Evolution Readiness

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http://www.concord.org/projects/evolution-readiness

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The Concord Consortium

- Nonprofit research and development organization
- Dedicated to transforming education through technology
- Pioneers of learning innovations for STEM
- Dedicated to Open Source software
- Primarily funded by NSF since starting in 1994

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Introduction

- First step of a planned learning progression
    1. Natural selection as an explanatory model for adaptation
    2. Genetics as an explanatory model for inheritance
    3. Molecular biology as an explanatory model for genetics

- What *is* evolution "readiness," anyway?

- What role can computer models play?

- What professional development is required?

- Does learning early steps at one grade level facilitate learning later ones in a higher grade?

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Description of the Project

- Target audience:
  - Fourth grade classes in MA, MO, and TX
- Materials developed:
  - Interactive computer and classroom activities
  - Three assessment instruments
- Professional Development:
  - Face-to-face workshops
  - Online course
- Research and Assessment:
  - Comparison to baseline data
  - Boston College

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Big Ideas

- Basic Needs of Organisms
- Life Cycle - Birth and Death Cycle
- Organisms and Their Environment
- Classification of Organisms
- Inter-specific Differences
- Interactions Between Species
- Intra-specific Differences
- Adaptation/Evolution
- Heritability of Traits
- Reproduction
- Descent with Modification

Hands-on Activities

- Life on Earth book
- Fast plants and lettuce
- Timeline
- Lego Tree of Life
- Clip Birds
- Food Web
- Science Classroom Environment Survey

CreativeCommons darwinsbulldog's photostream Flickr.com

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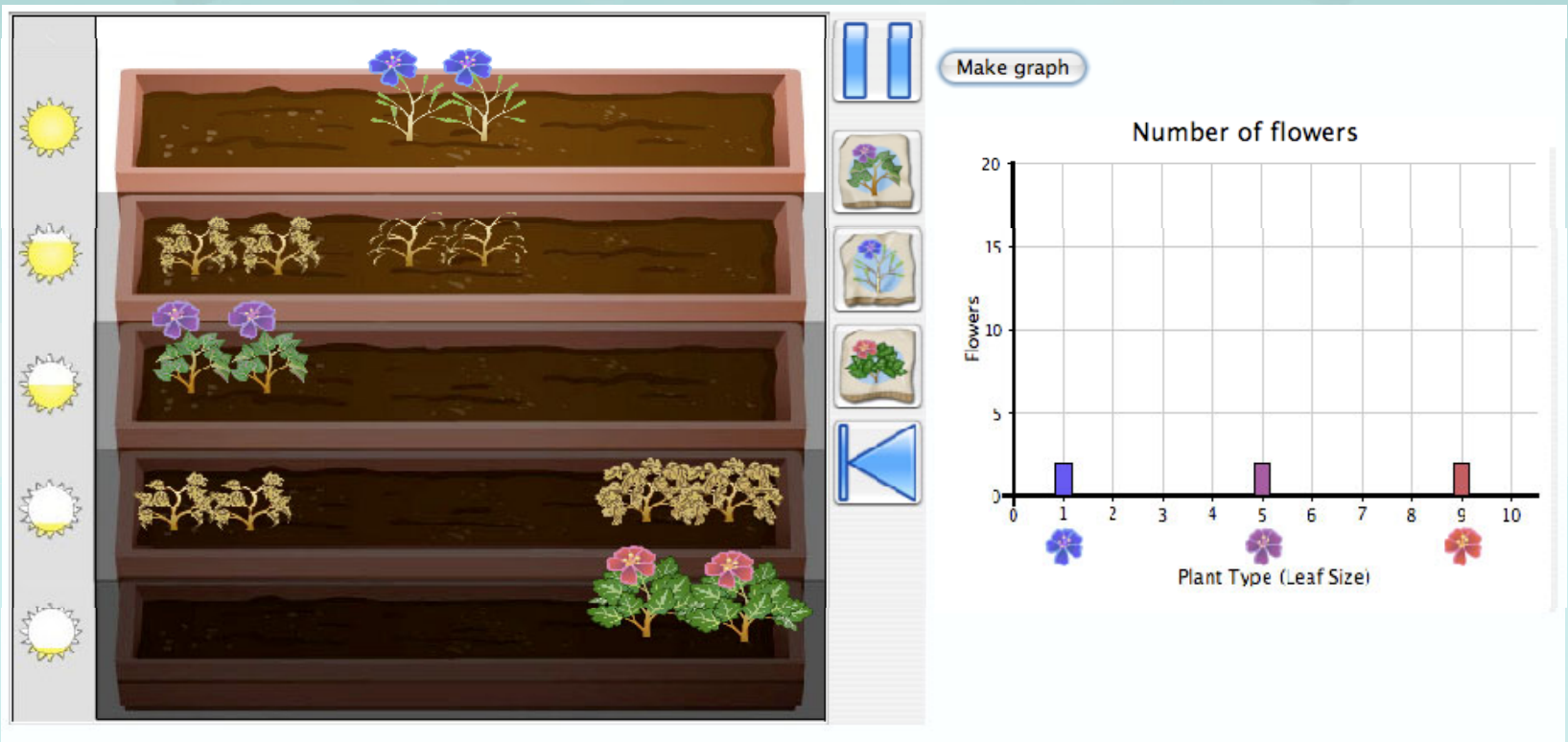
The Virtual Greenhouse

