STELLA® for Biology

*"It is much easier to demonstrate how to mathematically represent an ecological system with the **STELLA** software than any other programming software I have used. My students gain a better understanding not only of the subject material, but also the techniques needed to translate concepts to a working model."*

-- Professor Daryl Moorhead
Texas Tech University

Barriers and Opportunities

The vast majority of the biological sciences involve the investigation of the processes that govern biological activity. Whether you are teaching or conducting research in such diverse topics as parasite-host interactions, plant growth, or physiology, *dynamics* is the name of the game. Increasingly, modeling is being used to shed light on the relationships underlying these dynamic processes.

Unfortunately, many modeling techniques can become as complex as the biological processes themselves. It is impossible to find closed-form solutions for all but the simplest of differential equations. And, unless you have significant programming expertise, using numerical methods to model biological processes is usually out of the question.

As a result, only the exceptional student can work with biological dynamics. The typical student must accept biological "laws" on faith. Memorizing takes the place of truly internalizing the concepts. There is little chance to experiment with alternate assumptions about how a process is put together, and to then discover the dynamic behavioral implications of these assumptions.

The **STELLA**® software significantly lowers the barriers associated with modeling in the biological sciences. With the **STELLA** software, it is easy for you (or your students!) to model the dynamics of both simple and highly complex biological processes. Instead of abstract differential equations or arcane computer code, the **STELLA** software provides a set of simple, graphical building blocks for piecing together a process. The software centers the equation framework as you lay out building blocks. It's easy to click or sketch in the details needed to flesh out this framework. Then, you can test your assumptions quickly and inexpensively via simulation.

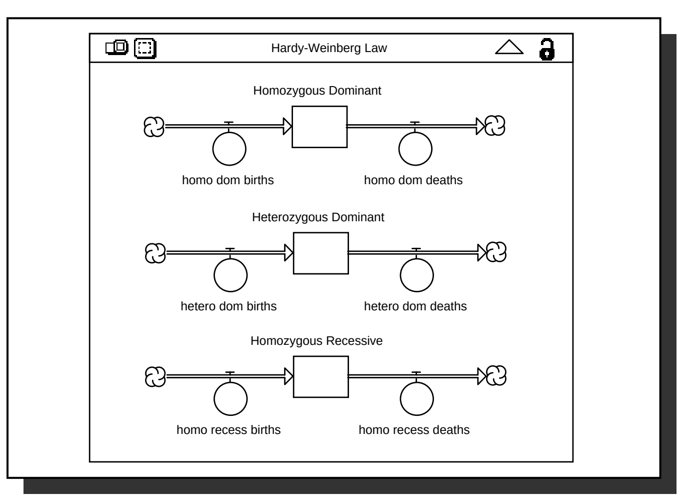
The **STELLA** software is a powerful tool for testing hypotheses, clarifying concepts, and communicating theories. With the **STELLA** software, you can put your energy to its best use – thinking – in the lab, or in the classroom.

Case Study

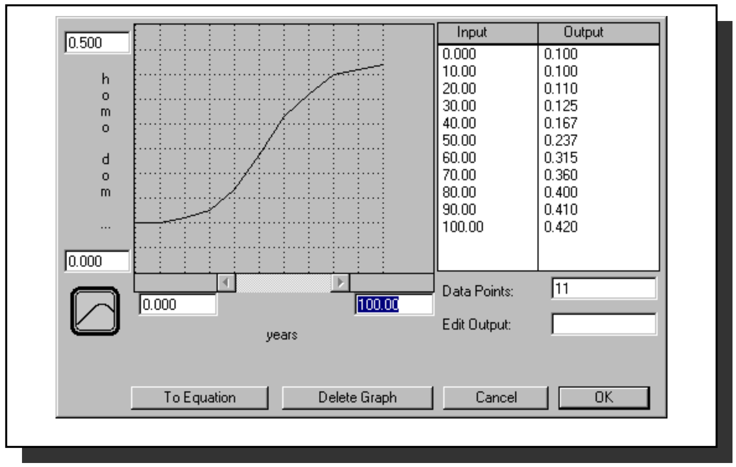
The Setting: A major high school in California
The Topic: Genetics
The Challenge: Teaching the Hardy-Weinberg Law

