

## Me as a microbe!

Previous compulsory steps / Prior students' knowledge	Cell Theory, Cell structure, Organelles, Mitochondria, Eukaryotic cell, ATP, Multicellularity, Aerobic respiration, Anaerobic function
Learning objectives	Familiarizing students with: <ul style="list-style-type: none"> <li>• Biology of cells in relation to their environment,</li> <li>• Micro-organisms,</li> <li>• Organelles and their functions,</li> <li>• Chemoplasts,</li> <li>• Chloroplasts,</li> <li>• Chemolithoautotrophy,</li> <li>• Flagellum</li> </ul> Exploring compounds and energy transformation in organisms
Subjects	Biology, Microorganisms, Evolution Theory
Recommended Age	15-18
Material needed	PCs that can run the game "Thrive"
Sequence duration	135 minutes
Individual or group activity	Classroom Group and Homework activities
Skills developed	Creativity, problem solving, collaboration
Price range of the game	Free or 3.99€ from STEAM
Similar games to use with the approach of the sequence	microcosmum

Tips for inclusion	In “Options/Inputs” menu there are a lot of settings (to change/adjust) to help people with various disabilities
Tips for shortening the duration of the sequence	Step 3 can be performed at home.

## Step by step: how to implement the sequence

In this pedagogical sequence, students are going to use “Thrive” and they are going to take the role of a microbiome (a micro-organism).

With this game, students will navigate the microcosm of microorganisms, create different cells and "watch" their lives in different habitats. They will look at how they take up and convert energy and approach the need for changes in order for these microorganisms to adapt and live in new environments with different characteristics (various gases, temperature, components, enemies, etc.).

- **Step 1: The educator reviews biology concepts and discusses the basic concepts in Cell's Biology (35 minutes)**

Educator reviews some biology concepts with the students and uses a snapshot of the game info/help and the game itself in order to connect the game with these biology concepts:

- Cell Theory
- Cells
- Cell structure,
- Organelles,
- Mitochondria,
- Eukaryotic cell,
- ATP
- Aerobic function,
- Anaerobic function

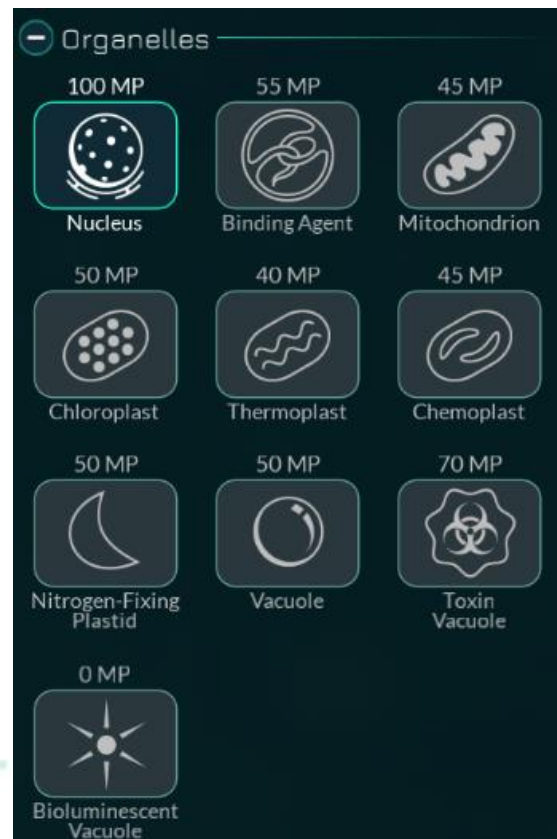


Figure 1. Organelles ("Thrive", Revolutionary Games, 2021)

W, A, S, D and mouse to move. E to shoot  
**OxyToxy NT** if you have a toxin vacuole. G to toggle engulf mode. You can zoom in and out with the mouse wheel.

Your cell uses **ATP** as its energy source, if it runs out you will die.

To unlock the editor and reproduce you need to gather **Ammonia** (Orange Cloud) and **Phosphate** (Purple Cloud).

You can also engulf cells, bacteria, iron chunks and cell chunks that are smaller than you by pressing G. This will cost additional ATP and will slow you down. Don't forget to press G a second time to stop engulfing.

**Hydrogen Sulfide** can be converted into **Glucose** via chemoplasts and chemosynthesizing proteins. **Iron** can be converted via rusticyanin into **ATP**.