Adaptation

- Three kinds of plants, five flowerboxes with differing amounts of light
- Kids experiment to discover which plants live in which flowerbox



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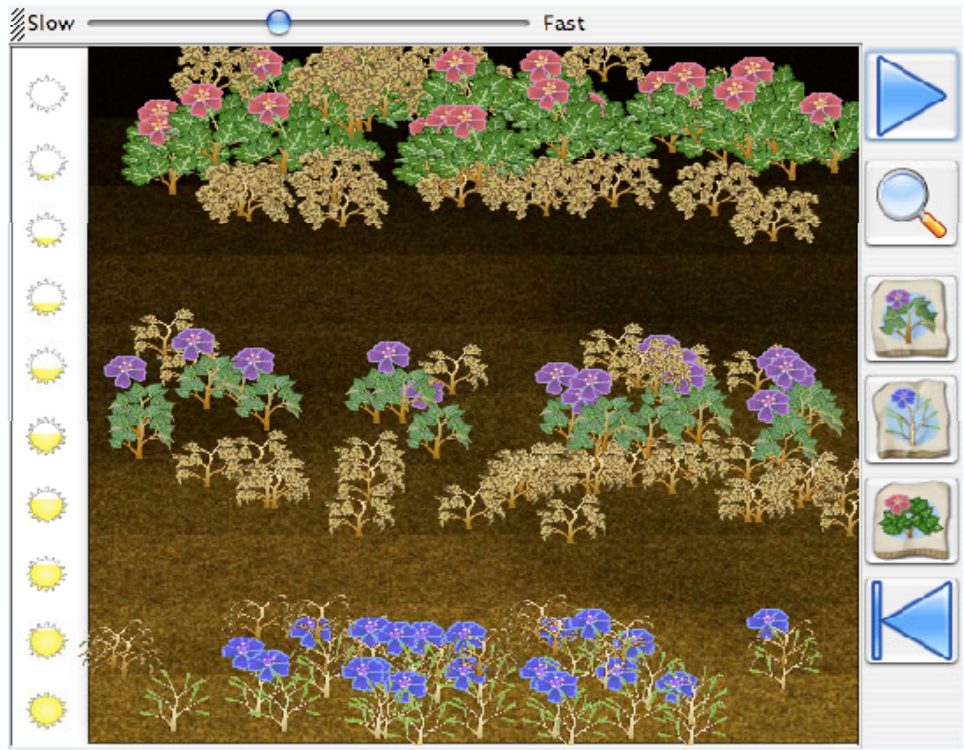
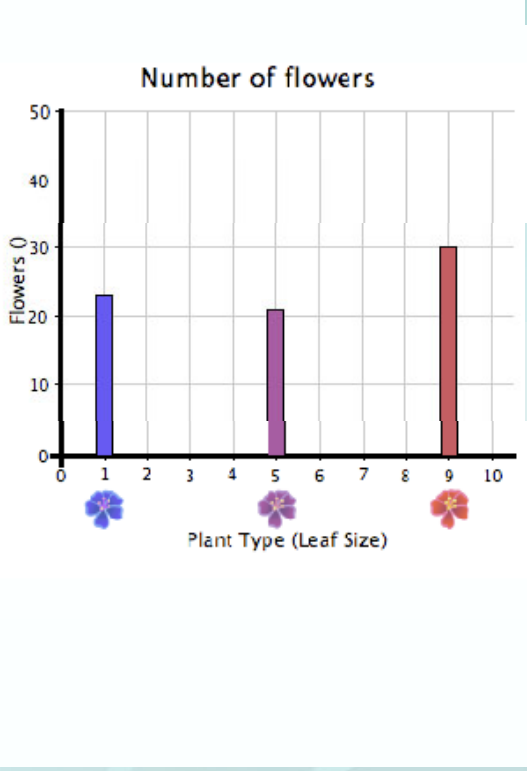
The Virtual Field

