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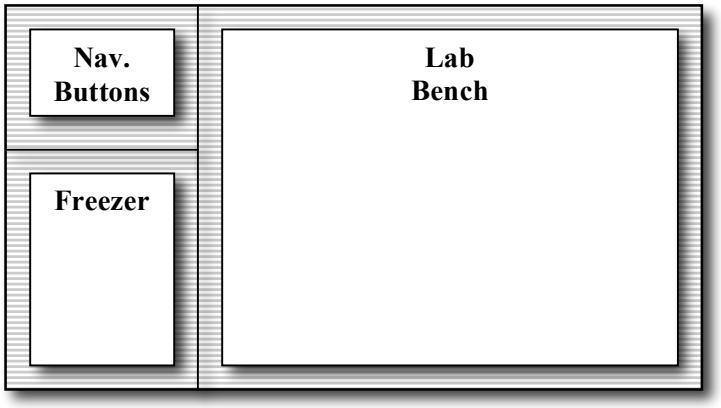
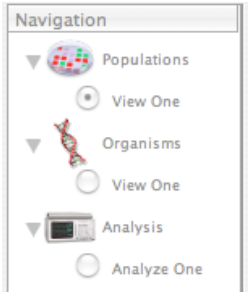
Avida-ED User Manual

I. General Avida-ED Workspace



(A) Navigation buttons

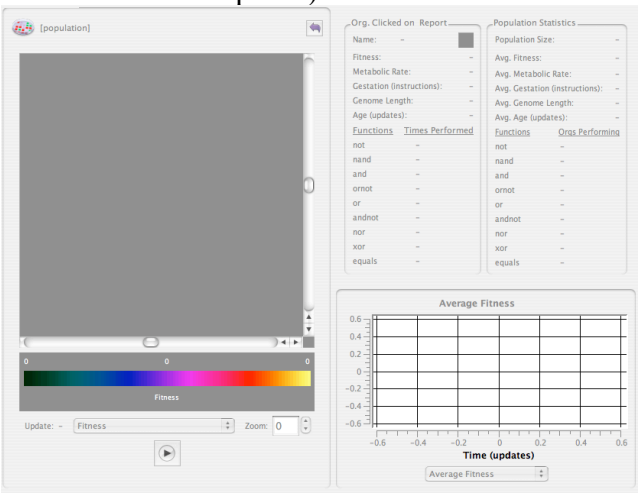
Switch between lab bench views



(B) Lab bench

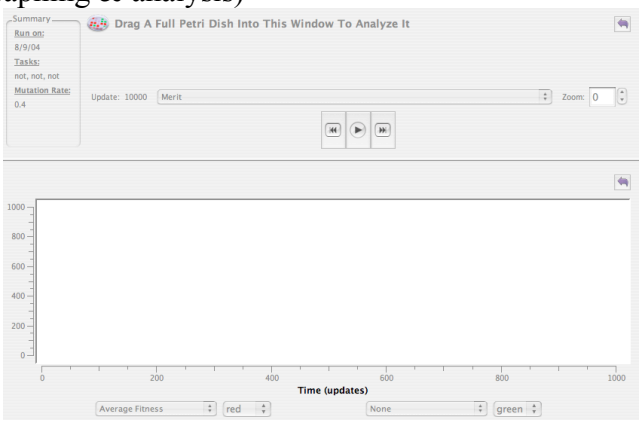
Three lab bench options:

1. Populations (Petri dish & stats viewpanes)



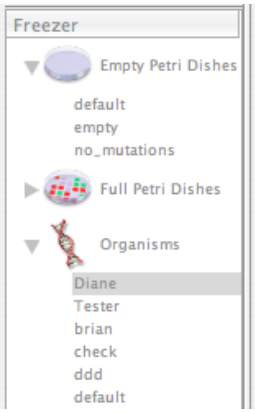
2. Organism (Genetiscope)

3. Analysis (Data graphing & analysis)



(C) The Freezer

• Storage shelves for:
- Empty Petri dishes (environmental settings but no orgs)
- Full Petri dishes (fixed environment settings and frozen orgs)
- Individual organisms removed from a Petri dish



• Drag and drop freezer items to or from an open lab bench.

