

Cellvival! Evolutionary Concepts as Playable Mechanics

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Introduction

Cellvival! is a game designed to teach high school students biology, particularly evolutionary concepts in a highly engaging way. The player controls a single *Tetrahymena* cell (a common freshwater protist) as it tries to survive and maintain its population for as long as possible.

Context and goals

This game is distributed to students as part of a module that repeatedly cycles between playing the game and discussing and reflecting on the experience with the class. This gives students a chance to compare experiences and perspectives and bring those to the next round of play. It also gives teachers a chance to guide discussion, introduce ideas, and correct possible misconceptions (“The cell is making an intelligent choice during reproduction”, for example).

The learning goals include developing a better understanding of 1) the ecosystem *Tetrahymena* live in (what are its food, its predators, how do they interact), 2) selective pressures, 3) the accumulation of changes over generations, and 4) how fitness depends on environmental context. It is hoped that by presenting these concepts through the game in an experiential, integrated way and facilitating reflection on them, students will develop a deeper understanding of the concepts, intuitions based on that understanding, and a better ability to apply evolutionary reasoning to novel situations. The educational effectiveness of the game as part of a module, relative to other approaches to this material, is being evaluated by an ongoing research project.

Game play description

Players control a single *Tetrahymena* cell, using simple mouse controls, as it navigates the environment and reproduces (as seen in Figure 1).

