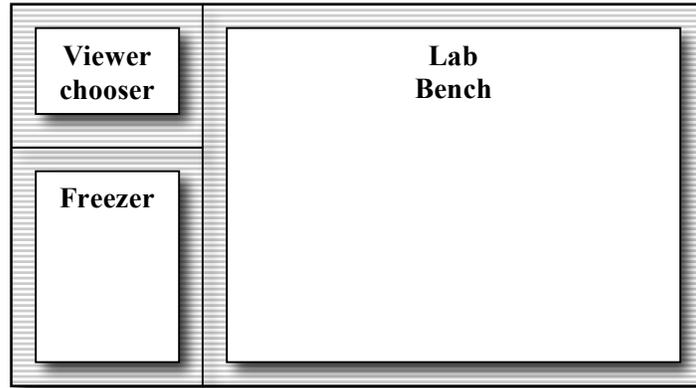


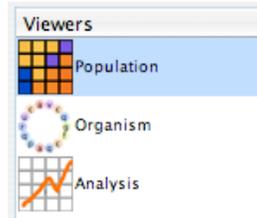
Avida-ED User Manual

I. General Avida-ED Workspace



(A) Viewer chooser buttons

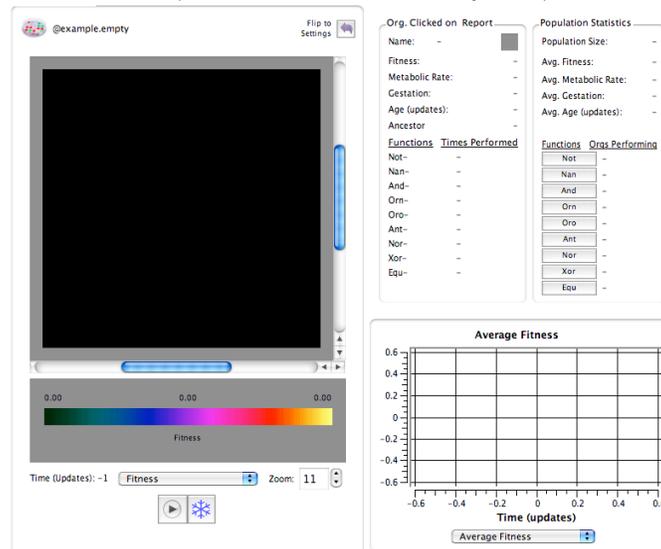
Switch between lab bench views



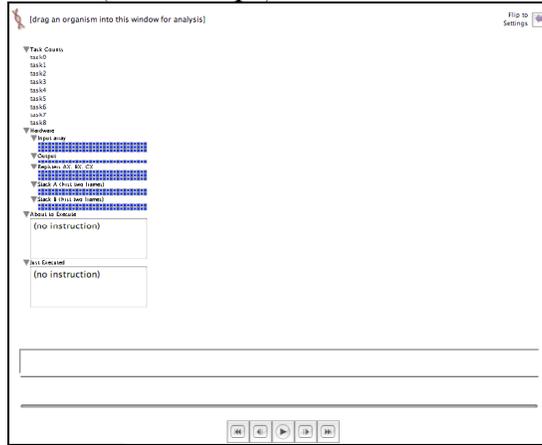
(B) Lab bench

Three lab bench options:

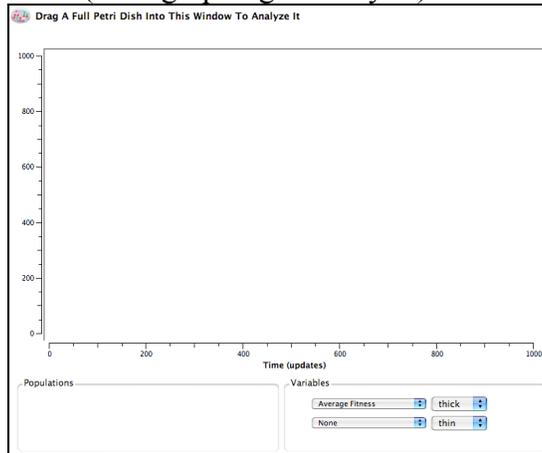
1. Population View Lab Bench (Petri dish & stats viewpanes)



2. Organism View Lab Bench (Genetiscope)



3. Analysis View Lab Bench (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.
- Right-click (Ctrl-click) item in freezer to rename, delete, export or open it.

