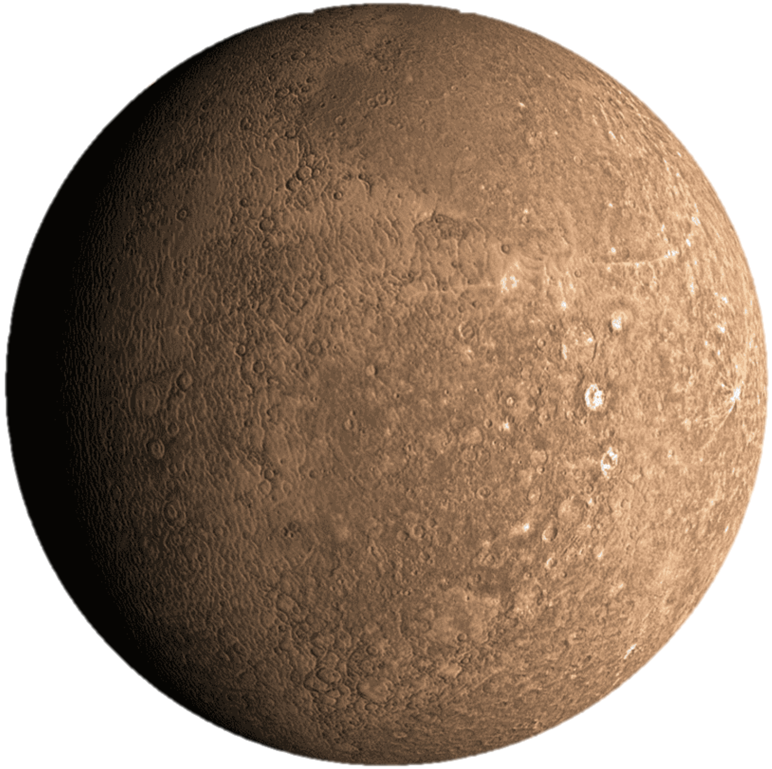
2.5D Daisyworld

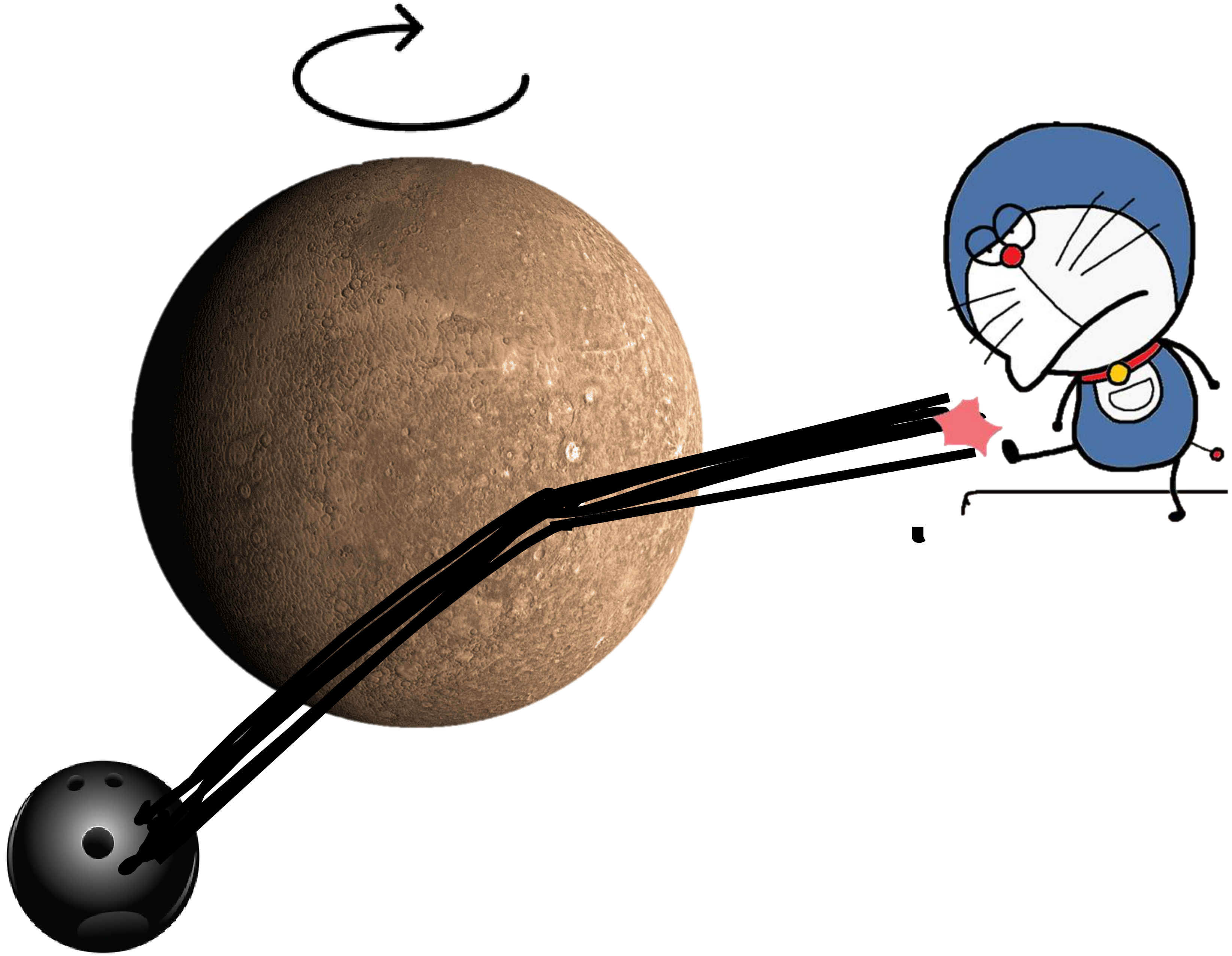
Minh Khanh Luong

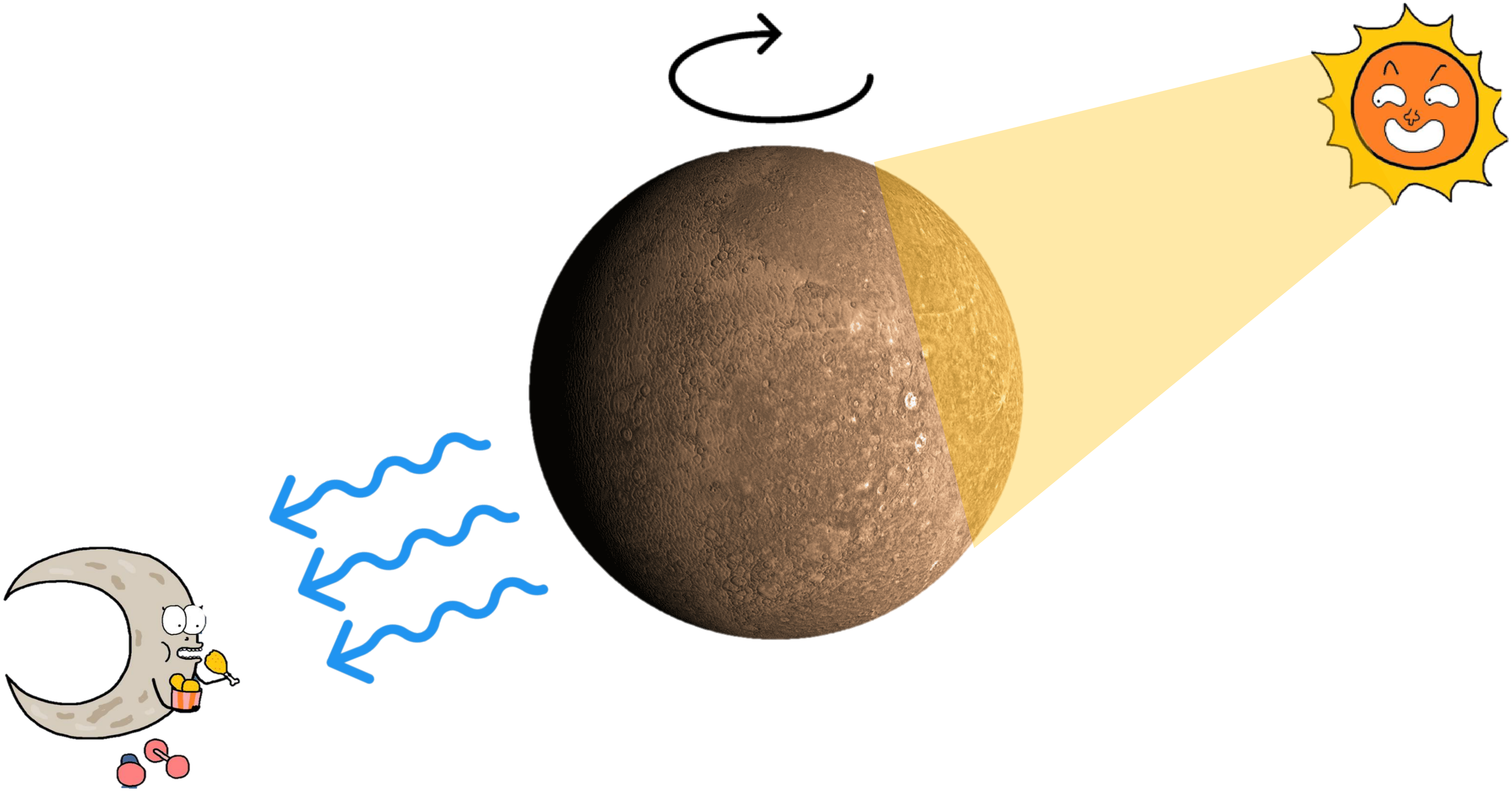