II. Lab Benches

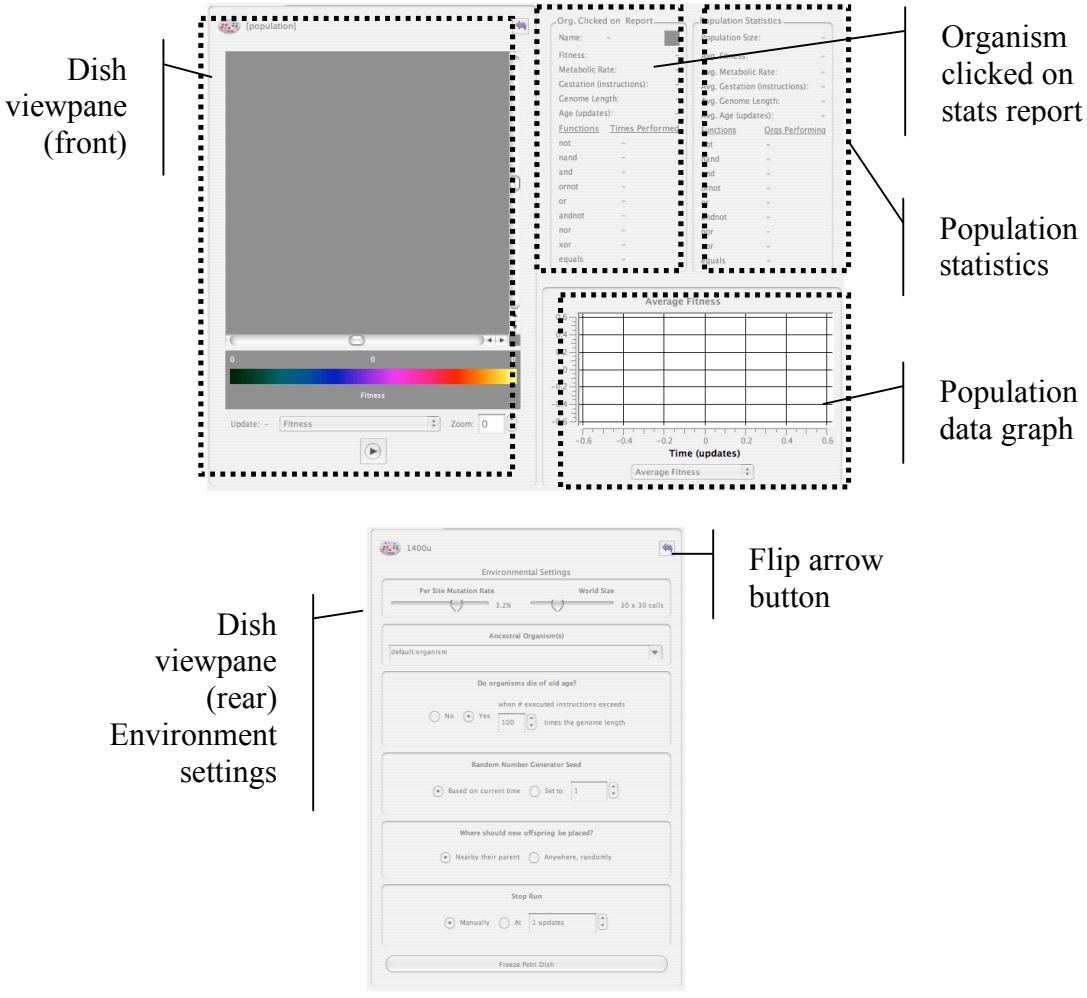
(1) Petri Dish Bench (Population & environment viewer)