II. Lab Benches

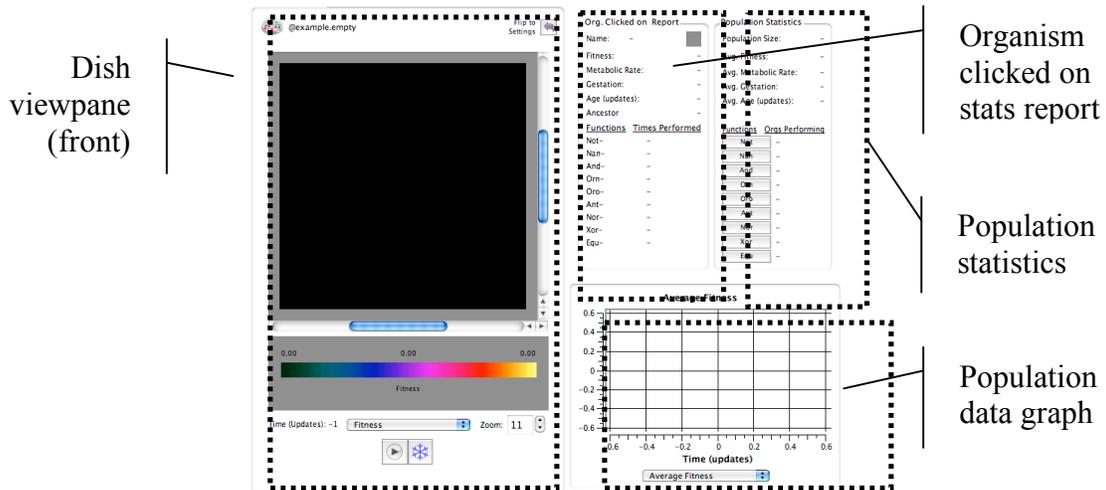
(1) Petri Dish Bench View (Population & environment settings)

Functionality

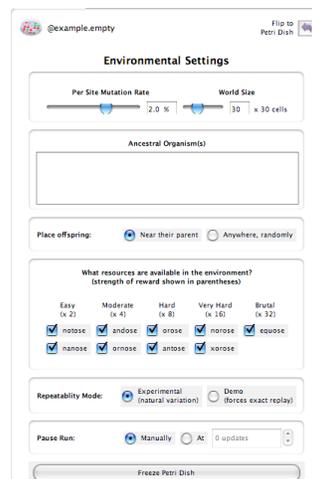
- Evolve a population in a Petri dish
- Click on an individual organism and observe its stats
- Observe whole population stats in real time
- Graph population stats in real time

Basic Controls

- **Drag** a Petri dish (empty or full) or one or more organisms into the Petri dish bench from the freezer to begin a new run.
- **Flip arrow button**: Switch between Petri dish front view and its environment settings.
- **Save images** of populations in viewer [MENU File -> Save Images]
- **Export** data to comma-delimited file. [MENU File -> Export Analysis]