I really don't know if I should present this using the story telling theme, if you feel like it's not appropriate, please tell me s
can make another presentation

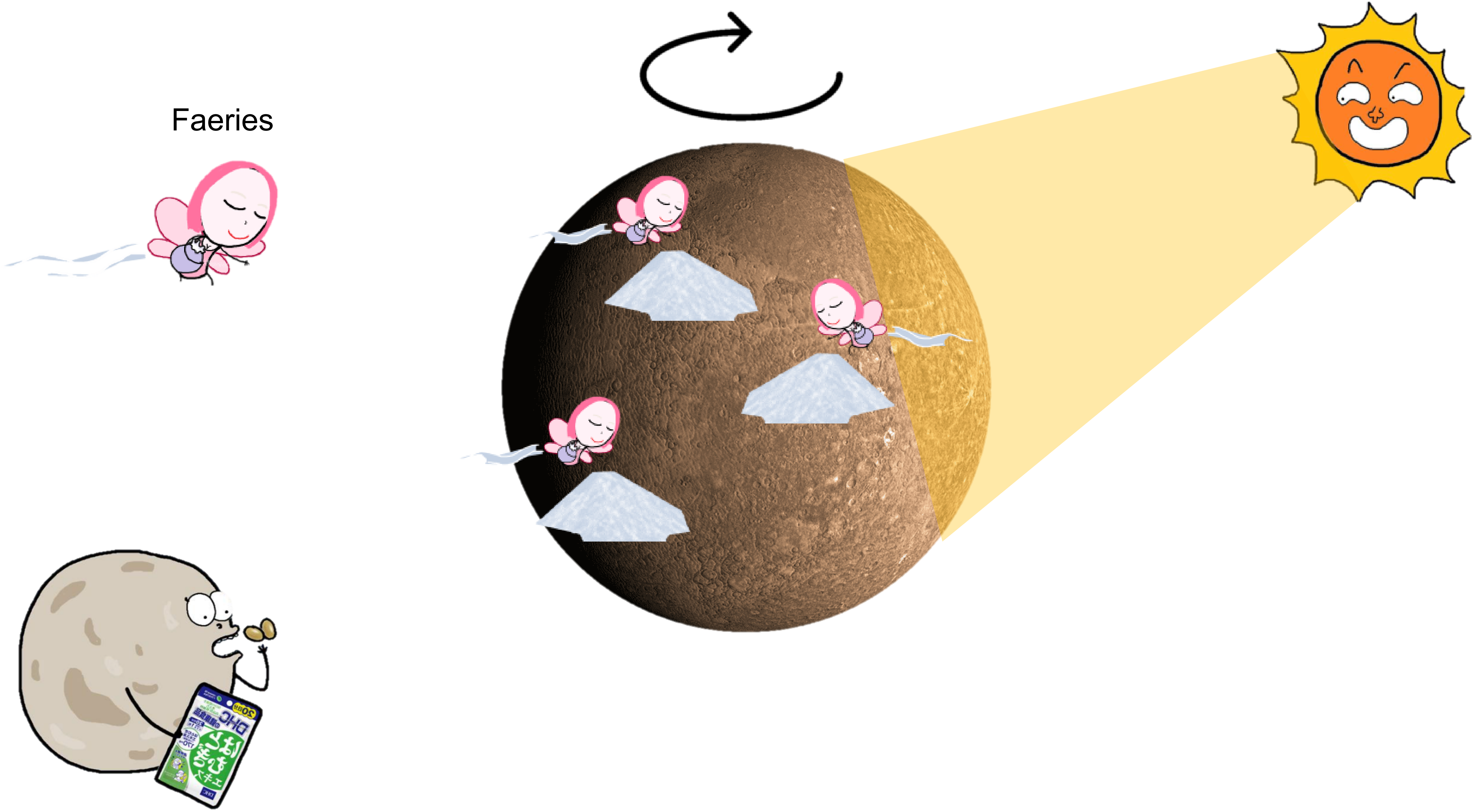
Parameters in the setting menus are explained in APPENDIX 2 and 