Functionality

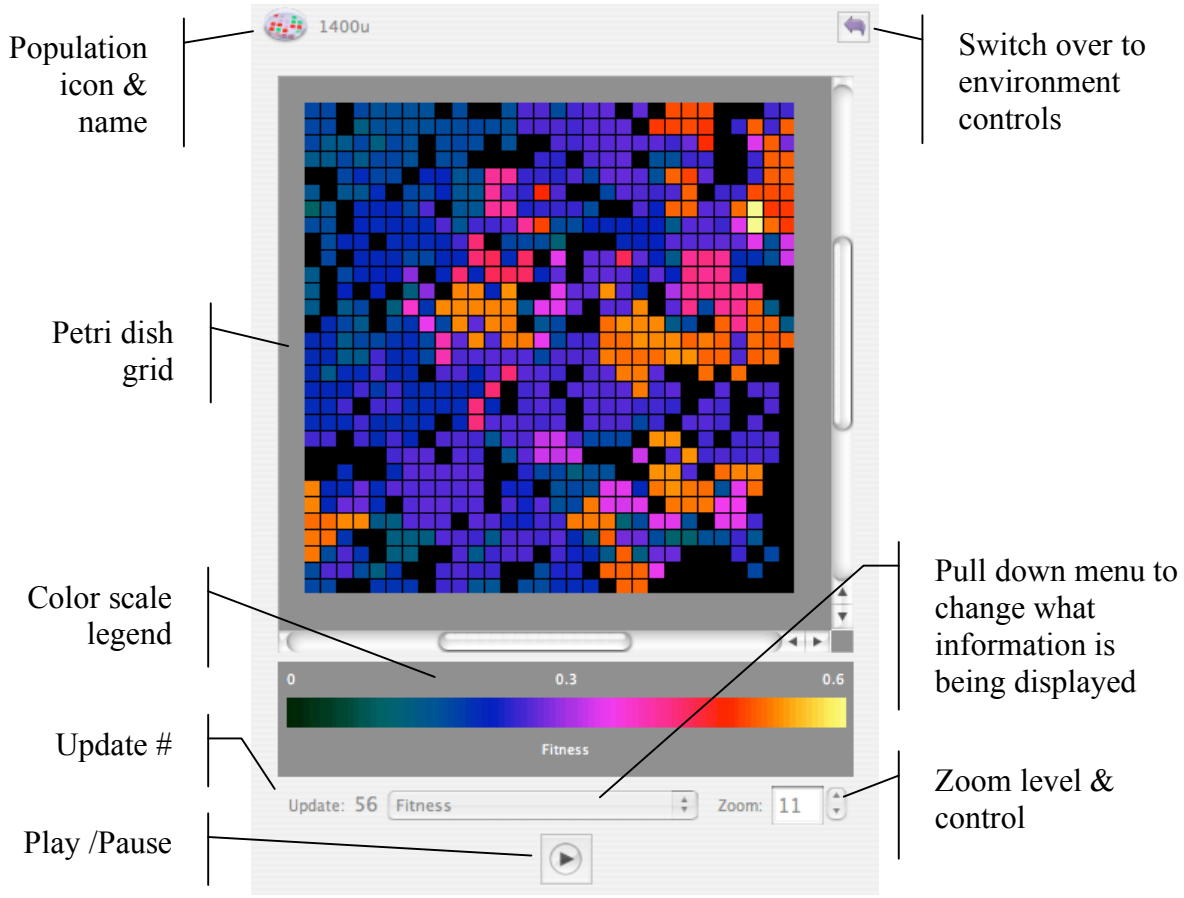
- Evolve a population in a Petri dish
- Click on an individual organism and observe its stats
- Observe whole population stats in real time
- Graph population stats in real time

Basic Controls

- **Drag** a Petri dish (empty or full) or one or more organisms into the Petri dish bench from the freezer.
- **Flip arrow button**: Switch between Petri dish view and its environment settings view.



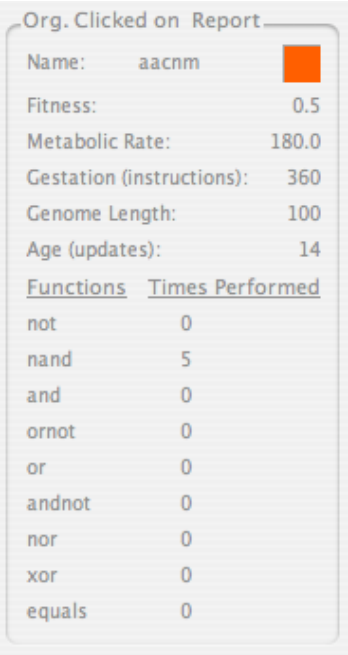
Dish viewpane (front)