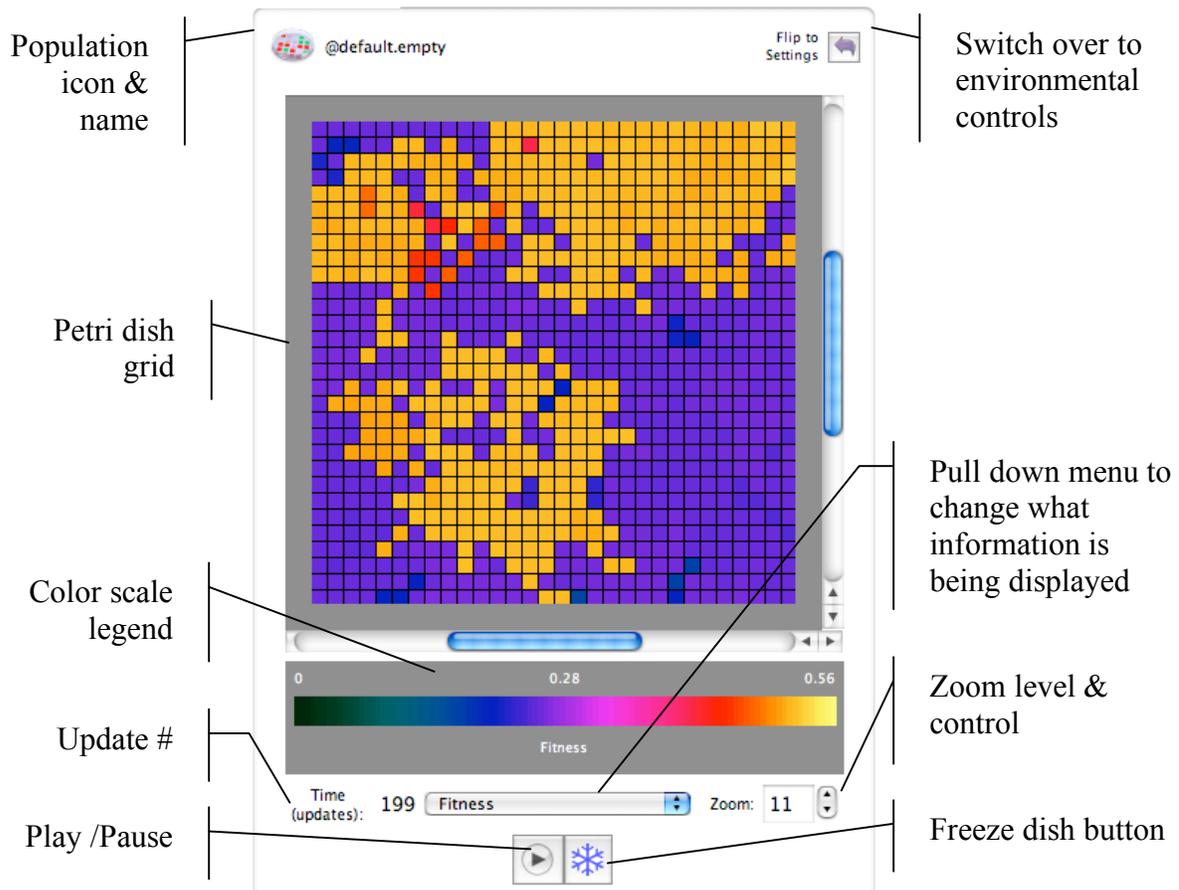


Dish viewpane (rear)
 Environment settings



Flip to Petri dish front

Dish viewpane (front)



- **Population icon & name:** Drag icon to freezer to save.
- **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.
- **Color Scale Legend:** During a run, the color scale will automatically adjust as numbers increase or decrease. ["Scaling" will appear in parentheses.] 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).
- **Update #** - Avida internal time; in number of [updates](#) since the beginning of a run.
- **Pull-down menu:** Select a feature of the population to indicate by color.
Options: Ancestor, [Metabolic Rate](#), [Fitness](#), [Gestation Time](#), [Genome Size](#).
- **Zoom:** Set the zoom level for the Petri dish
- **Play/pause button:** Starts and temporarily stops a run.
- **Freeze button:** Save the population and/or environmental settings to the freezer.

