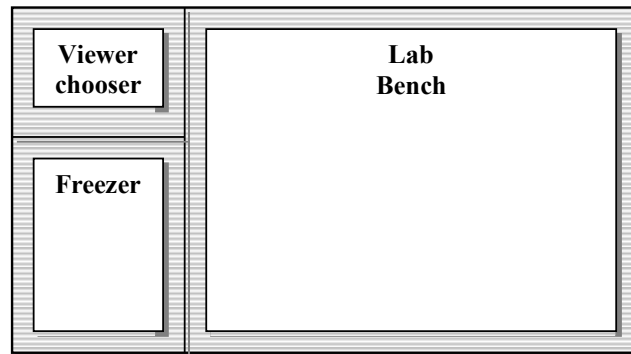




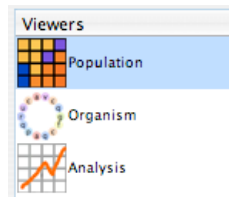
Avida-ED Quick Start User Manual

I. General Avida-ED Workspace



(A) Viewer chooser buttons

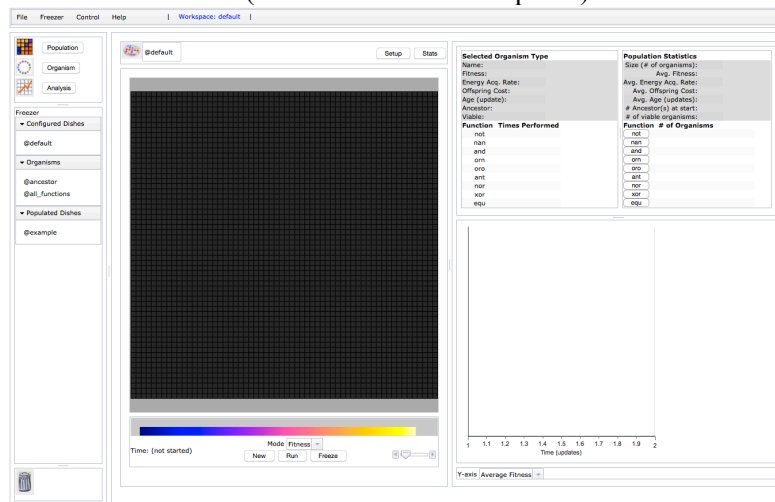
Switch between lab bench views



(B) Lab bench

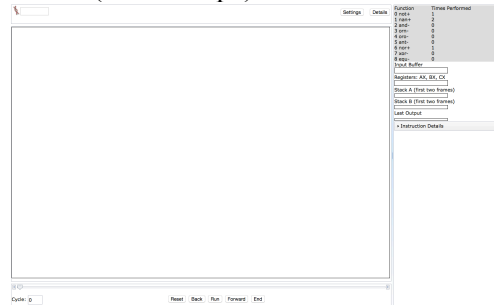
Three lab bench options:

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

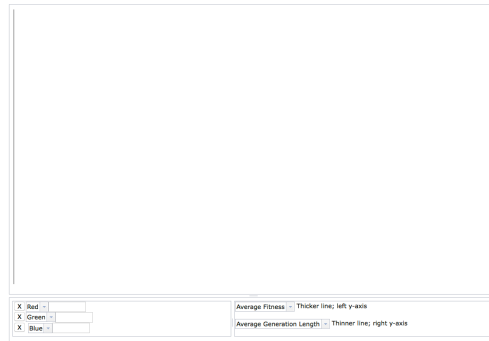




2. Organism View Lab Bench (Genetiscope)

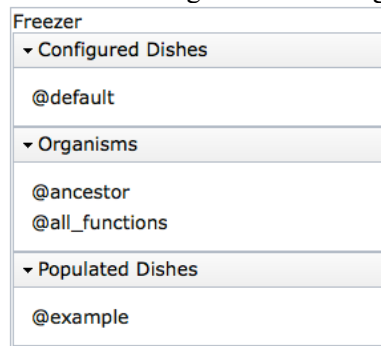


3. Analysis View Lab Bench (Data graphing & analysis)



(C) The Freezer

- Storage shelves for:
 - Configured Petri dishes (environmental settings but no organisms)
 - Individual organisms removed from a Petri dish
 - Populated Petri dishes (environment settings and frozen organisms)



- Drag and drop freezer items to or from an open lab bench.
- Right-click (Ctrl-click) or double-click item in freezer (except default items) to rename, delete or export it.
- Click a disclose triangle to hide or show lists of items
- Export selected item. [MENU File -> Export Freezer Item...]