- **Population icon & name**: Drag icon to freezer to save. [not yet implemented]
- **Flip arrow switch**: Go to environmental settings for this Petri dish.
- **Petri dish grid**: More or less is visible depending upon the size of the grid. Use scroll bars and/or zoom control if grid extends beyond window.
- **Zoom**: Set the zoom level for the Petri dish
- **Pull-down menu**: Select a feature of the population to indicate by color.
  Options: Metabolic Rate, Fitness, Genome Size, Gestation Time.
- **Color Scale Legend**: Note that during a run, the color scale will automatically adjust as numbers increase or decrease. The spectrum will thus always show relative values, but particular colors will represent different absolute values as a population evolves.
  Special colors: Black indicates an empty cell and white indicates a cell whose value is above the maximum portrayed on the scale (as the scale readjusts to accommodate this new value it will be colored appropriately).
- **Play/pause button**: Starts and temporarily stops a run.
- **Update #** - Number of updates since the beginning of a run.

Stats viewpanes

Organism Clicked on Statistics Report

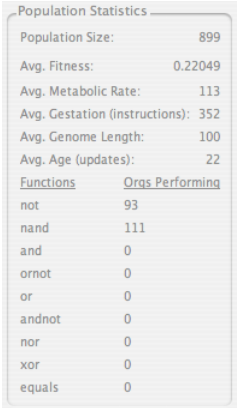


Name: Avida-ED automatically assigns names to new varieties of Avidians as they evolve in a population. The square's color matches the color of the selected Avidian in the current Petri dish grid.

Basic Statistics: The following stats related to the selected organism are listed in real time: Fitness, Metabolic Rate, Gestation (instructions), Genome Length, Age (updates).

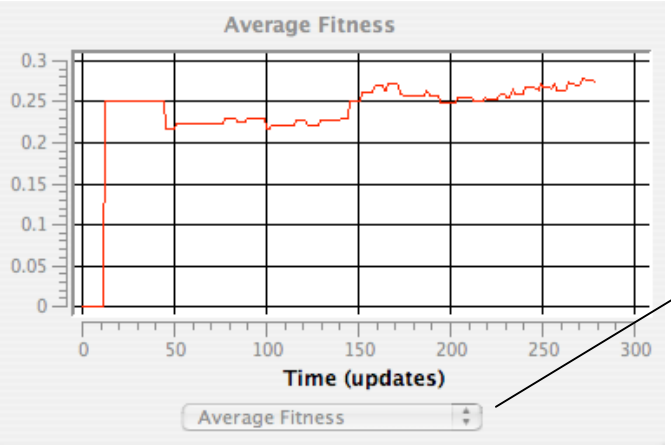
Functions list: Metabolic functions, listed in ascending order of complexity, that the organism may have evolved the ability to perform. If "Times Performed" is "0" the organism has not performed that function yet in this lifetime (or never does). Organisms get more energy (SIPs) if they perform more or more complex functions more often.