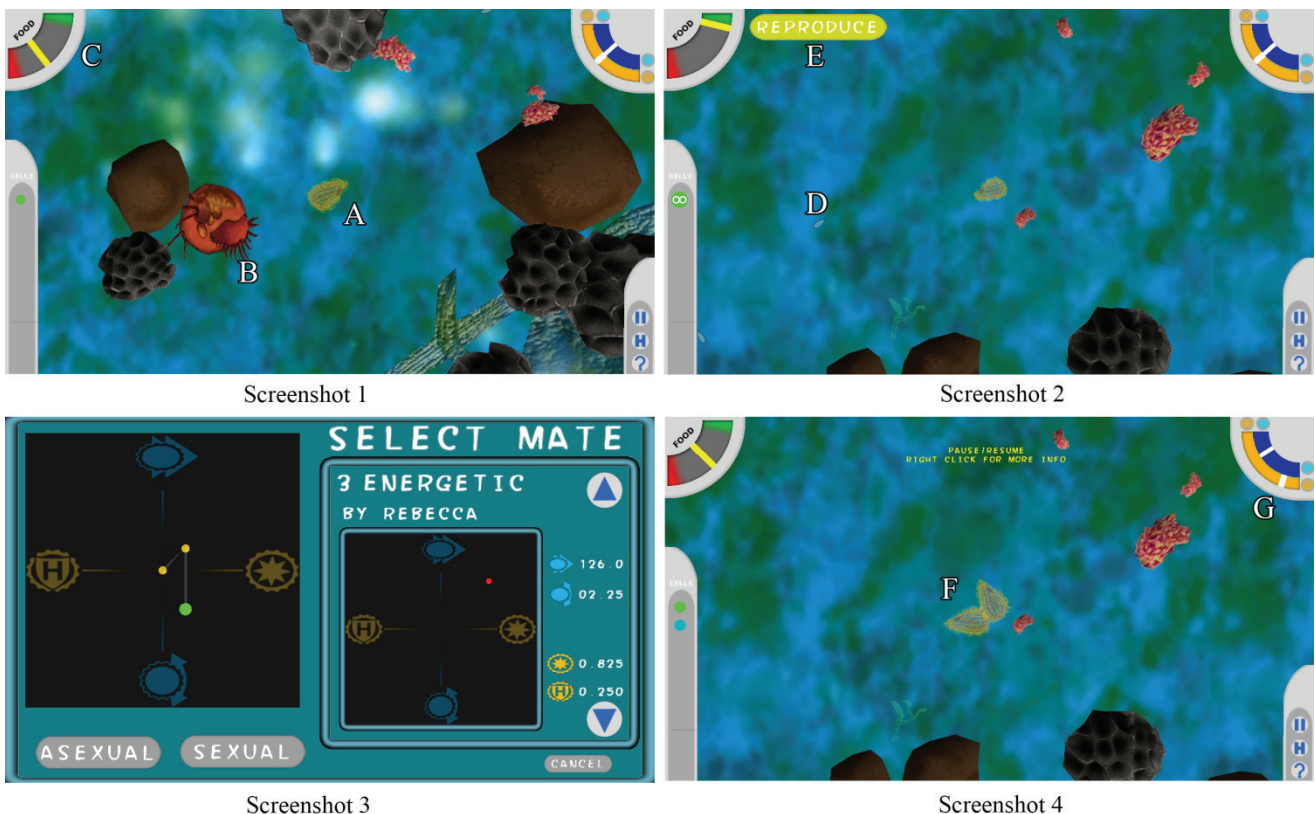


Figure 1: Annotated screen shots of game play.

The player's cell (A), must avoid predators (B) while trying to fill their food meter (C). When they have consumed enough smaller food bacteria (D) to fill their food meter, the reproduce button appears (E). This button takes the player to the reproduction interface (as seen in Screenshot 3), which gives them feedback about their cell history, and allows them to choose to reproduce asexually or sexually (as *Tetrahymena* can do both). If they reproduce sexually, they also have a choice of mates, which they can browse and select using the right side of the interface. Once they make their reproductive choice, they return to normal game play, now controlling the offspring (F) while an AI takes control of the parent cell. The change in the traits of the offspring is shown by an indicator (G) during normal game play, as well as the cell history graph during reproduction. Following reproduction, the player continues trying to survive and attempts to get enough food to reproduce again, either to alter their traits more or to get a larger population as both will help them survive longer.

Design considerations

Normal game play

The normal game play conveys a lot of information about the ecosystem of *Tetrahymena*, provides an immediately engaging experience, and provides a basis for more advanced concepts. The scale of controlling one cell (as opposed to a population) allows the player to invest and identify with that cell, and pilot testers often vocally enthusiastic about finding food and anxious when predators are near.

All the predators are based on actual predators (including their feeding behaviors) and they are kept to scale, relative to the player's cell. This includes one predator that is approximately 100 times as large as *Tetrahymena*, making it larger than the screen in game. Encountering it has proven exciting and memorable with pilot testers. The differences between predator behaviors and scales are made sharply salient by putting the player in the role of a *Tetrahymena* trying to avoid being predated.

The reproduction interface and graphs

One of the distinguishing features of *Cellvival!* is the "genespace graph" used repeatedly in the reproduction interface. These graphs use the cell's four traits to form a 2D space of all the possible cells. A cell's traits define a point in the space, and a cell with different traits defines another point; this means the change in traits across generations can be visually presented as a line. This allows the game to present the accumulation of changes across generations visually by plotting a path. Additionally the four traits all directly affect game play: move speed, turn speed, metabolism (the amount of food each prey is worth), and hazard resistance. This makes changes in these traits both very relevant to the cell's survival, and noticeable in play, even if the various indicators are ignored.

In the reproduction interface, on the left graph is the history of the player's current cell line, showing both the cell's current traits and the traits of past generations (which the player has experienced playing as). To the right is one possible mate and its histories and current traits, with an option to browse through others. Reproducing asexually produces more offspring for a larger population, but changes the cell's traits very little, while sexual reproduction allow for larger changes but creates fewer offspring (as in actual *Tetrahymena*). In this way the game demonstrates the pros and cons of both methods. It should be noted that if the player's cell dies, they are shifted to controlling any surviving members of the population, providing incentive to maintain a large, healthy population. Feedback on current population size is provided in the lower left side of the basic game play interface.

By having the player play as each generation, they experience how difficult it is to survive with one set of traits, get to change traits, then play more experiencing the impact of the changes on the difficulty or surviving in that environment. By letting players experiment repeatedly, the game attempts to convey how changes accumulate over generations and selective pressures work through game play.

Level design

Cellvival! currently has two non-tutorial levels, which are designed to favor different traits. These provide not only variety to the visuals and challenges, but can demonstrate how traits that are advantageous in one environment are detrimental in another; how fitness is context dependent.

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