To reproduce you need to divide each of your organelles into two. Organelles need ammonia and phosphate to split in half.

For now, if your population drops to zero, you go extinct.

But if you survive for twenty generations with 300 population, you are considered to have won the current game. After winning you get a popup and can continue playing as you wish.

Be wary because your competitors are evolving alongside you. Every time you enter the editor they evolve as well.

Figure 2. Snapshot of in-game help ("Thrive", Revolutionary Games, 2021)

**45 Mitochondrion**

Turns **Glucose** into **ATP**. Rate scales with concentration of **Oxygen**.

**Aerobic Respiration**  
 0,038 → 18,27 /second @ 21%

+1 Storage  
 +2 Osmoregulation Cost

The powerhouse of the cell. The mitochondrion (plural: mitochondria) is a double membrane structure filled with proteins and enzymes. It is a prokaryote that has been assimilated for use by its eukaryotic host. It is able to convert glucose into ATP at a much higher efficiency than can be done in the cytoplasm in a process called Aerobic Respiration. It does, however, require oxygen to function, and lower levels of oxygen in the environment will slow down the rate of its ATP production.

**100 Nucleus**

Allows for the evolution of more complex, membrane-bound organelles. Costs a lot of ATP to maintain. This is an irreversible evolution.

**No processes**

+4 Storage  
 +10 Osmoregulation Cost

The defining feature of eukaryotic cells. The nucleus also includes the endoplasmic reticulum and the golgi body. It is an evolution of prokaryotic cells to develop a system of internal membranes, done by assimilating another prokaryote inside of themselves. This allows them to compartmentalize, or ward off, the different processes happening inside the cell and prevent them from overlapping. This allows their new membrane bound organelles to be much more complex, efficient, and specialized than if they were free-floating in the cytoplasm. However, this comes at the cost of making the cell much larger and requiring a lot of the cell's energy to maintain.

Figure 3. Snapshot of in-game info cards about Mitochondrion and Nucleus ("Thrive", Revolutionary Games, 2021)

- **Step 2: Educator explains the gameplay of the game to the students (10 minutes)**

The educator uses the game and its tutorials to help explain the gameplay of the game to students.

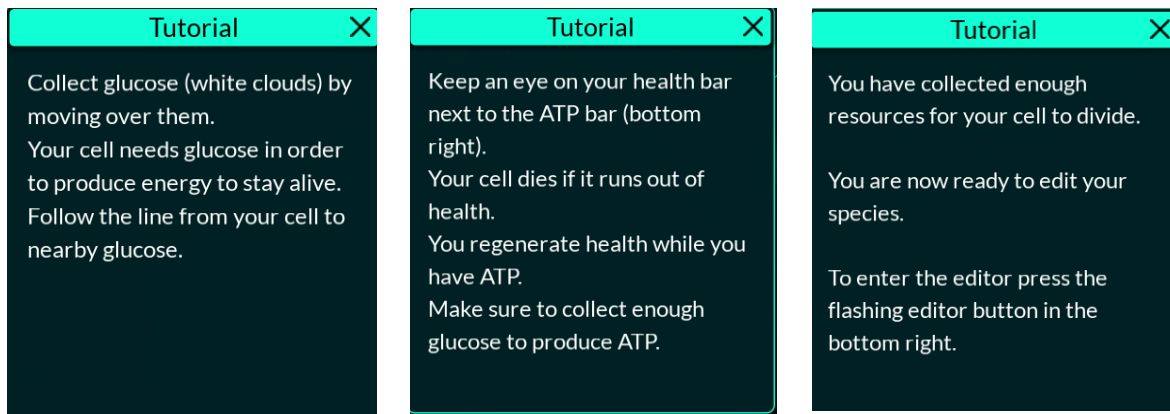


Figure 4. Snapshots of in-game tutorial tips ("Thrive", Revolutionary Games, 2021)

During the game, the screen has information windows for the environment, the components the micro-organism absorbs, the number of individuals in the species' population, and the energy the organism has.