Population statistics



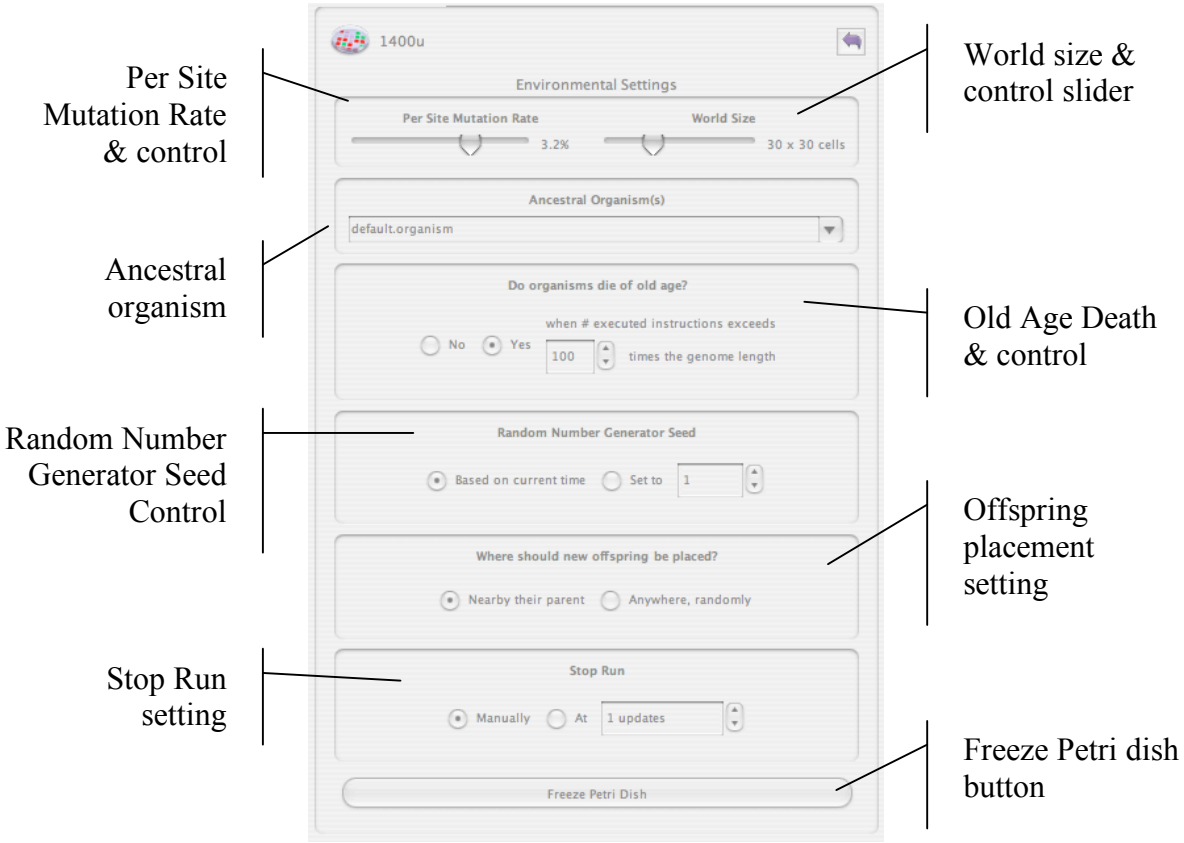
Same properties as above, but data is for the population as a whole.

Population data graph



- **Pull down property menu**: Pick the property of the population to graph in real time. Options include: Average Metabolic Rate, Average Fitness, Average Gestation Time, Average Genome Length, and Number of Organisms in the population.
- **Vertical axis**: Units change depending upon property being graphed. The scale dynamically changes during a run to accommodate the evolving population.
- **Time axis**: Time, in updates, since beginning of run of this population.

Environmental settings & controls



- **Per site mutation rate**: This rate reflects the percent chance that an instruction is incorrectly copied. So, if the per site mutation rate is 1%, there is a 1% chance that when an instruction is copied, it will end up as any one of the 26 possible instructions (one of which is itself, so it could 'mutate' back to itself). With a 1% per site mutation rate, if 100 instructions are copied one of them will be mutated on average (although this number could be higher or lower in any instance).
- **World size**: Sets the maximum number of Avidians that can exist in the population. The two numbers specify the number of Avidians per row, and per column. So, 10 x 10 = a population of 100 organisms.
- **Ancestral organism**: This is the organism the population starts with.
- **Old Age Death**: Some mutations make an organism unable to replicate, so they stay in their cell cycling through instructions endlessly without making a child. Without old age death, they will continue to do so until they are overwritten by another Avidian. You can set when an organism dies in terms of how many instructions it is able to execute before it dies. If it successfully reproduces before this threshold, its counter is reset in the next generation. The threshold is set in terms of the number of instructions it can execute as a multiple of its genome length. So, if the genome length of an Avidian is 100 and you set the threshold for 10 times its genome length, the organism will die (and the cell it occupies empties) if it has not replicated before it executes 1000 instructions.