Inheritance and life cycle: all plants die every winter but healthy plants leave seeds

- Field with linear light level gradient
- Offspring look exactly like parent plants





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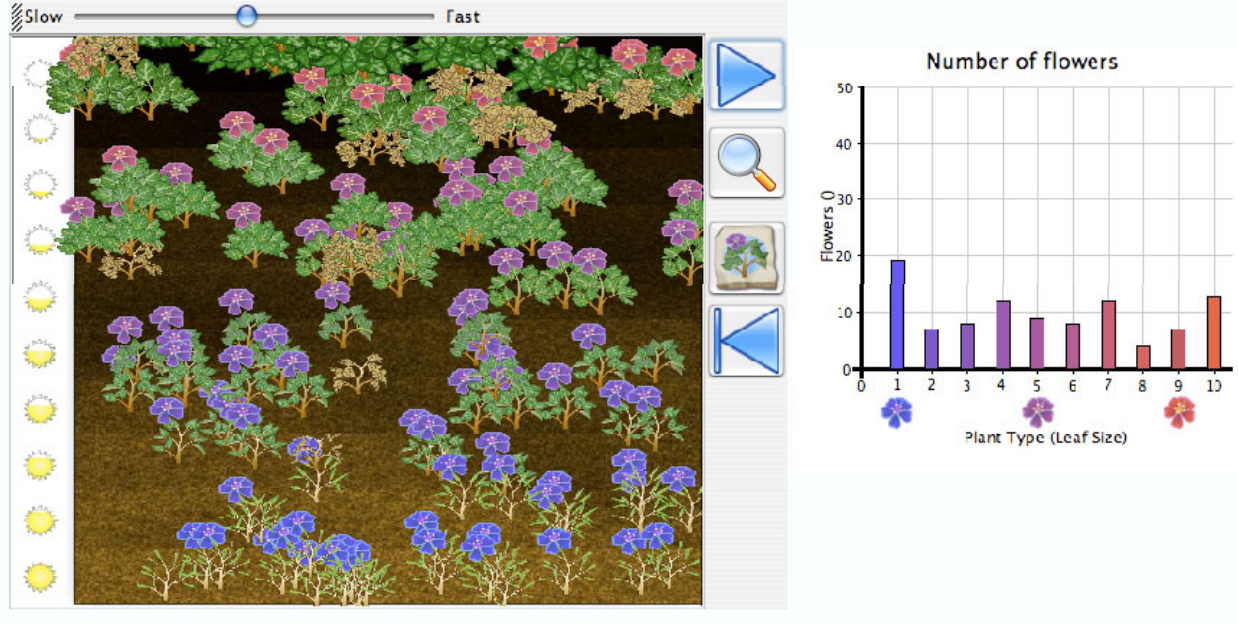
Plants with Variation

Variation: some offspring differ from parents: over many generations small variations build up

- A single variety of plant evolves into nine others
- The different varieties are adapted to different regions of the field; eventually they can grow everywhere



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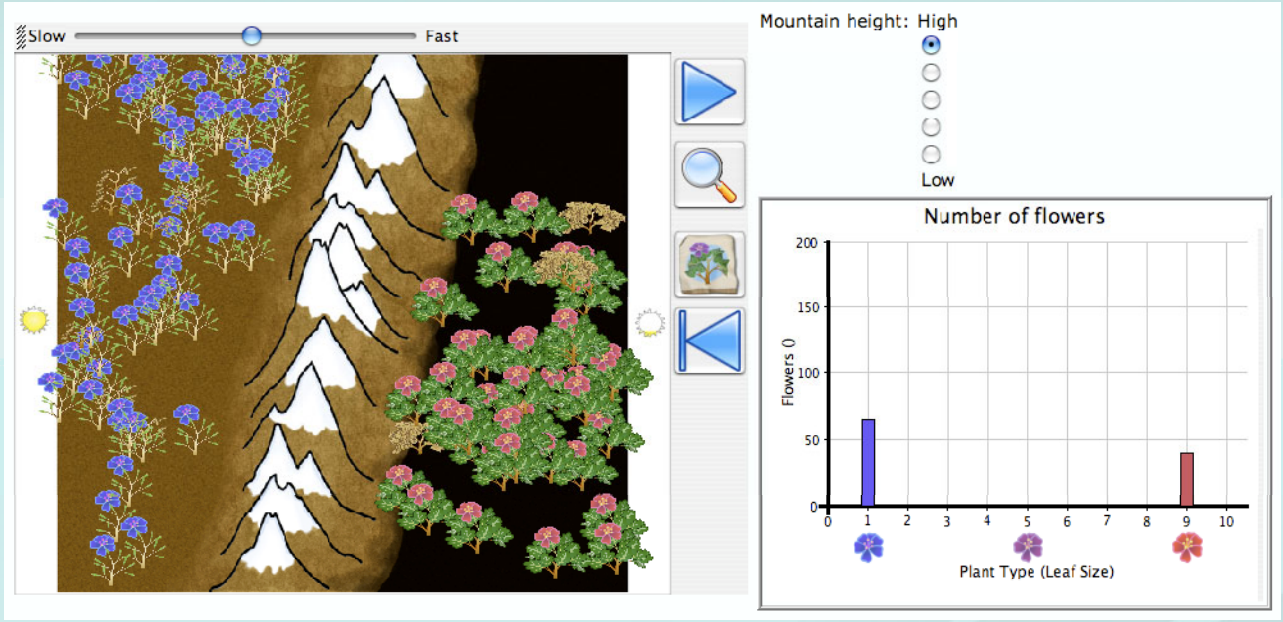
Evolution!

