

Slides, videos, links and more:

<https://github.com/physicell-training/02-How-to-nanoHUB>

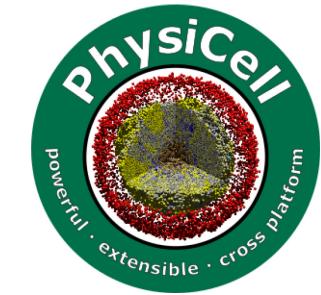
Lesson 2: How to use a PhysiCell nanoHUB app

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 @MathCancer

PhysiCell Project

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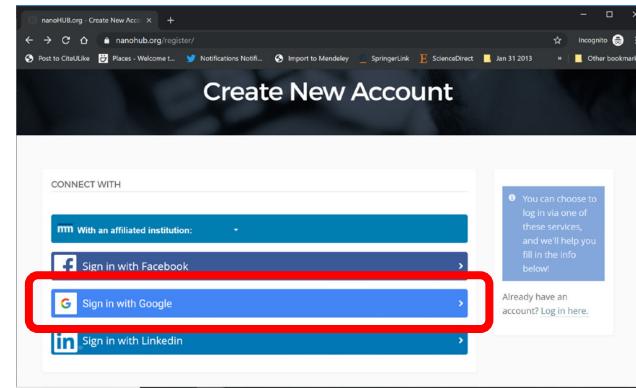
nanoHUB Account

- These tutorials use cloud-hosted PhysiCell models on [nanoHUB.org](https://nanohub.org).
- nanoHUB is **free**, but it requires a one-time registration.

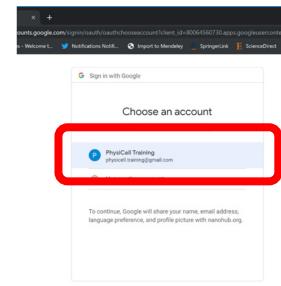
Steps:

1. Visit <https://nanohub.org/register>
2. Choose "Sign in with Google"
3. Choose a Google account
4. Click "No" (so it doesn't try to associate with some other nanoHUB account)
5. Finish filling in details, and you're done!
6. Use your google account for future logins.

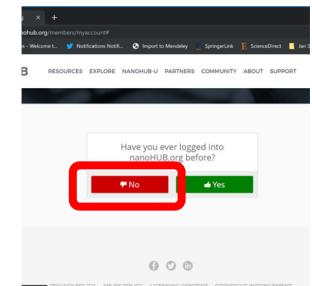
2



3



4



Goals

- Many of the PhysiCell lessons are paired with **educational microapps**: targeted cloud-hosted models designed to illustrate a core PhysiCell concept.
- All PhysiCell-powered nanoHUB apps share common features.
- This brief lesson will walk you through those features.

Tools versus Apps

- After considerable debate, the nanoHUB community arrived at these definitions:
 - A **tool** is an application with broader feature sets and less constrained use cases. A tool tends to require more extensive training to understand the full feature set.
 - ◆ Future PhysiCell-powered nanoHUB resources may be tools if they allow general-purpose modeling using PhysiCell as the engine.
 - An **app** is purpose-driven model or constrained tool with relatively constrained and focused use cases. Users can generally learn an app in one or two unguided sessions.
 - ◆ Most PhysiCell-powered nanoHUB resources are apps.
- There may be blurred distinctions between tools and apps in some cases, such as PhysiCell apps that can simulate a broad variety of nanotherapies.

Sample nanoHUB app: biorobots

- This sample model explores how engineered cells could be used as a **multicellular cargo delivery system**.