II. Lab Benches

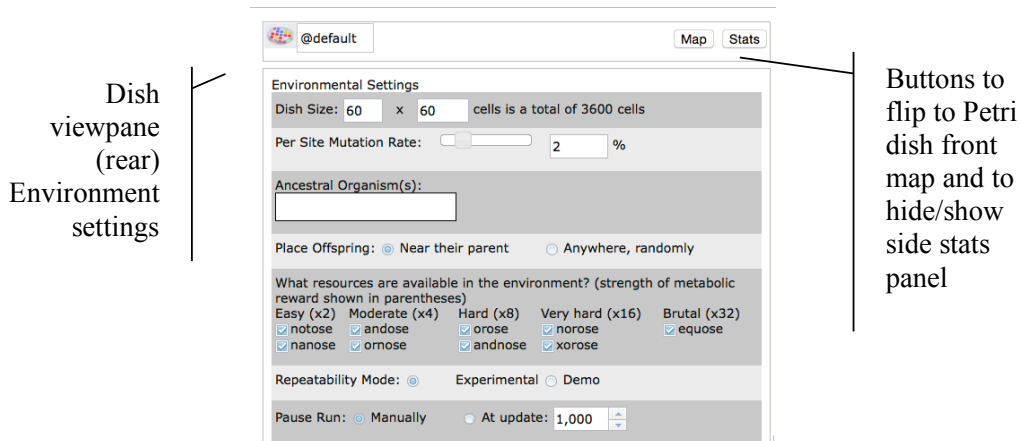
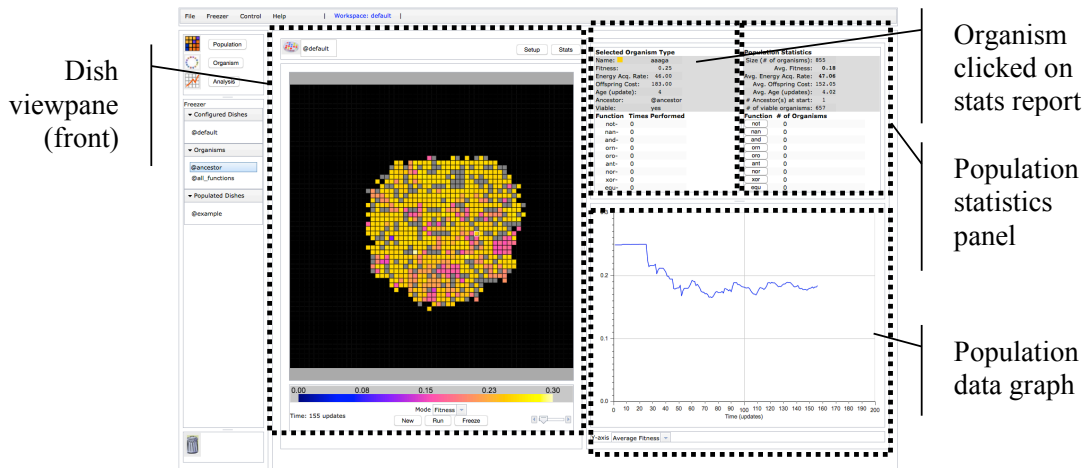
(1) Population Viewer (“Petri Dish” & environment settings)