4, information regarding how to run the game can be
found in APPENDIX 3

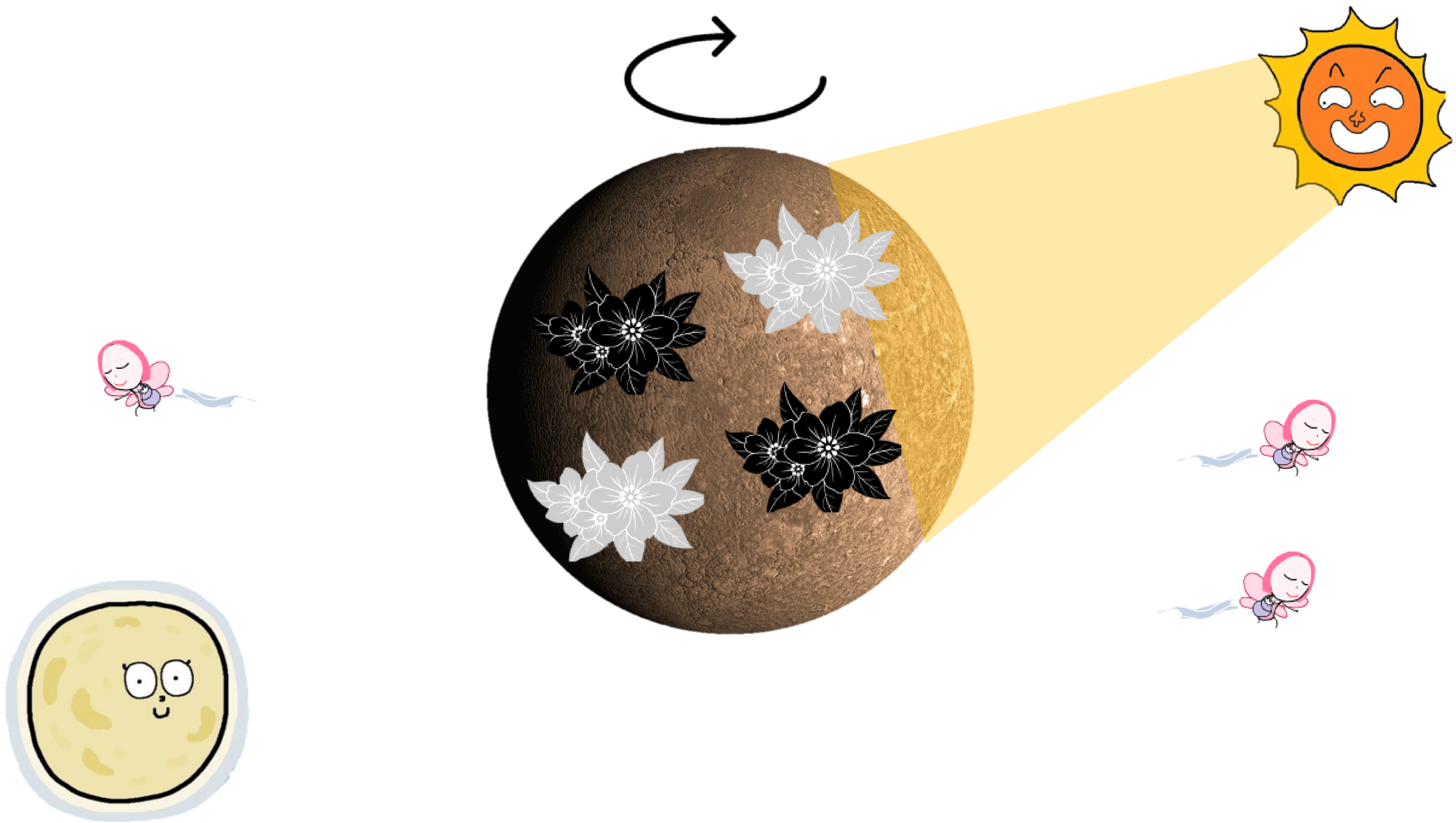
Let me tell you about a dead planet.