- **Random Number Generator Seed**: If you set this number to a value, and you use this same random number seed with the exact same environmental configurations, the run will be identical. If you change only the number, you will get multiple tests of the same settings. If you set this number to time, you will get a new run each time but you will never be able to replicate the experiment (for this number is not saved).
- **Offspring placement**: When an offspring is born, it can either be placed in a cell adjacent to its parent, or anywhere (at random) in the population.
- **Stop Run**: If you set a specific number ahead of time, the run will stop when this many updates have passed. If you set the run to stop manually, it will continue indefinitely until it is paused using the button under the Petri dish.
- **Freeze Petri Dish Button**: Push button to save either just the environmental configuration (by saving an 'empty') Petri dish, or else the environment plus the organisms (by saving a 'full Petri dish').

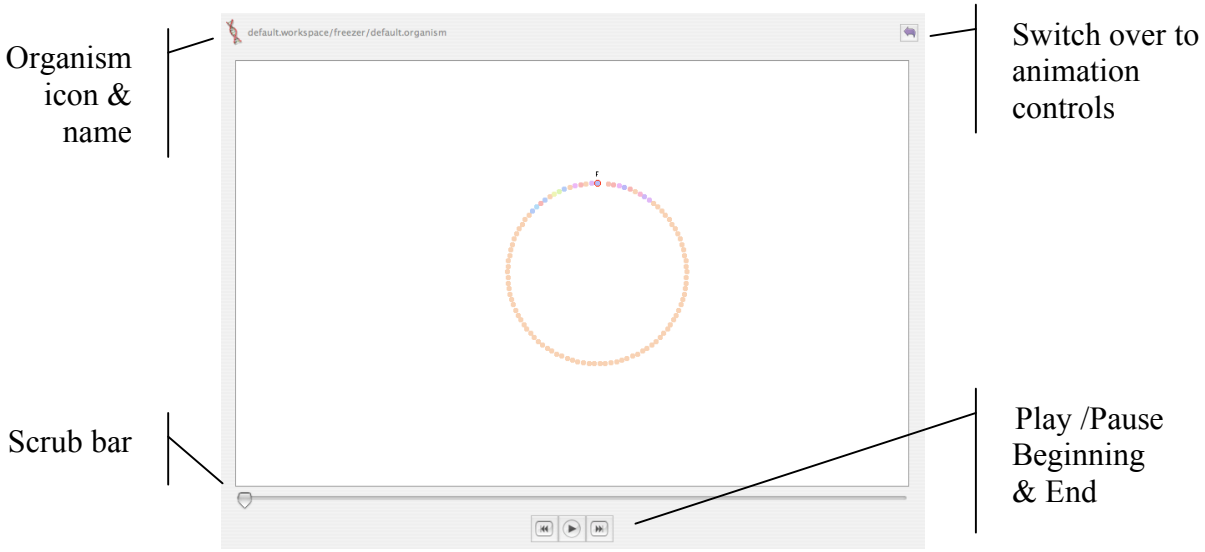
(2) Genetiscope (Organism genome viewer)

Functionality

- Observe the genome of an individual organism.
- Play a movie of the genome instructions' operation.
- Choose how much of the genetic machinery is visible.

Basic Controls

- **Drag** an organism from the freezer. (A progress bar will indicate that the organism is being readied for viewing.)
- Press **play/pause** to start/stop the movie of the genome's execution. Use the **scrub bar** to move back and forth in the movie.
- Press **flip arrow** button for the checkbox controls. These toggle on/off which components of the genetic machinery are shown. [*Note: Currently, only the instruction head options are available.*]



- **Organism icon & name**: Name of the organism whose genome is being viewed.
- **Flip arrow switch**: Go to animation settings for the genetic machinery.
- **Scrub bar**: Move forward or backward in the movie after it has rendered.
- **Play/pause button**: Starts and temporarily stops movie.