Background: Biology teachers at a California high school faced a difficulty that confronts many high school and college biology teachers – how to teach the Hardy-Weinberg law in a way so that students can truly *understand* the processes involved in genetic selection. It is easy enough to teach the mathematics of Hardy-Weinberg. And, it's also easy to provide examples. But the teachers wanted to create an environment in which their students could in some way experience Hardy-Weinberg in action. They decided to use the **STELLA** software to create a discovery-oriented learning environment.

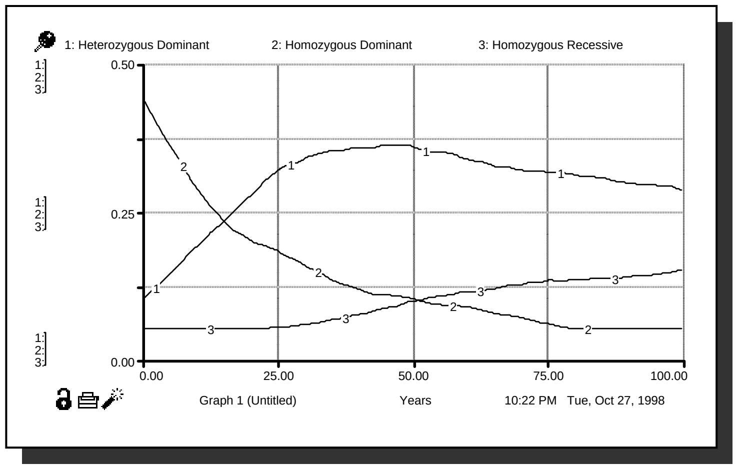
Step1: Map: The teachers began by creating a diagram of the key stocks, and associated flows, of a simple population system. A simplified version of their diagram is shown below. As the diagram shows, the teachers divided the population into three categories: homozygous dominant individuals, homozygous recessive individuals, and heterozygous dominant individuals. Each population category was represented with a stock. Birth and death flows were attached to each. This core structure was essential to account for the distribution of alleles in the population over time.



Step 2: Model. After the basic plumbing had been laid out, the next task was to incorporate assumptions about how the different categories of individuals in the population combined to produce subsequent generations. In this case, fleshing out the diagram was a straightforward task. The teachers entered the probabilities of *different* combinations of alleles in the populations. These probabilities determined the birth flows into each population category. In addition, the teachers used the **STELLA** software's graphical function to develop a set of model-testing variables. For example, the graphical function at right allowed students to experiment with different selection pressures for the homozygous dominant population.



Step 3: Simulate. After all of the relationships had been defined, the teachers began an extensive set of simulation tests. First, they established a baseline simulation in which the system maintained its initial equilibrium genetic frequency. Then, the teachers conducted a raft of tests in which they altered the initial distribution of alleles in the population, incorporated different selective pressures, and simulated the breakdown of isolating mechanisms for the population. In conducting these tests, the teachers made extensive use of the **STELLA** software's animation, tabular output, and plotting capabilities. The plot at right shows the results of one such test.



The results of their tests convinced the teachers that their model now was ready to face testing by their students. They felt confident that just as they had learned a significant amount about genetics as they built and tested the model, their students would benefit greatly from being able to "play" with the concepts.

Step 4: Celebrate! The teachers report that the **STELLA** software and the model of the Hardy-Weinberg law have transformed their unit on genetics. What before had been a set of standard textbook lectures and algebraic exercise has become an engaging, interactive classroom experience for the students. Through experimentation with the model, students are able to see – and understand – how selective pressures can change the characteristics of a population. More importantly, the students are truly learning, and hence retaining, the substance of genetics.