Stats viewpanes

Organism Clicked on Statistics Report

Org. Clicked on Report

| | | |
|------------------|------------------------|---|
| Name: | aaalk |  |
| Fitness: | 0.50810 | |
| Metabolic Rate: | 94.0 | |
| Gestation: | 185 | |
| Age (updates): | 1 | |
| Ancestor | @ancestor | |
| <u>Functions</u> | <u>Times Performed</u> | |
| Not- | 0 | |
| Nan+ | 1 | |
| And- | 0 | |
| Orn- | 0 | |
| Oro- | 0 | |
| Ant- | 0 | |
| Nor- | 0 | |
| Xor- | 0 | |
| Equ- | 0 | |

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), 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 complex functions.

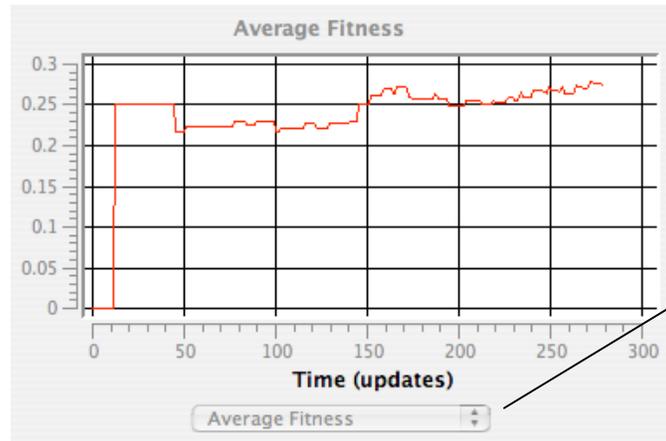
Population statistics

Click buttons to highlight
organ in dish that have
these phenotypes

| Population Statistics | |
|-----------------------|------------------------|
| Population Size: | 366 |
| Avg. Fitness: | 0.35294 |
| Avg. Metabolic Rate: | 67 |
| Avg. Gestation: | 192 |
| Avg. Age (updates): | 4 |
| | - |
| <u>Functions</u> | <u>Orgs Performing</u> |
| Not | 151 |
| Nan | 5 |
| And | 0 |
| Orn | 5 |
| Oro | 0 |
| Ant | 0 |
| Nor | 0 |
| Xor | 0 |
| Equ | 0 |

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

Population data graph



Pull down menu
for property to
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](#), 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

The screenshot shows the 'Environmental Settings' panel in Avida-ED. It includes a header with a user icon '@example' and a 'Flip to Petri Dish' button. The main settings are organized into several sections: 1. 'Per Site Mutation Rate & control' and 'World size & control slider' at the top, featuring sliders for 'Per Site Mutation Rate' (set to 2.0%) and 'World Size' (set to 30 x 30 cells). 2. 'Ancestral seed organism(s)' section with a drag-and-drop area containing '@ancestor'. 3. 'Place offspring:' section with radio buttons for 'Near their parent' (selected) and 'Anywhere, randomly'. 4. 'Environmental resources settings' section titled 'What resources are available in the environment?' with a table of nutrient options: Easy (x 2), Moderate (x 4), Hard (x 8), Very Hard (x 16), and Brutal (x 32). Each category has several nutrient types with checkboxes, all of which are checked. 5. 'Repeatability Mode:' section with radio buttons for 'Experimental (natural variation)' (selected) and 'Demo (forces exact replay)'. 6. 'Pause Run setting' section with radio buttons for 'Manually' (selected) and 'At' followed by a '0 updates' input field. 7. A 'Freeze Petri Dish' button at the bottom.

- **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 seed organism(s):** The organism(s) the population begins from. Drag in or out additional organisms at the beginning of a run.
- **Environmental Resource Settings:** Avidians can receive extra energy if they evolve the ability to “metabolize” nutrients. Here you can set what nutrients are available in the environment.
- **Exact Repeatability:** Many steps in an Avida evolutionary run happen randomly (e.g. what mutations will occur in the genome, into what cell a new organism will be placed

at division), so each run will be slightly different even with the same general environmental values, as in nature. This is the default setting. However, if you need to repeat a run (e.g. for a demonstration) you can switch this to exactly replicate the sequence with the same mutations and values.