When the environment changes the population of plants may be able to adapt (or not…)

- Kids control the growth of mountains to change the environment on both sides of the mountain range
- If the environment changes too abruptly the plants all die



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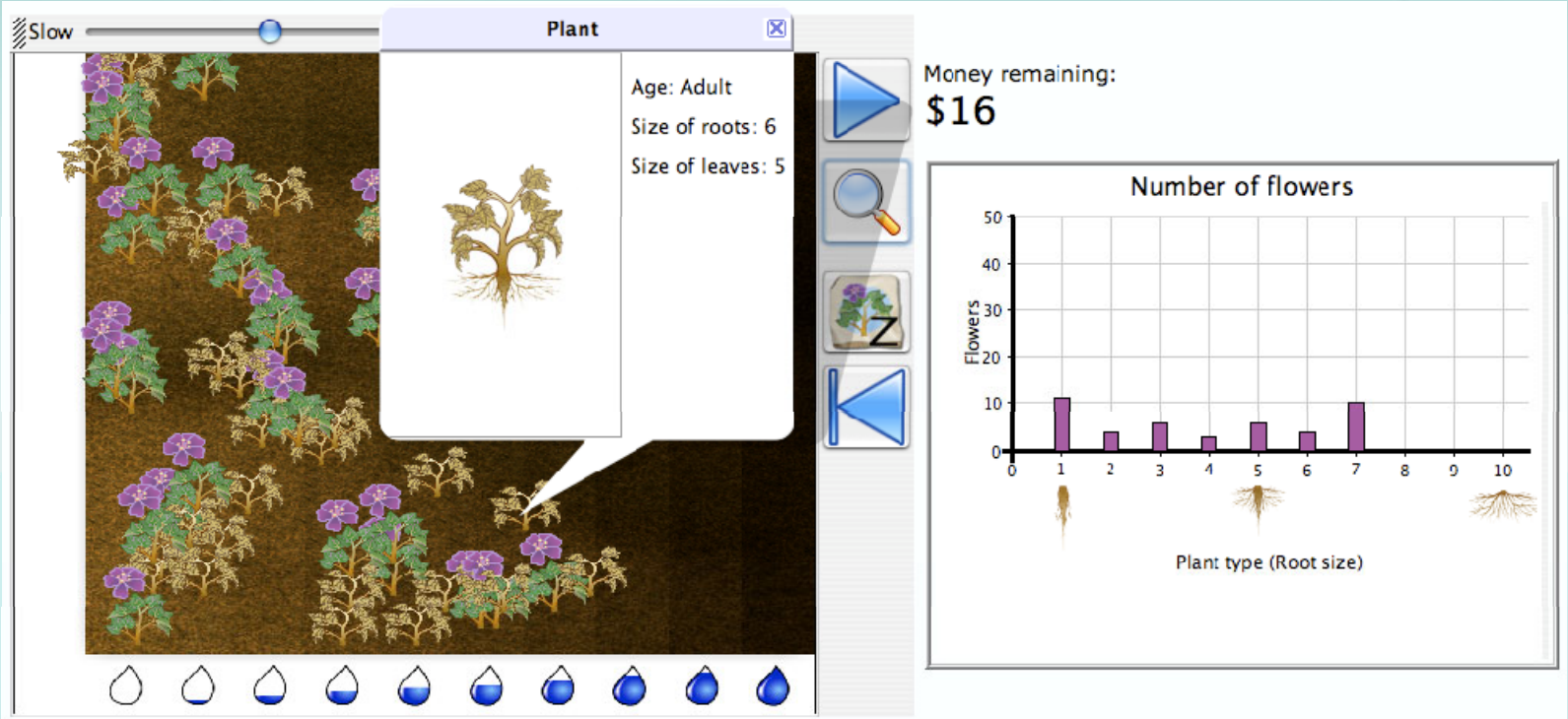
Finally, a transfer task…

