabi and kai-lan (all of these are the same species).
- Many important ethical, legal, and social values questions may arise during gameplay – including why someone might prioritize one trait over another, what it means for humans to intervene in nature through selective breeding (and other genetic tricks, e.g. CRISPR/Cas9), and who gets to make the decisions about what we eat, how new foods are developed, what makes something healthy or environmentally responsible, etc.

Acknowledgements

This game was developed by Catherine Swanwick and Jon Nardolilli of Catlilli Games (www.catlilli.com) for the National Human Genome Research Institute (NHGRI) at the National Institutes of Health (NIH).

Special thanks to the all the students, teachers, and chaperones from Every Girl Can Learn, Gaithersburg Middle School After School STEM Club, the Parkmont School, and Takoma Middle School for play testing the game, providing EXCELLENT feedback, and generally rocking our tubers off.

Special thanks also to the incredible staff in the NHGRI Division of Policy, Communications, and Education for your feedback and insights into what makes things fun, educational, and the right amount of competitive.