- **Offspring placement:** When an offspring is born, it can either be placed (at random) in any of the eight cells adjacent to its parent, or anywhere (at random) in the population. If the cell is already occupied the org there is overwritten.
- **Pause Run Manually/Automatically:** If you set a specific number ahead of time, the run will pause 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 snowflake 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).

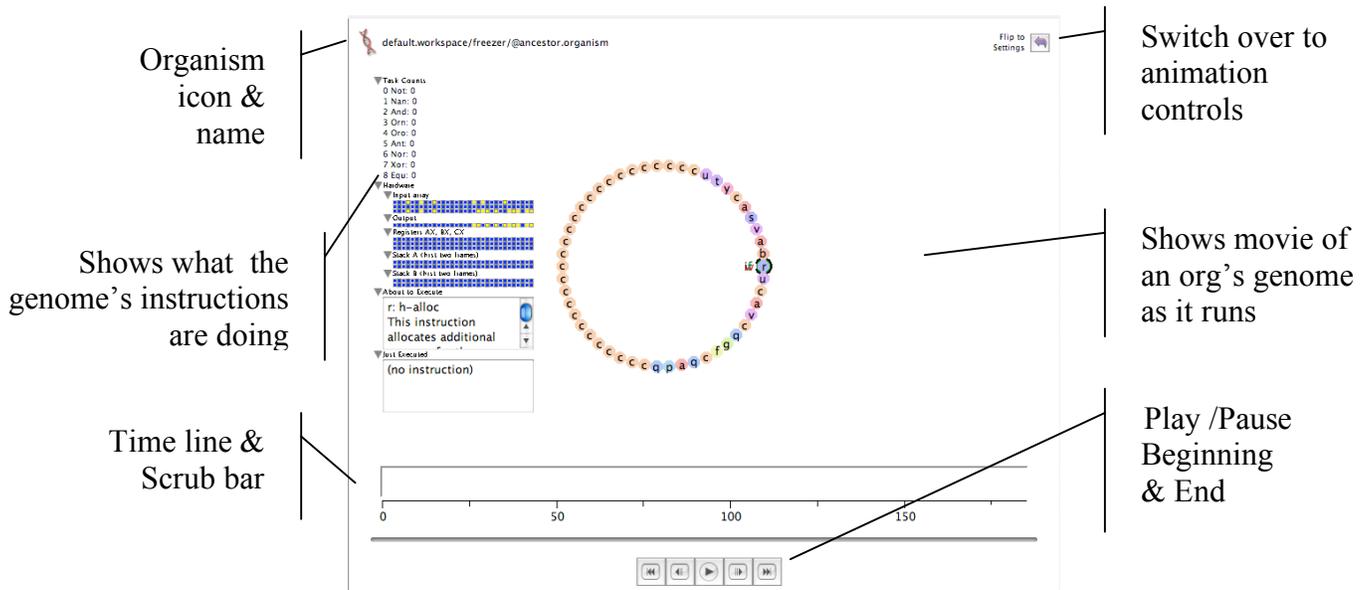
(2) Genetiscope (Organism genome viewer)

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.
- Save viewer images

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.
- **Save images** of orgs in viewer [MENU File -> Save Images]