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

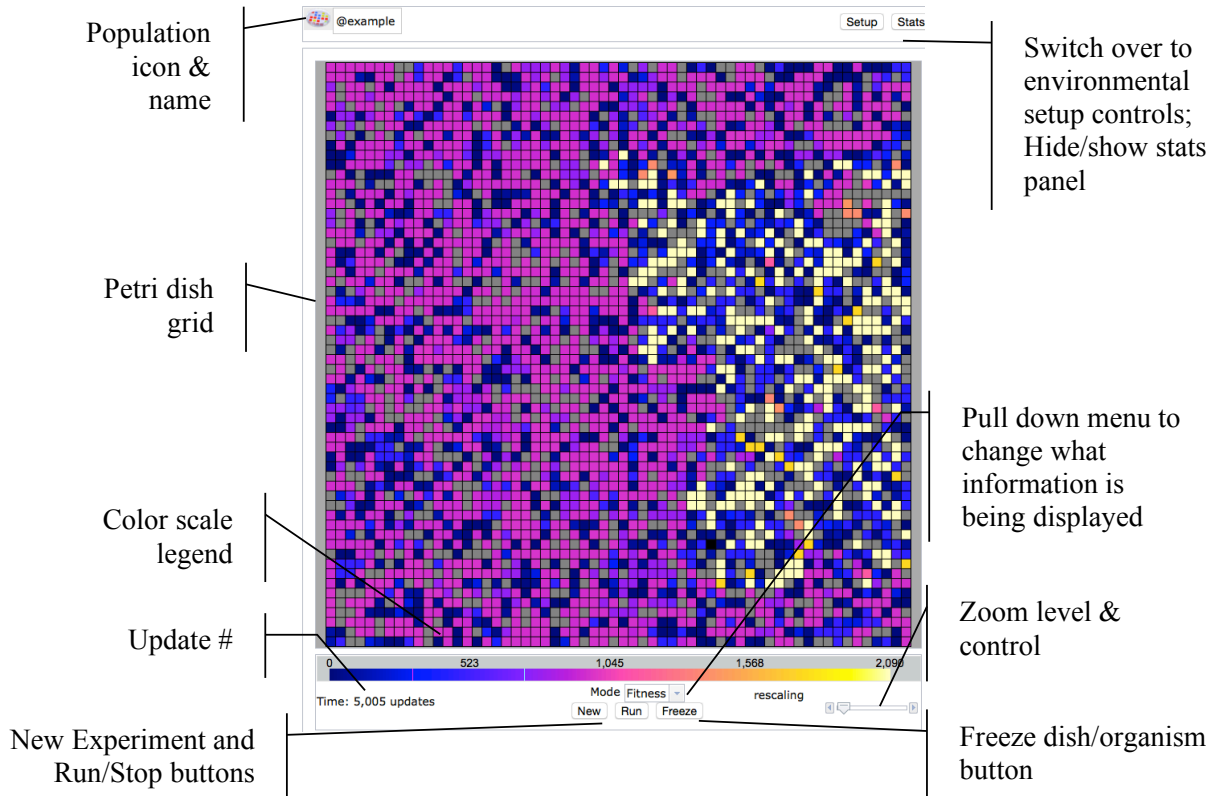
Basic Controls

- **Drag** a Petri dish (configured or populated) or one or more organisms into the Petri dish bench from the freezer to begin a new run.
- **Setup/Map button:** Switch between Petri dish front view and its environment settings.
- **Export** data to comma-delimited file. [MENU File -> Export Data...]
- **Save images** of population or graph in viewer [MENU File -> Export Graphics...]
- **Import** or **Export** a dish or organism. [MENU File -> Import/Export Item...]





Dish viewpane (front)



- **Population icon & name:** Drag icon to freezer to save either the populated dish or just the dish environmental configuration. Click name to rename.
- **Setup button:** Go to environmental settings for this Petri dish.
- **Stats button:** Hide/reveal stats side panel for this dish.
- **Petri dish map:** More or less of the map 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. [“Rescaling” 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). Grey indicates that the organism in the cell is not viable.
- **Time** - Avida internal time; in number of [updates](#) since the beginning of a run. This is a constant internal time; it does not correspond to external time because updates take longer for larger populations.



- **Mode menu:** Pull down menu to select a feature of the population to indicate by color. Options: [Fitness](#), [Offspring Cost](#), [Energy Acquisition Rate](#), Ancestor Organism.
- **New** button: Ends the current run (after offering to discard or save it) and then resets the Petri dish for a new experiment.
- **Run/Stop** button: Starts and temporarily stops a run.
- **Freeze** button: Save the population and/or environmental settings to the freezer.
- **Zoom:** Set the zoom level for the Petri dish. Use scroll bars if zooming in causes the grid to extend beyond window.