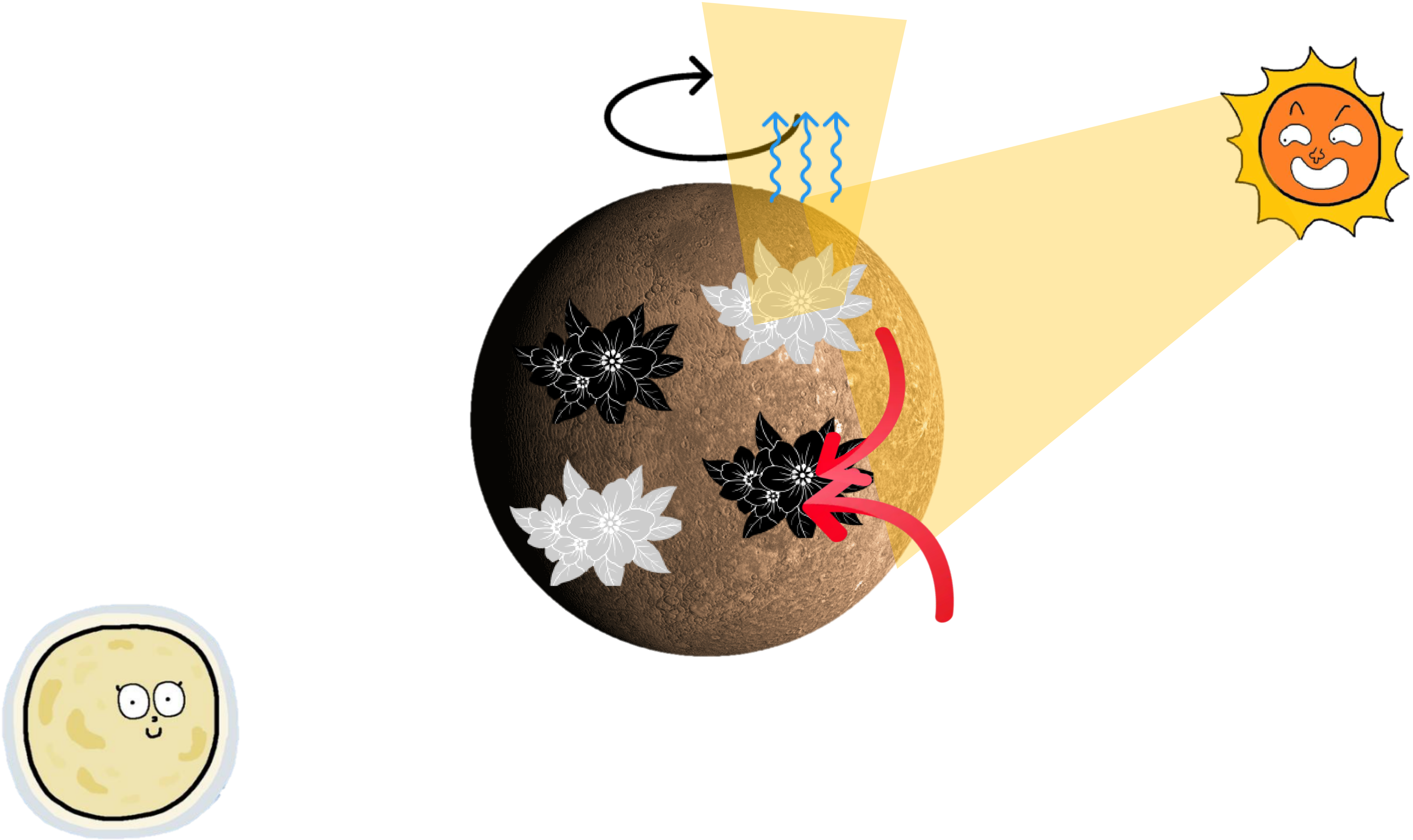