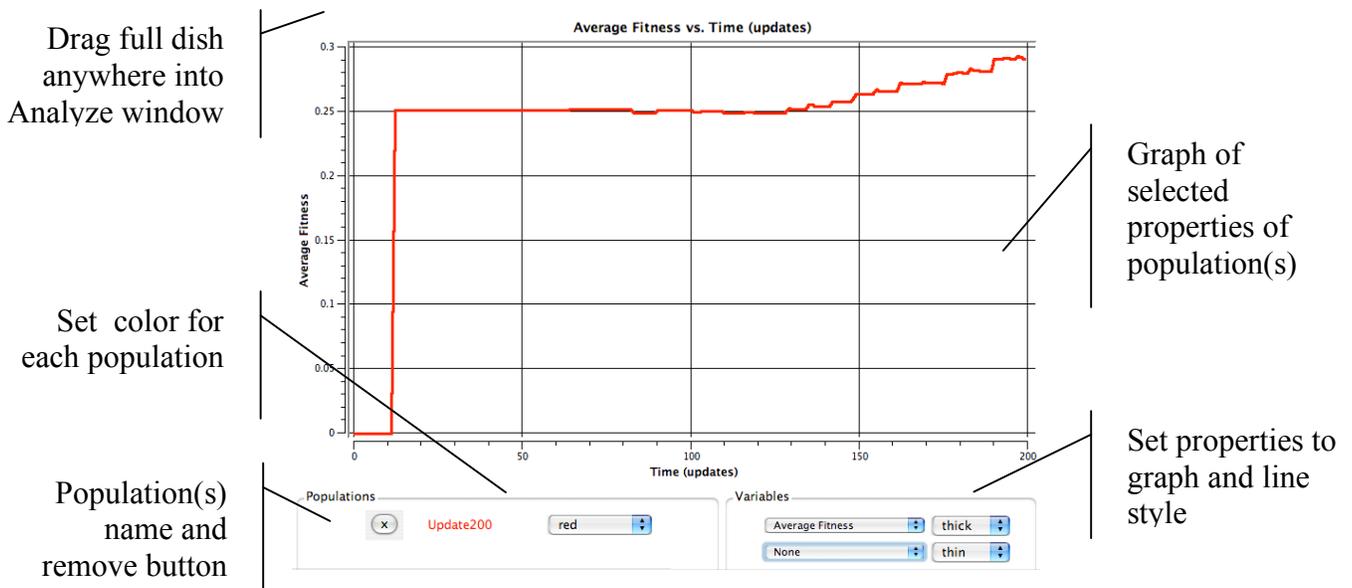
(3) Analyzer Lab Bench (Data graphing & analysis)

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** full Petri dish(s) from the freezer onto the analyzer lab bench.
- 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.
- **Click-drag** within the graph to show just that segment.
- **Save images** of graphs [MENU File -> Save Images]
- **Export** data to comma-delimited file. [MENU File -> Export Analysis]



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.

Death

In Avida-ED, an Avidian will die of “old age” if it does not self-replicate within a given number of instructions, set here as 20 times its genome length. It may die earlier if another Avidian divides and one of the daughter cells is placed by chance onto its spot on the grid, overwriting it.

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. In Avida-ED the size of the genome is fixed at a length of 50 instructions.

Gestation

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

Instruction Set

The genome of an Avidian is comprised of a series of simple computer instructions. There are 26 instructions in the basic set. Different instructions are symbolized by the lower-case letters “a” through “z” and by different colored dots in the organism viewer.

Metabolic Functions

Organisms may gain additional energy by evolving abilities to perform special “metabolic” functions or tasks. These tasks are logic functions performed on either one or two 32-bit numbers. The organism must manipulate these numbers with the instructions in its genome. In Avida-ED there are 9 functions that that may be evolved (not, nand, and, or_not, or, and_not, neither_or, exclusive_or, equals). All functions require some

complex sequence of instructions to perform. The simplest of these functions (not) takes a minimum of 6 instructions (we think). The most complex tasks (exclusive_or, equals) take a minimum of 19 instructions (we think). The ability to perform a task multiplies the org's basic metabolic rate by the task's energetic value.

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 — “merit”—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*]

Time

Avida time is internally constant and is measured in “[updates](#)”. Avida standard time 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

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 less fit organisms will have executed less).