Shortcuts:

- **Click** on an organism in the Petri Dish and **drag** it to the Freezer to save it.
- **Click** on an organism in the Petri Dish or the Freezer and **drag** it to the Organism Viewer icon in the Viewer Chooser to open it directly in the Organism Viewer.
- **Click** on an organism in the Petri Dish to select it. Use arrow keys (up, down, left or right) to select a neighboring organism.
- **Click** on the Petri Dish icon in the Petri Dish and **drag** it to the Freezer to save it.
- **Click** on the Petri Dish icon in the Petri Dish or on the name of a populated dish in the Freezer and **drag** it to the Analyze Viewer icon in the Viewer Choose to view it directly in the Analyzer without having to save it to the Freezer first.
- **Click** on an item in the Freezer and **drag** it to the trash can icon to delete it.



Stats viewpanes

Selected Organism Type Statistics Report

| Selected Organism Type | |
|------------------------|-----------------|
| Name: | abqfx |
| Fitness: | 1,260.31 |
| Energy Acq. Rate: | 196,608.00 |
| Offspring Cost: | 156.00 |
| Age (update): | 2 |
| Ancestor: | @ancestor |
| Viable: | yes |
| Function | Times Performed |
| not- | 0 |
| nan- | 0 |
| and- | 0 |
| orn+ | 1 |
| oro+ | 1 |
| ant+ | 1 |
| nor+ | 1 |
| xor- | 0 |
| equ- | 0 |

Name: Upon initial replication, Avida-ED automatically assigns temporary placeholder names to new varieties of [Avidians](#) as they evolve in a population. (New kinds of organisms that have not replicated, perhaps because they are not viable, are listed as no_name.) The square's color matches the color of the selected Avidian in the current Petri dish grid.

Basic Statistics: The listing of stats related to the selected organism are updated as the population is running: [Fitness](#), [Energy Acquisition Rate](#), [Offspring Cost](#), Age ([updates](#)), Ancestor, and Viability.

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.



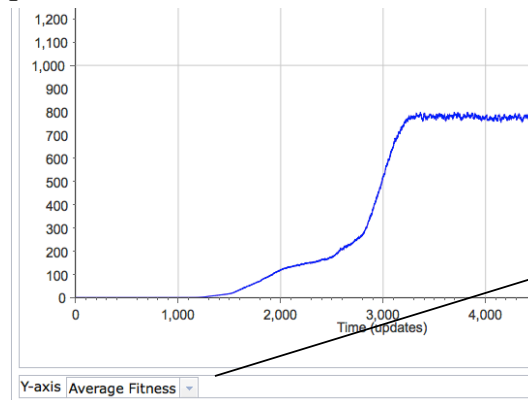
Population statistics

Click buttons to highlight
orgs in dish that have
these phenotypes

| Population Statistics | | |
|-------------------------|-----------|---|
| Size (# of organisms): | 3,599 | |
| Avg. Fitness: | 447.95 | |
| Avg. Energy Acq. Rate: | 76,299.69 | |
| Avg. Offspring Cost: | 126.68 | |
| Avg. Age (updates): | 6.03 | |
| # Ancestor(s) at start: | 1 | |
| # of viable organisms: | 2,591 | |
| Function # of Organisms | | |
| not | 365 | |
| nan | 61 | |
| and | 1 | |
| orn | 2199 | |
| oro | 1729 | |
| ant | 1610 | |
| nor | 1753 | |
| xor | 0 | |
| equ | 0 | |
| | | Number Performing All Selected Functions |
| | | 1635 |

- These are the same functions as in the Org. Clicked on Report, but data is given for the population as a whole.
- Click a single function button to highlight organisms in the dish that have the given function. Clicking two or more function buttons highlights organisms that have ALL the selected functions.