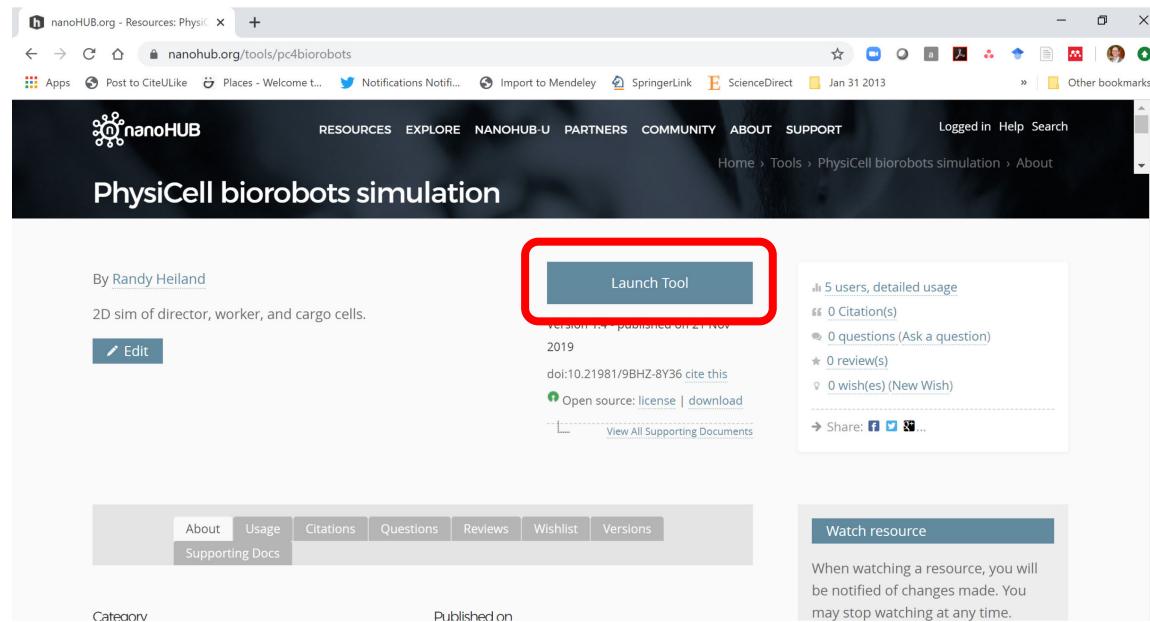
<https://nanohub.org/tools/pc4biorobots>



- **Director cells:** Release a chemoattractant to guide delivery of cargo
- **Cargo cells:** Release a chemoattractant to guide worker cells until they are attached.
- **Worker cells:**
 - When unattached to cargo, use chemotaxis to seek cargo cells and adhere to them.
 - When attached to cargo, use chemotaxis to drag cargo towards directors for delivery.

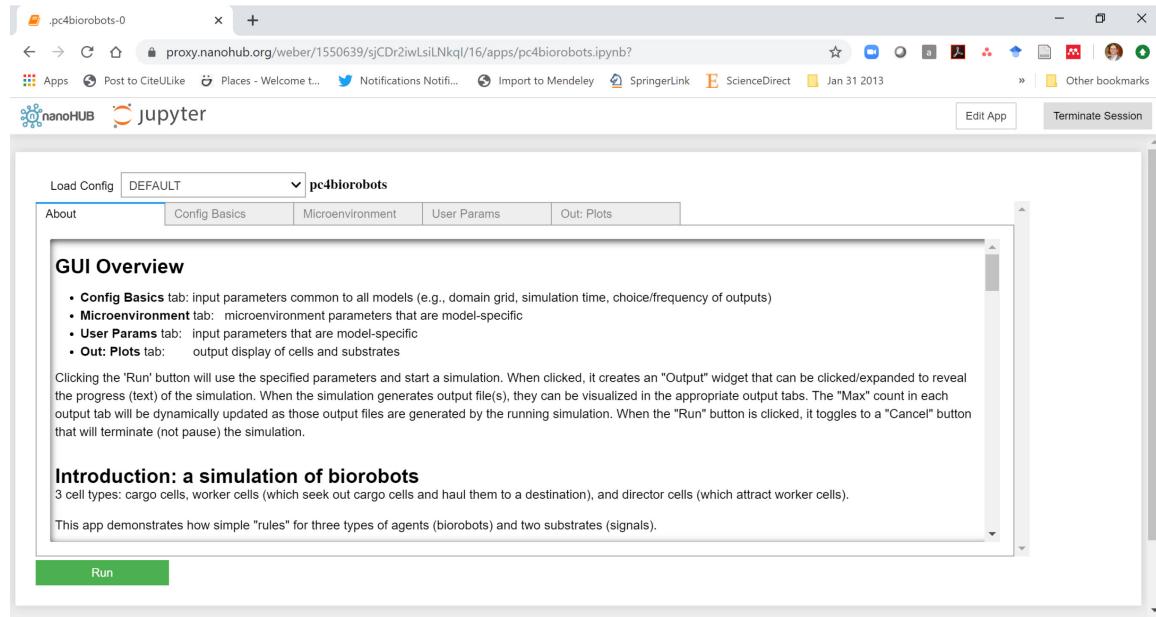
Splash screen and launching the tool

- Each PhysiCell-powered nanoHUB app has a splash page:
 - Background information on the tool and model
 - Use metrics
 - Citation information
 - A **LAUNCH TOOL** button.
Click this!