Environment differs in amount of water, not light

Plants all look the same but have different roots

- Differences between plants are invisible without special tools



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The Virtual Ecosystem

Competition for resources (timed)

- Single rabbit eating plant population
- Population of rabbits join your rabbit and compete for the plants

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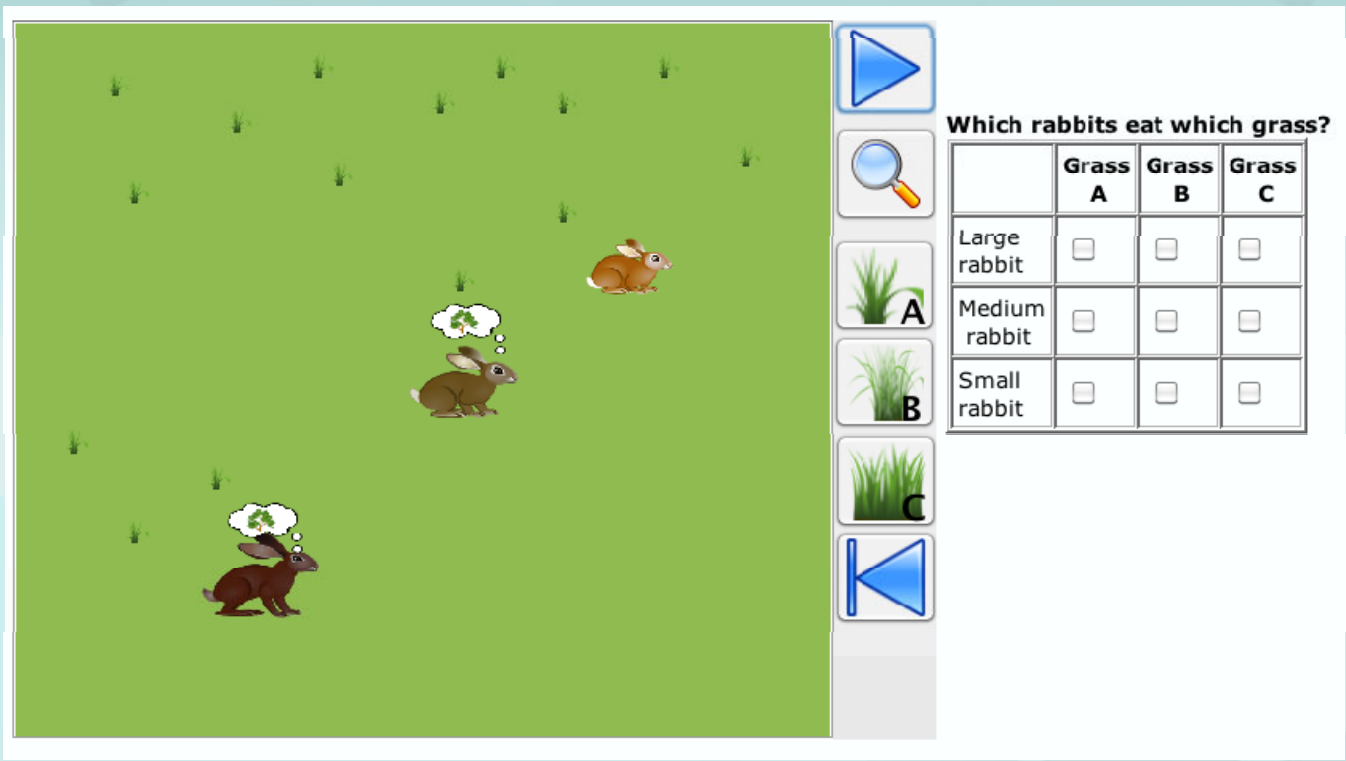
Variations and Adaptations

Plants and animals adapat to survive best in certain environments

- Different types of grasses grow best with a certain levels of water
- Kids observe which type of grasses the different types of rabbits eat