Population data graph



- **Pull down property menu:** Pick the property of the population to graph in real time. Options include: Average [Energy Acquisition Rate](#), Average [Fitness](#), Average [Offspring Cost](#), 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' dialog box in Avida-ED. Annotations on the left and right point to specific features:

- Petri Dish size setting:** Points to the 'Dish Size' field, which is set to 60 x 60, with a note that this results in a total of 3600 cells.
- Ancestral seed organism(s):** Points to the text input field containing '@ancestor'.
- Environmental resources settings:** Points to the section titled 'What resources are available in the environment? (strength of metabolic reward shown in parentheses)'. It includes checkboxes for various resources: Easy (x2) with notose, andnose, andnanose; Moderate (x4) with ornose andornose; Hard (x8) with orose andandnose; Very hard (x16) with norose andxorose; and Brutal (x32) with equose.
- Per Site Mutation Rate & slide control:** Points to the 'Per Site Mutation Rate' slider, which is set to 2%.
- Offspring placement setting:** Points to the 'Place Offspring' radio buttons, with 'Near their parent' selected and 'Anywhere, randomly' as an option.
- Exact repeatability control:** Points to the 'Repeatability Mode' radio buttons, with 'Experimental' selected and 'Demo' as an option.
- Buttons to show Petri dish map; show/hide stats side panel:** Points to the 'Map' and 'Stats' buttons in the top right corner of the dialog.
- Pause Run setting:** Points to the 'Pause Run' radio buttons, with 'Manually' selected and 'At update' as an option.

- **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).
- **Dish 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. If seed organisms are added to the dish using this setting they are automatically placed in a set pattern on the Petri Dish (e.g. in the exact center for a single organism or at the points of an equilateral triangle for three organisms). If you want to place organisms manually at specific points on the dish, drag them there on the front map side of the dish instead of seeding them here.
- **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 precisely 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 one of the eight cells adjacent to its parent, or anywhere (at random) in the population. If the cell is already occupied, the organism 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.



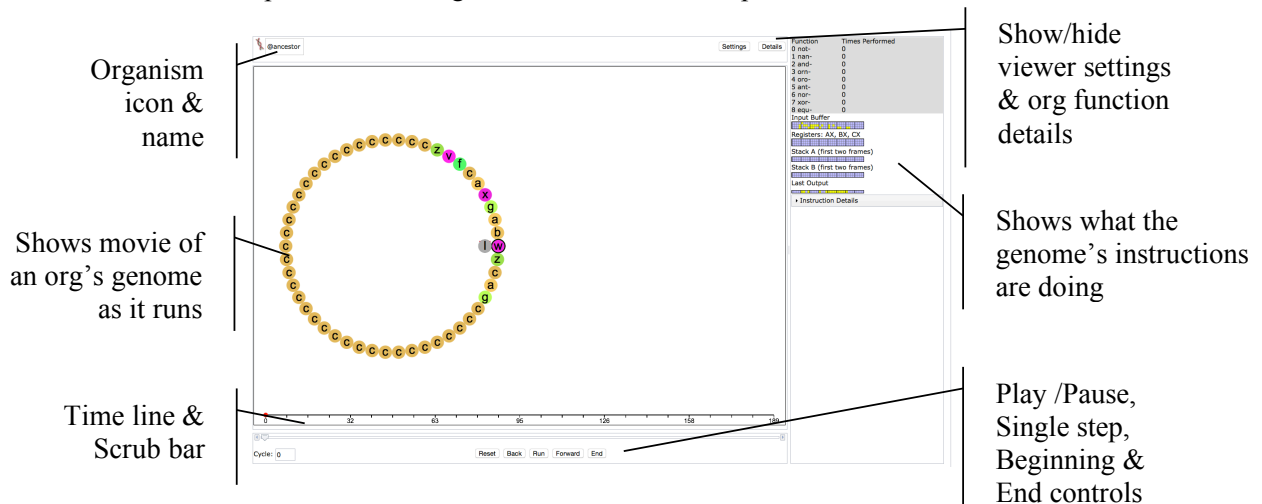
(2) Genetiscope (Organism genome viewer)

Functionality

- Observe the genome of an individual organism.
- Play a movie of the genome instructions' operation.
- Check aspects of an organism's phenotype, including its viability.
- 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 **Run/Stop** to start/stop the movie of the genome's execution. Use the **scrub bar** to move back and forth in the movie, or press **Back** or **Forward** to move just one instruction at a time. **End** jumps to the final instruction. Press **Reset** to reset the genome to the start position for a fresh execution.
- **Click** the **DNA icon** of the parent or daughter cell and then **drag** into the freezer to save that genome. The daughter cell icon will only appear after division.
- Press **Settings** button for the viewer settings. Use the settings to change the per site mutation rate and the repeatability mode.
- Press **Details** to show or hide the side panel, which lists the org's functions and shows the bit-level operations of the genome instructions that produce them.