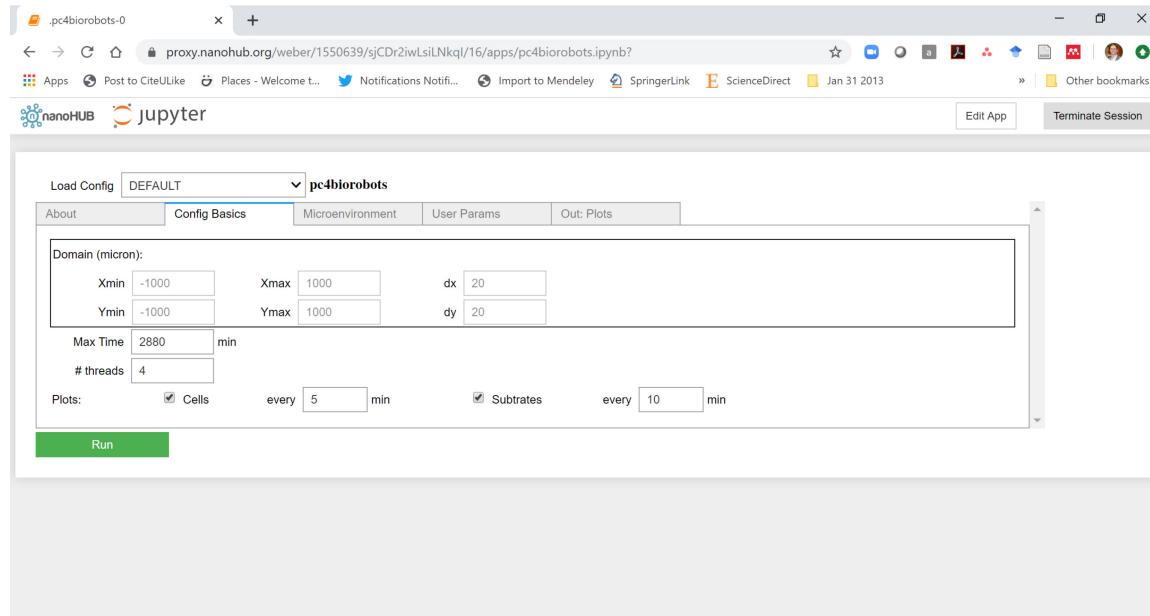
About

- The **about** tab gives *in-app* documentation about the mathematics of the model:
 - background
 - diffusing substrates
 - key cell types and behaviors
- This tab also describes the main user parameters of the model.