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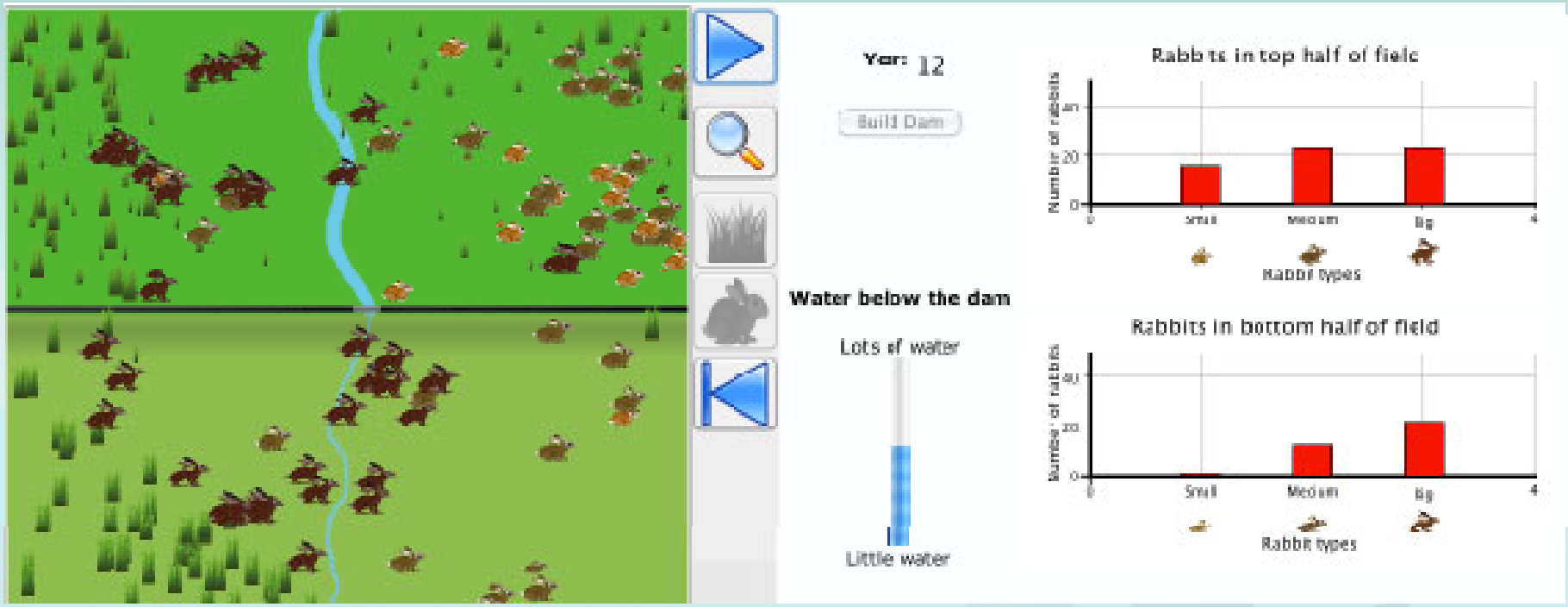
Natural Selection

Environment changes so plants and animals adapt in order to survive

- **Kids build (and later remove) a dam**
- Observe how the population of grasses and rabbits change



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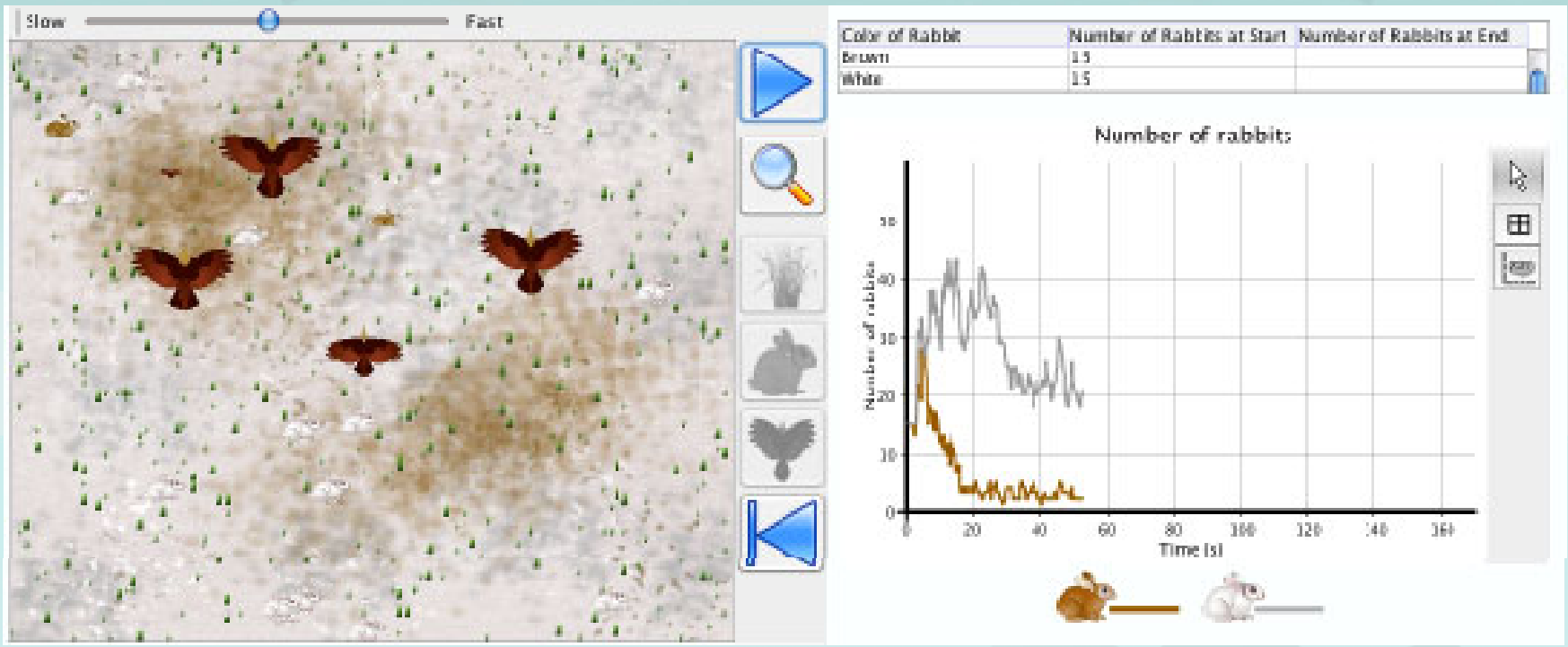
Predator and Prey