- **Organism icon & name:** Name of the organism whose genome is being viewed.
- **Time line:** Shows the cycle number of the instruction being executed and the number corresponding to any function that is completed at that point.
- **Run/Stop button:** Starts and temporarily stops movie.
- **Save images** of orgs in viewer [MENU File -> Export Graphics...]



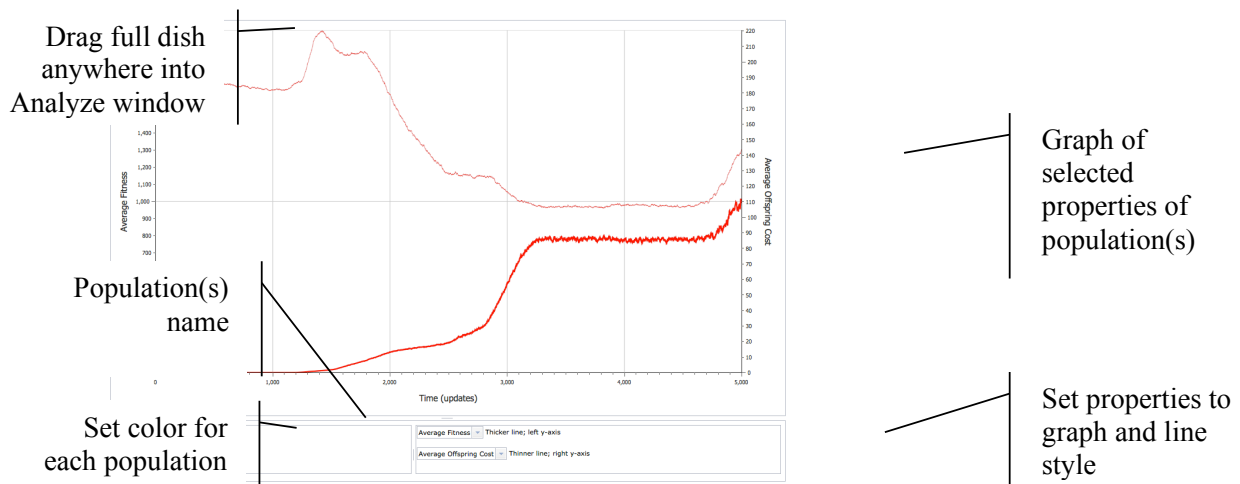
(3) Analyzer Lab Bench (Data graphing & analysis)

Functionality

- Graph one or two data sets from a population.
- Graph and compare data from one to three populations.
- Export selected data for external analysis in Excel or other programs.
- Save viewer images.

Basic Controls

- **Drag** full Petri dish(s) from the freezer onto the analyzer lab bench.
- Use **pull down menus** to choose the color for each population and what information you wish to graph (you can graph two properties at once).
- **Save images** of graphs [MENU File -> Export Graphics...]
- **Export** selected data to comma-delimited file. [MENU File -> Export Data...]





(4) Menus

| | |
|--|--|
| <div> <div>FileFreezerControl</div> <div> Save Current Workspace Save Workspace As Open Default Workspace Open Workspace Import Freezer Item Export Data Export Graphics Stand Alone Application </div> </div> | <div> <div>ControlHelpWorkspace</div> <div> Run Pause Forward (Do one update) Start New Experiment Put Selected Organism in Organism View Put Offspring in Organism View </div> </div> |
| <div> <div>FreezerControlHelpWorkspace: default</div> <div> Save Experiment Configuration to Freezer Save Current Population to Freezer Save Selected Organism to Freezer Save Offspring Organism to Freezer Add Highlighted Configured Dish in Freezer to Experiment Add Highlighted Organism in Freezer to Experiment Add Highlighted Populated Dish in Freezer to Experiment Put Highlighted Organism from Freezer in Organism View Put Highlighted Populated Dish from Freezer in Analysis </div> </div> | <div> <div>HelpWorkspace</div> <div> About Quick Start Manual Ancestor and Hardware More info about Avida-ED Report Problem(s) </div> </div> |