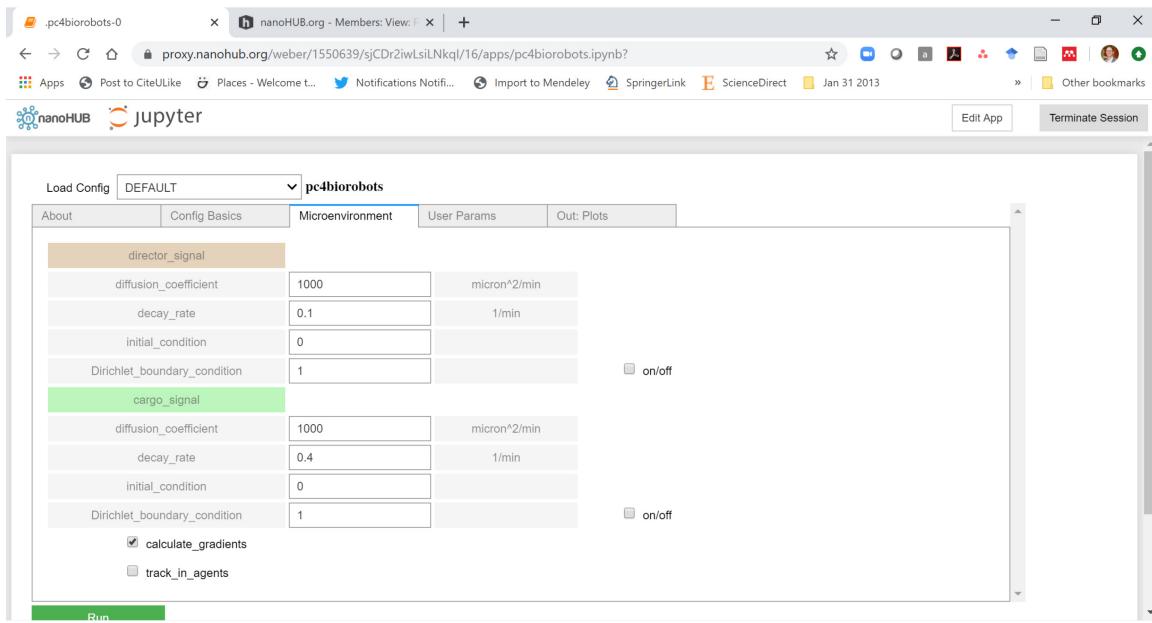
Configuration basics

- The **config basics** tab lets you set up the simulation:
 - Set the domain size and spatial resolution
 - ◆ Might be disabled in some apps.
 - Set the final simulation time
 - Set the number of threads (capped at 4 on nanoHUB)
 - Specify how often to save cell plots
 - Specify how often to save diffusing substrate data



Microenvironment

- The **microenvironment** tab lets you set diffusion options:
 - For each substrate, set:
 - ◆ diffusion coefficient
 - ◆ decay rate
 - ◆ initial condition
 - » applied uniformly throughout the domain
 - ◆ Dirichlet boundary condition
 - » applied uniformly to the boundary
 - » "uncheck" to disable this and revert to Neumann (zero flux) conditions
 - Enable or disable calculation of substrate gradients
 - ◆ needed for cell chemotaxis
 - Enable or disable full tracking of internalized substrates in each cell
 - ◆ needed for some models



User parameters

- The **user parameters** tab is where you set parameters that are specific to the app.
- Each row is a parameter:
 - parameter name
 - parameter value
 - units
 - short parameter description
- Consult the **about** tab for more mathematical information on the parameters

The screenshot shows a web browser window with the URL proxy.nanohub.org/weber/1550639/sjCDr2iwLsLNgq/16/apps/pc4biorobots.ipynb?. The page title is "User params". The interface includes a header with "nanoHUB" and "jupyter" logos, and a top navigation bar with links like "Edit App" and "Terminate Session". Below the header is a toolbar with tabs: "Load Config" (set to "DEFAULT"), "pc4biorobots", "About", "Config Basics", "Microenvironment", "User Params" (which is active), and "Out: Plots". The main content area is a table titled "User Params" with 14 rows, each containing a parameter name, its value, its unit, and a short description. The table has alternating green and brown rows.

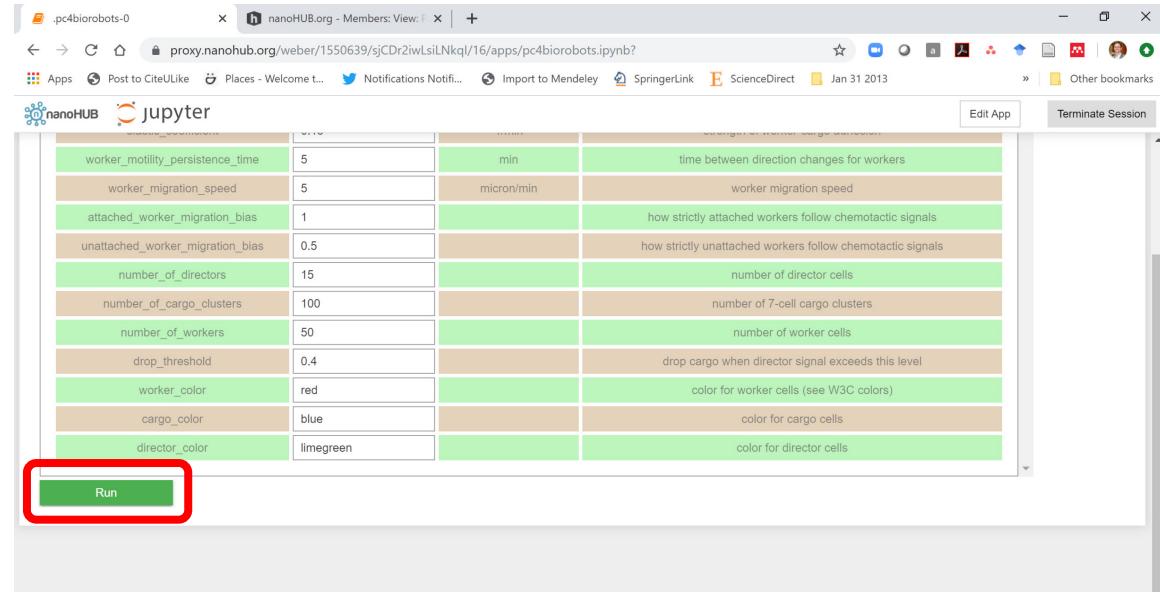
Parameter	Value	Unit	Description
random_seed	0		
elastic_coefficient	0.15	1/min	strength of worker-cargo adhesion
worker_motility_persistence_time	5	min	time between direction changes for workers
worker_migration_speed	5	micron/min	worker migration speed
attached_worker_migration_bias	1		how strictly attached workers follow chemotactic signals
unattached_worker_migration_bias	0.5		how strictly unattached workers follow chemotactic signals
number_of_directors	15		number of director cells
number_of_cargo_clusters	100		number of 7-cell cargo clusters
number_of_workers	50		number of worker cells
drop_threshold	0.4		drop cargo when director signal exceeds this level
worker_color	red		color for worker cells (see W3C colors)
cargo_color	blue		color for cargo cells
director_color	limegreen		color for director cells