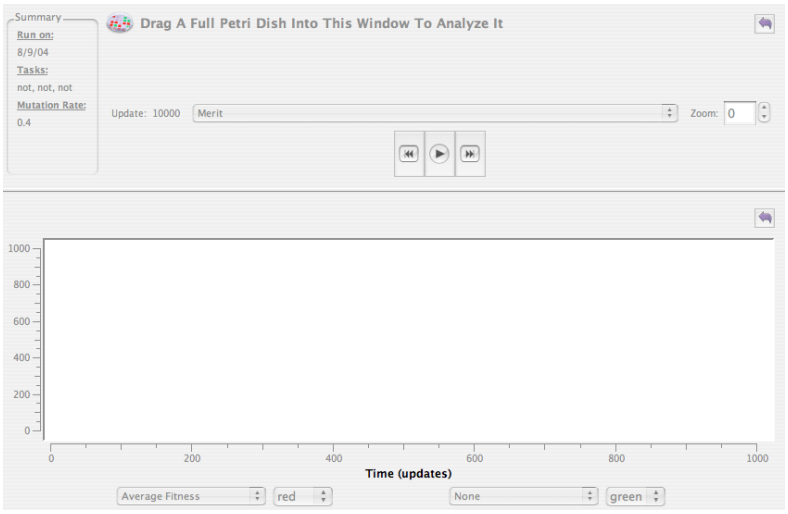
(3) Analyzer (Data graphing & analysis)

Functionality

- Graph one or two data sets from a population.
- Analyze graphed data as a whole or close up in selected sections.

Basic Controls

- **Drag** a full Petri dish from the freezer [Broken] or **double click** on a full Petri dish from the freezer when the Analyzer is open.
- Press **play/pause** to start/stop the movie of the population's evolution. [*Not yet implemented*.]
- Press **flip arrow** buttons for the pane setting controls. [*Not yet implemented.*]
- Use **pull down menus** to choose what information you wish to graph (you can graph two things at once) and the corresponding color for that information.



Glossary

Avida

Pronounced Aveeda. From A-life (artificial life) in Spanish (vida = life). Avida is the evolutionary computation engine at the heart of Avida-ED.

Avidian

Pronounced Ah-vîd-ian. An organism in the Avida environment.

Fitness

Metabolic rate divided by gestation time. Holding the environment constant, if organism X has twice the fitness of organism Y, it means that it, on average, X will reproduce twice as fast as Y. This fitness measure is objective, in that it measures non-relative things (metabolic rate and gestation time). It is important to realize that, in terms of natural selection, the fitness of an organism must be compared to the organisms it competes with. An organism with a fitness of .3 will have a selective advantage in a population where every other organism has a fitness of .1, whereas this same organism with a fitness of .3 will be at a selective disadvantage in a population where every other organism has a fitness of 10.

Genome

This is the genetic code of an Avidian. It consists of a 'string' (list) of instructions comprised of the instruction set. Its biological analogy is an organism's DNA.

Gestation

The number of instructions it takes for an organism to reproduce.

Metabolic Functions

Organisms can perform functions to gain energy. There are 9 functions that they can perform (not, nand, and, or_not, or, and_not, neither_or, exclusive_or, equals). The performance of any task doubles the metabolic rate of the organism. The bonus is not realized immediately, however. Instead, an organism starts with all of the merit the system thinks it deserves based on the total number of functions it performs. These functions are logic functions performed on either one or two 32-bit numbers, that the organism performs by manipulating these numbers with its instructions. The simplest of these tasks (not) takes a minimum of 6 instructions (we think). The most complex task (exclusive_or, equals) takes a minimum of 19 instructions (we think).

Metabolic Rate

Each organism has a value called metabolic rate associated with it, which indicates how fast the organism is able to execute instructions. Metabolic rate is a unitless quantity, and is only meaningful when compared to the merits of other organisms. Thus, if organism X has twice the merit of organism Y than X should execute twice as many instructions

in any given time frame. Therefore, if the gestation times of X and Y are the same, and X has twice the merit of Y, then, on average, X will reproduce twice as fast as Y (see also fitness).

SIP (Single Instruction Processing unit)

A unit of "energy" in Avida. [*Not yet explicit in Avida-ED*]

Update

An "update" is the unit of time in Avida-ED. Avida time is internally constant, but is not constant relative to real time; a single update for a large population takes longer in real time than an update for a small population. "Update" is defined as the passage of enough SIPS (executions of single instructions) such that each organism, on average, has executed 30 instructions (however, more fit organisms will most likely have executed more and les fit organisms will have executed less).