Society for Mathematical Biology

DONALD DANFORTH PLANT SCIENCE CENTER

The Biology of Drought Defense in Plant Cells

The purpose of this activity is to integrate concepts in plant and mathematical biology for high school students through video gaming. Scientists study drought to develop better farming practices, more resilient crops, and to create strategies to help ecosystems survive. Engaging with mathematical models via technological tools helps increase student interest and confidence, while learning more about plants increases student interest in plant biology and awareness of the roles plants play in our environment.

You can find the game at: https://rdale.itch.io/plants
The password is: plantGame

Introduction

How does our brain know when we are thirsty? Our bodies send messages to our brains using proteins. Our brains then tell us it's time to drink water – and the thirstier we are, the more water we need. How would this happen in plants if they don't have brains?

All organisms use delicate balances of proteins to send and receive signals. The amount and type of protein is important to successfully send these signals – otherwise, you may think you are thirsty when you aren't. Responding to signals costs energy, and cells want to be as efficient as possible. Our bodies use lots of proteins to tell us that we are hungry, thirsty, happy, and tired. If you are hungry and forget to eat, your body will make you feel tired so you will spend less energy. This also happens when plants run out of water.

In the plant cell, when the plant feels thirsty (called 'drought'), the protein ABA is produced. ABA is produced only when plants are thirsty. When the plant cell is flooded with this protein, the cell can begin to respond to the danger. Plants need water to transform energy from light (photosynthesis). If a plant doesn't reduce photosynthesis, it will use up all its water reserves.

Unlike us, plants can't simply get up to grab a cup of water. The plant needs to let the DNA know that drought is occurring. The DNA can make other proteins that save water. ABA does this by finding the protein PP2C. When PP2C and ABA hit each other, SNRK2 is released and travels to the DNA. The number of signals from SNRK2 that the DNA receives tells the DNA how severe the drought is. The better the signal, the better the DNA can respond, and the plant can survive drought and continue to grow.

Details about the game

In this game, you will play as a plant cell defending itself from drought. Drought is represented by salt particles. When scientists want to study drought's effects on individual cells, they use salty solutions. This is because salt can draw water out of cells by osmosis.

You will control the number and type of proteins in the cell. Note how the proteins work together to send messages to the DNA. Proteins move through the cell randomly. Successfully sending messages to the DNA will give you 'amino acid' points you can spend to make more proteins.

You can also build chloroplasts to save energy – but the drought must be controlled in order to accomplish this, as photosynthesis requires water! Finally, for extra challenge, you can adjust the 'stickiness' of protein interactions, which changes the difficulty to successfully send signals in the cell.

After play questions:

- How much energy were you able to collect?
- What protein did you build the most of: ABA, ABPF, or PP2C/SNRK2? The least?
- What happened when you reduced the binding rate? Increased it?
- What happened to the chloroplasts if the salt particles hit them?

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