Running

- Once ready, click **Run**
- The standard model outputs will start appearing below
- Click **Cancel** to end early and choose new parameters

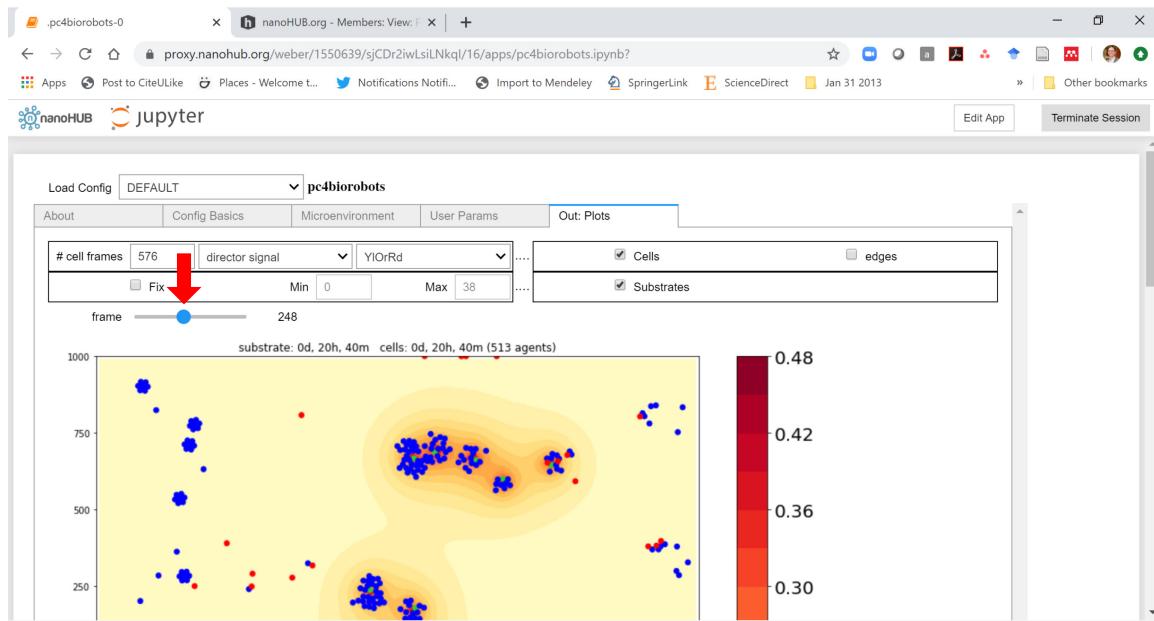
```
See ALL_CITATIONS.txt for this list.  
current simulated time: 0 min (max: 2880 min)  
total agents: 513  
interval wall time: 0 days, 0 hours, 0 minutes, and 3.7956e-05 seconds  
total wall time: 0 days, 0 hours, 0 minutes, and 4.5622e-05 seconds  
  
Using method diffusion_decay_solver_constant_coefficients_LDD_2D (2D LDD with Thomas Algorithm) ...  
  
current simulated time: 10 min (max: 2880 min)  
total agents: 513  
interval wall time: 0 days, 0 hours, 0 minutes, and 0.350292 seconds  
total wall time: 0 days, 0 hours, 0 minutes, and 0.350344 seconds  
  
current simulated time: 20 min (max: 2880 min)  
total agents: 513  
interval wall time: 0 days, 0 hours, 0 minutes, and 0.434458 seconds  
total wall time: 0 days, 0 hours, 0 minutes, and 0.784682 seconds  
  
current simulated time: 30 min (max: 2880 min)
```