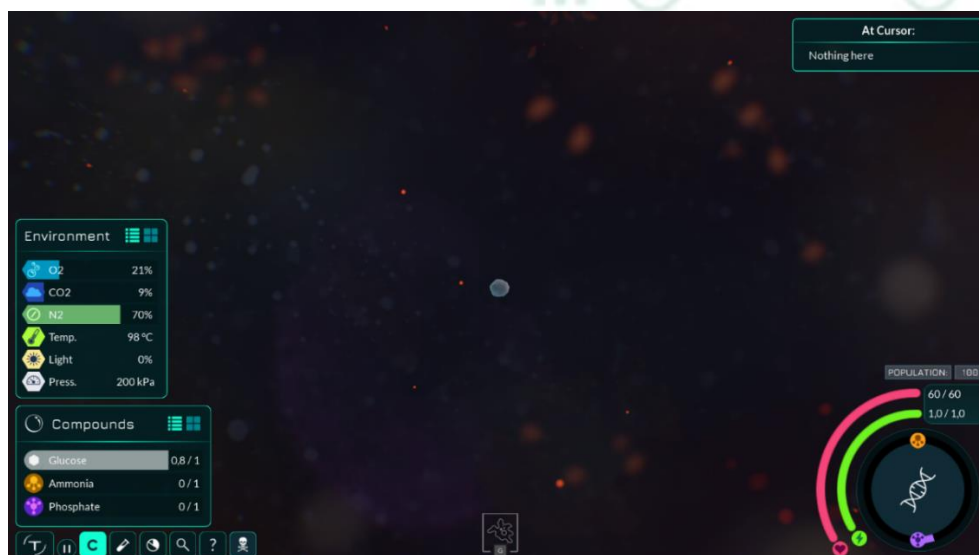


Figure 5. Snapshot of the first screen of the game ("Thrive", Revolutionary Games, 2021)

- **Step 3: Students discover the game by playing it (45 minutes)**

Students may start to play the game, choosing the “Pangonian Vents” patch from the 11 environments/habitats given. They start the game as a single cell and try to gather the appropriate compounds in order to live in the patch/habitat they had selected.

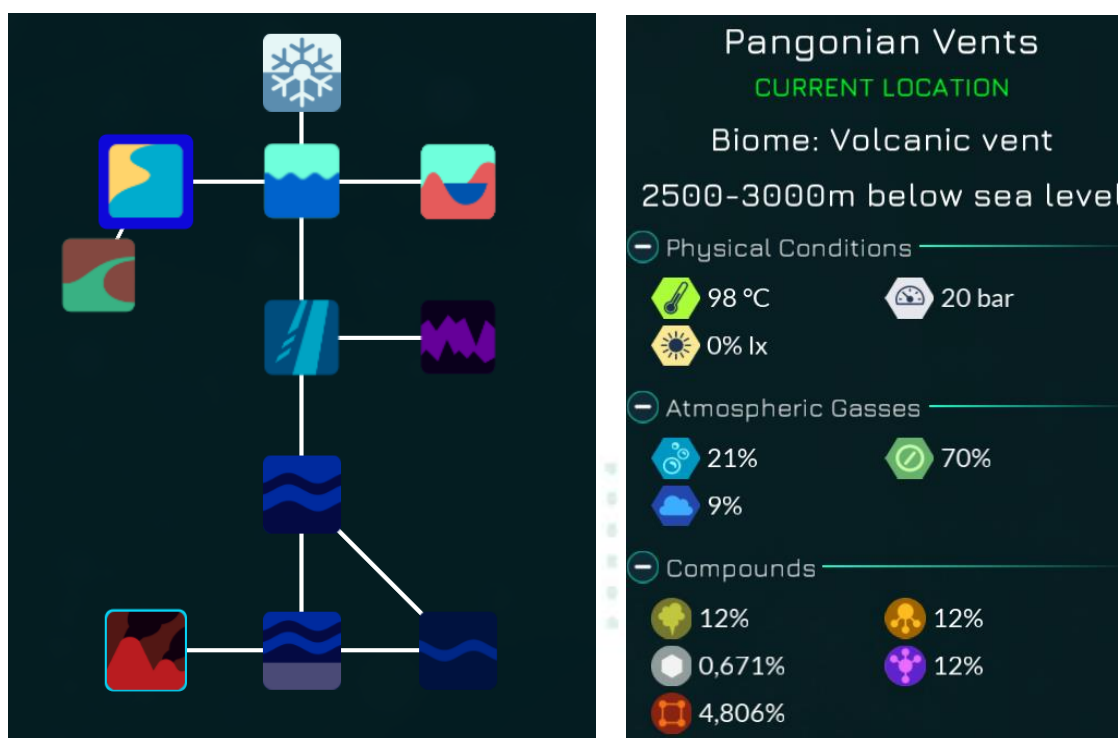


Figure 6. Snapshots of Patch selection screen - Pangonian Vents selected (“Thrive”, Revolutionary Games, 2021)

Students will use the game’s info cards to gain information, and for every new concept or function they meet, they will try to understand its function and mechanism. They can discuss any difficulties they encounter with the educator.