Introduction of a predator to the rabbit

- **Introduction of food chains (and food webs)**
- Kids watch as the environment changes (the snow melts)



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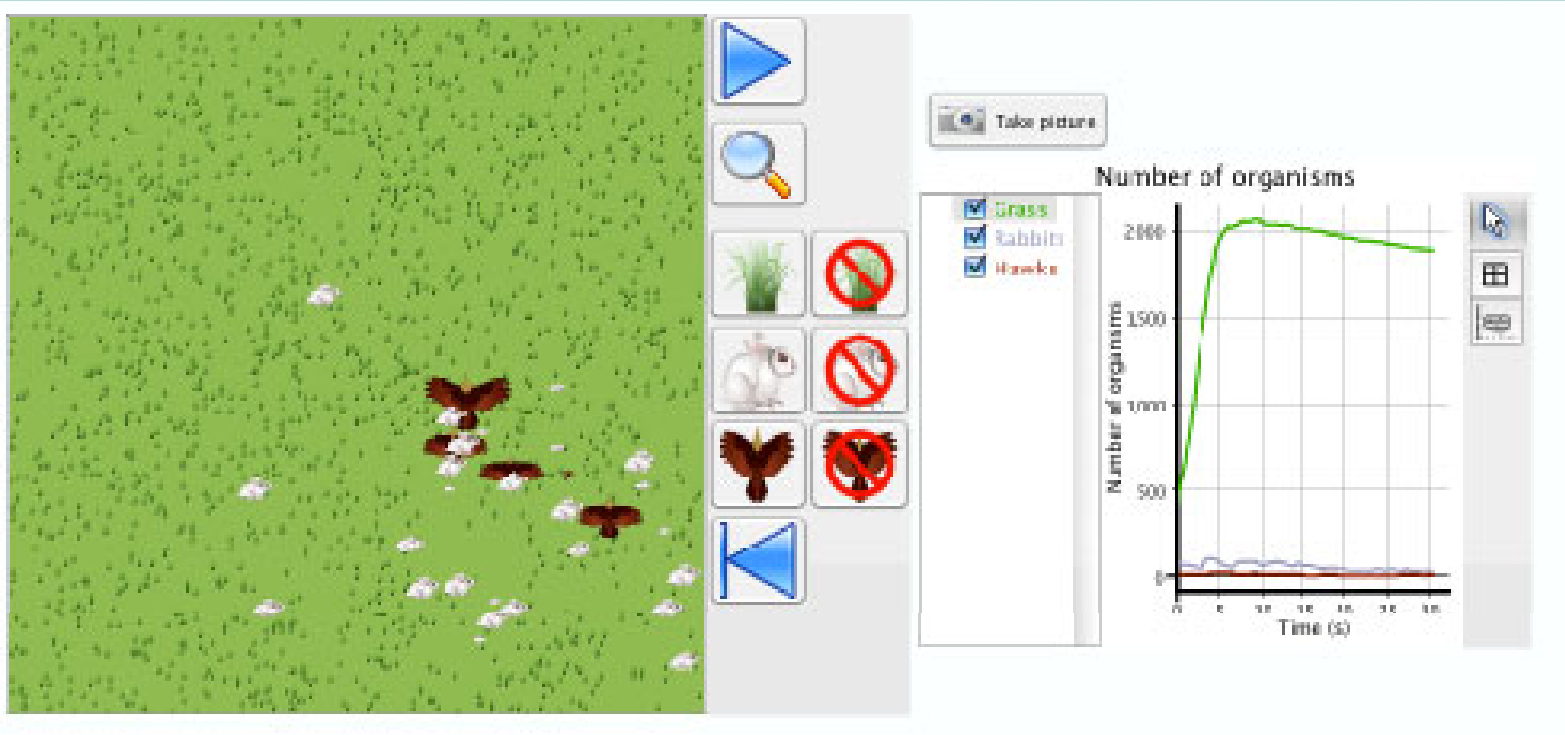
Nature of Science