Start Time: 16:43:20
Cancel



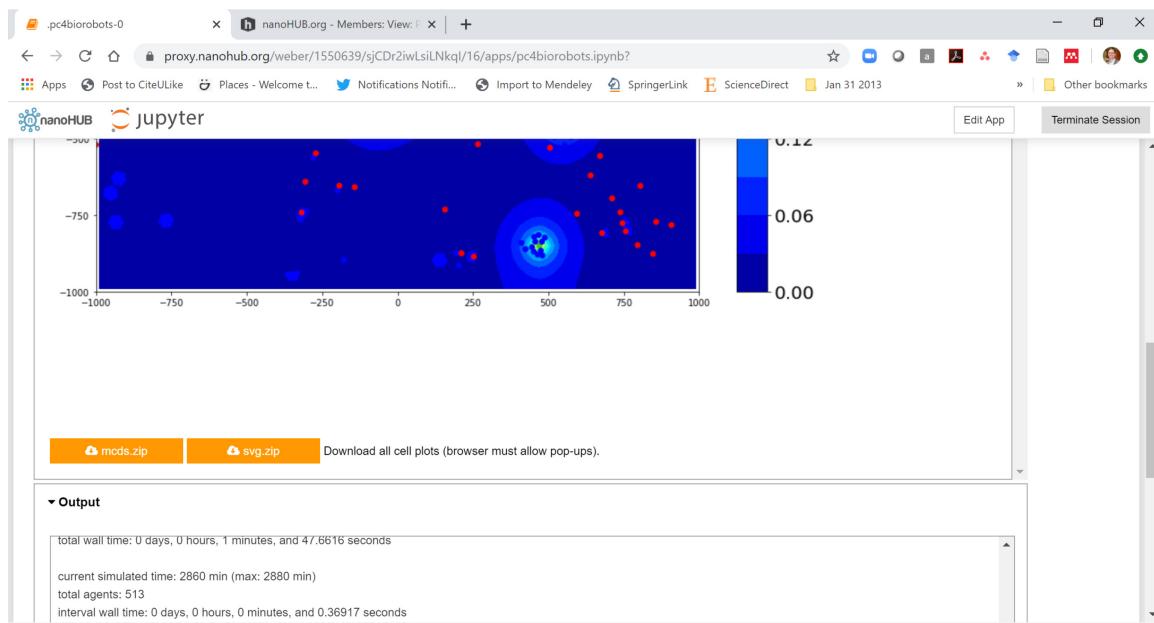
Simulation output

- The **Out: Plots** tab shows the simulation outputs as it runs.
- Slide the "frame" bar to advance time in the simulation.
- Use the dropdown box to choose a different substrate for visualization.
 - Use "fix" to manually set the plot range
 - Click the righthand dropdown box to change coloring (YlOrRd, viridis, jet, ...)
- The checkboxes on the right let you choose plotting options for the cells.
- **Note:** Some older apps may split the output into separate "substrate" and "cell" tabs, rather than overlay them.



Downloading simulation plots and data

- At the bottom of the output tab, you can find options to download your simulation data.
- Click **svg.zip** to download all the SVG cell plots as a single ZIP file.
- Click **mcds.zip** to download all the simulation data (in MultiCellIDS format) as a single ZIP file.
- **Note:** These download buttons only work after a simulation has finished running.
- See the [PhysiCell-Tools](#) ecosystem for tips on loading simulation data in Matlab, Python, and other environments.



Live demo

Next steps

Super fast: Please proceed to 4 (Introduction to PhysiCell)
<https://github.com/physicell-training/04-PhysiCell-intro>

Intermediate: Please proceed to 4 (Introduction to PhysiCell)
<https://github.com/physicell-training/04-PhysiCell-intro>

Full training: Please proceed to 3 (What is an agent-based model?)
<https://github.com/physicell-training/03-What-is-ABM>

More lessons: <https://github.com/physicell-training/master-list>

Credits

Lesson Planning:	Paul Macklin, Drew Willis*, Randy Heiland
Slides:	Paul Macklin, Drew Willis, Randy Heiland
Recording:	Paul Macklin, Drew Willis*
Post-production:	Paul Macklin, Drew Willis*, Kali Konstantinopoulos*
Microapps:	https://www.nanohub.org/tools/pc4biorobots

* denotes undergraduate researcher

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