File Menu

- **Workspace controls:** All the settings and data generated in your workspace may be saved and reopened later.
- **Export / Import controls:** Configured and populated dishes, and individual organisms can be separately exported and then later imported into another workspace or used by some other program.
- **Export Data:** Exports a CSV file with five columns [average Fitness, average Offspring Cost, average Energy Acquisition Rate, Population Size, Viable Population Size] for the entire population, the sub-set of organisms performing the picked logic functions and for the set of descendants of each starting ancestor.
- **Export Graphics:** Direct export of graphics has not yet been implemented, so this gives instructions for taking screenshots and snips.
- **Stand Alone Application:** Provides instructions on how to create a stand-alone version of Avida-ED for situations when you will not have internet access.

Freezer Menu

- **Save:** Petri dish environmental configurations, individual selected organisms, or entire populated Petri dishes in your workspace may be saved to the freezer for later reuse.
- **Highlighted organisms** may be added to dish for an experiment or opened in the Organism Viewer or Analysis Viewer. This is useful for tablets.



Control Menu

- **Run/Pause/Forward** a population that is set up in the Petri Dish. *Forward* advances the population just a single update.
- **Start New Experiment**: Discard or save the current setup and start a new experiment
- **Put Selected Organism in Organism View**: Copies an organism selected in the population viewer Petri Dish and puts it in the organism viewer.
- **Put Offspring in Organism View**: Takes the offspring of an organism in the organism view and puts it in the organism view in the ancestor position.

Help Menu

- **Help Files**: Links to a few basic help files.
- **Report Problem(s)**: Use to send a bug report to the Avida-ED software developer.



Glossary

Avida

Pronounced Ah-vee-da. 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.

Energy Acquisition Rate

Each organism in Avida-ED has a value associated with it that indicates how fast the organism is able to acquire the “energy” ([SIPs](#)) that it uses to execute instructions. Avidians acquire energy more rapidly by performing [metabolic functions](#), which let them process resources in the environment. Energy acquisition rate is meaningful relative to other organisms—if organism X has twice the energy acquisition rate of organism Y than X should execute twice as many instructions in any given time frame.

Fitness

Measured in Avida as [energy acquisition rate](#) divided by [offspring cost](#). Holding the environment constant, if organism X has twice the fitness of organism Y, it means that, on average, X will reproduce twice as quickly as Y. 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 0.3 will have a selective advantage in a population where every other organism has a fitness of 0.1, whereas this same organism with a fitness of 0.3 will be at a selective disadvantage in a population where every other organism has a fitness of 1.4.

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 time/length

The number of instructions it takes for an organism to reproduce. This term was used in versions 1.0 through 2, but has been dropped in version 3 and replaced by [offspring cost](#), which expresses reproduction in terms of the amount of energy required to replicate.



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 receive a base amount of energy, but 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 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 organism’s basic energy acquisition rate by the task’s energetic value.

Metabolic Rate

In Avida-ED versions 1 through 2, “metabolic rate” was a unitless number used to indicate how fast an organism is able to execute instructions. Version 3 replaces this with “[energy acquisition rate](#)” to highlight the energy metabolism.

Mutation Rate

The percent chance that each instruction will be copied incorrectly. 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). What mutations will occur is determined by a random number generator and will be different each run unless the demo mode is checked to force exact repeatability. In Avida-ED 1.0 - 3.0 only point mutations are allowed but no deletions or insertions in order to keep the genome at a uniform size to preserve legibility.

Offspring Cost

The amount of energy it takes for an organism to reproduce (i.e. to execute the number of instructions it takes for it to self-replicate).

SIP (Single Instruction Processing unit)

A unit of “energy” in Avida. It takes one SIP to execute one instruction.

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 fewer).

Viability

Organisms that have the ability to develop and reproduce are viable. Inviability organisms are those that are unable to replicate. In the fitness mode of the population viewer, inviable Avidians are shown colored grey.