Experiment with Ecosystems

- Experiment with the ecosystem
- Kids create and test their hypothesis around the environment



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Guiding Research Questions

1. Do students come to understand the complex web of models and data, observations and experiments that underpin and validate the theory of evolution?

2. Do students develop a better understanding of the nature of science? Does knowledge about the nature of science play a role in students' success in understanding and applying the concepts of evolution?

3. Does the Science Classroom Environment change as a result of program implementation?

Big Ideas – Learning Goals

(1) Basic Needs of Organisms *Both plants and animals need air and water; plants also need light and nutrients; animals also need food and shelter. Different species have different preferred conditions for survival.*
(2) Life Cycle - Birth and Death Cycle *Organisms are born, live, and die. A species can survive even though every individual in a given generation eventually dies. All organisms have a finite lifetime and populations will survive only if their constituent organisms have enough offspring over time to compensate for the number of deaths.*
(3) Organisms and Their Environment *Organisms thrive in environments that match their specific needs.*
(4) Classification of Organisms *Plants and animals are classified into species and other groups based on shared characteristics.*
(5) Interspecific Differences *There are differences between species.*
(6) Interactions between Species *Organisms with similar needs compete with one another for resources. Animals obtain energy and resources by eating other animals and plants. Plants produce their own food. The presence of other plants and animals, as well as environmental factors, can affect the survival of plants and animals.*

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Big Ideas – Learning Goals

(7) Intra-specific differences *Individuals of the same species may differ. Not all offspring from the same parents look alike, even with respect to inherited traits. Purposeful selection of certain traits over many generations can result in substantial changes in the physical characteristics of organisms in a population.*
(8) Adaptation and evolution *Species are adapted to their environments. If the environment changes, only certain species survive. Organisms carrying traits that are better suited for a particular environment will have more offspring on average. Selection pressure can lead to a change in the characteristics of a population.*
(9) Heritability of Traits *Offspring inherit some, but not all, of their traits from their parents.*
(10) Reproduction *Organisms have offspring, and without reproduction the species cannot continue. Only members of the same species can have viable fertile offspring.*
(11) Descent with modification *Species evolve from common ancestors. Different species can arise from one species if different groups have different selection pressures.*

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Research Design: Cohort Design

- Year 1

  Developed and piloted instruments (spring 2009)
  Collected baseline data from the students of participating teachers using the traditional curriculum (spring 2009)

- Year 2

  Project implementation began in September 2009
  Collected data in Randolph, MA in Oct/Nov 2009
  Collected data in TX, MO in February – April 2010

- Year 3

  Will collect data this year from classes *taught by the same teachers* using our treatment

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Data Sources

Student Data

~ Content assessment data:

• Concept Inventory for Evolution Readiness (CIER)

~ Survey instrument data:

•Nature of Science (NOS)

• Scientific Inquiry (SI)

• Science Classroom Environment Scale (SCES)

Teacher/Classroom Data

~Observation protocols – implementation fidelity and reformed teaching dimensions

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CIER: Easy Concepts

Easier concepts for students to understand:

~ Particular physical traits help an organism to survive in a given environment (Big Idea 8, Learning Goal 7)

~ Individuals of the same species may differ (Big Idea 7, Learning Goal 1)

~ Plants and animals need air and water; plants also need light and nutrients; animals also need food and shelter (Big Idea 1, Learning Goal 1)

~ An organism thrives in specific environments that match its specific needs (Big Idea 3, Learning Goal 1)

CIER - Difficult Concepts

- Most difficult concepts for students to understand:

  ~ Selection pressure could lead to a change in the characteristics of a population (Big Idea 8, Learning Goal 5)

  ~ Different species could arise from one species if different groups had different selection pressures (Big Idea 11, Learning Goal 2)

  ~ Species adapt to changes in their environment (Big Idea 8, Learning Goal 3)

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