### 45 Metabolosomes

Turns Glucose into ATP. Rate scales with concentration of Oxygen.

**Aerobic Respiration**  
0,025 → 7,98 /second @ 21%

+0.5 Storage  
+1 Osmoregulation Cost

Metabolosomes are clusters of proteins wrapped in protein shells. They are able to convert glucose into ATP at a much higher speed than can be done in the cytoplasm in a process called Aerobic Respiration. It does, however, require oxygen to function, and lower levels of oxygen in the environment will slow down the rate of its ATP production. Since the metabolosomes are suspended directly in the cytoplasm, the surrounding fluid performs some glycolysis.

### 45 Chemosynthesizing Proteins

Turns Hydrogen Sulfide into Glucose. Rate scales with concentration of Carbon Dioxide. Also turns Glucose into ATP.

**Glycolysis**  
0,006 → 2 /second

**Chemosynthesis**  
0,07 → 0,04 /second @ 9%

+0.5 Storage  
+1 Osmoregulation Cost

Chemosynthesizing proteins are small clusters of protein in the cytoplasm that are able to convert hydrogen sulfide, water, and gaseous carbon dioxide into glucose in a process called Hydrogen Sulfide Chemosynthesis. The rate of its glucose production scales with the concentration of carbon dioxide. Since the chemosynthesizing proteins are suspended directly in the cytoplasm, the surrounding fluid performs some glycolysis.

### 45 Chemoplast

Turns Hydrogen Sulfide into Glucose. Rate scales with concentration of Carbon Dioxide.

**Chemosynthesis**  
0,14 → 0,09 /second @ 9%

+1 Storage  
+2 Osmoregulation Cost

The chemoplast is a double membrane structure containing proteins able to convert hydrogen sulfide, water, and gaseous carbon dioxide into glucose in a process called Hydrogen Sulfide Chemosynthesis. The rate of its glucose production scales with the concentration of carbon dioxide.

### 22 Cytoplasm

Turns Glucose into ATP.

**Cytoplasm Glycolysis**  
0,011 → 3 /second

+1 Storage  
+1 Osmoregulation Cost

The gooey innards of a cell. The cytoplasm is the basic mixture of ions, proteins, and other substances dissolved in water that fill the interior of the cell. One of the functions it performs is glycolysis, the conversion of glucose into ATP energy. For cells that lack organelles to have more advanced metabolisms, this is what they rely on for energy. It is also used to store molecules in the cell and to grow the cell's size.

Figure 7. Snapshots of in-game help ("Thrive", Revolutionary Games, 2021)

- **Step 4: The educator sums up (35 minutes)**

The educator sums up the following basic biology concepts that students encountered during the game:

- Biology of cells in relation to their environment,
- Micro-organisms,
- Organelles and their functions,
- Chemoplasts,
- Chloroplasts,
- Chemolithoautotrophy,
- Flagellum
- Compounds and energy transformation in organisms
- Metabolosomes

Then they may conduct a discussion with the students about the alternative options they could have chosen in order for the microorganism to Thrive!!!

- **Step 5: The educator proposes homework (10 minutes)**

At home, students may proceed to change the habitat, or they may use the same habitat but make other choices for the microorganism itself in order to explore additional concepts.

**Note: Some options of the game are not implemented yet. It will be a complete tool for further use in the future.**

**Getting the game:**

<https://store.steampowered.com/app/1779200/Thrive/>

<https://github.com/Revolutionary-Games/Thrive-Launcher/releases/tag/v1.2.9>



## References

Microbe stage. (2020). Thrive Developer Wiki. Retrieved December 16, 2021, from [https://wiki.revolutionarygamesstudio.com/wiki/Microbe\\_Stage](https://wiki.revolutionarygamesstudio.com/wiki/Microbe_Stage)