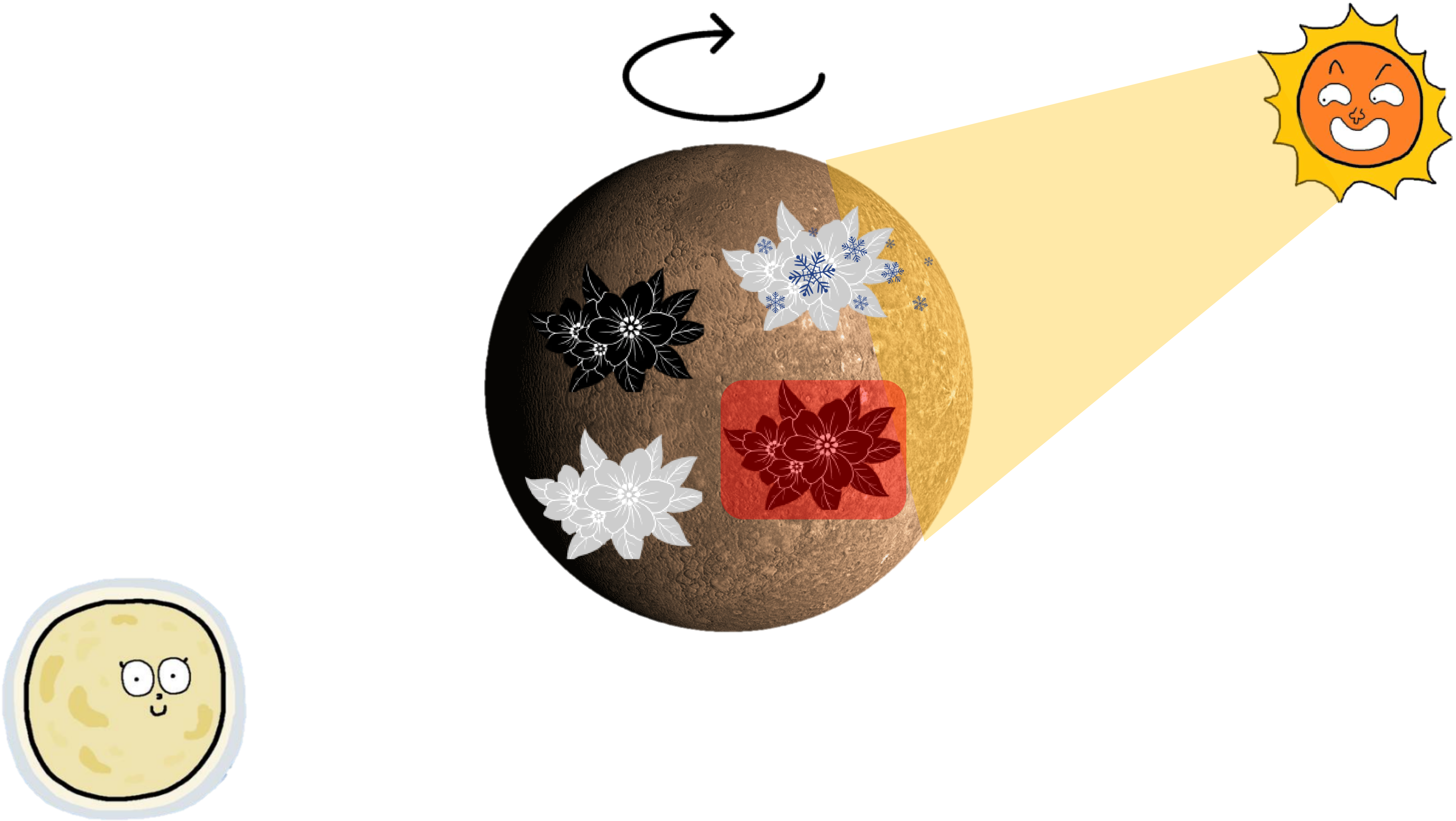


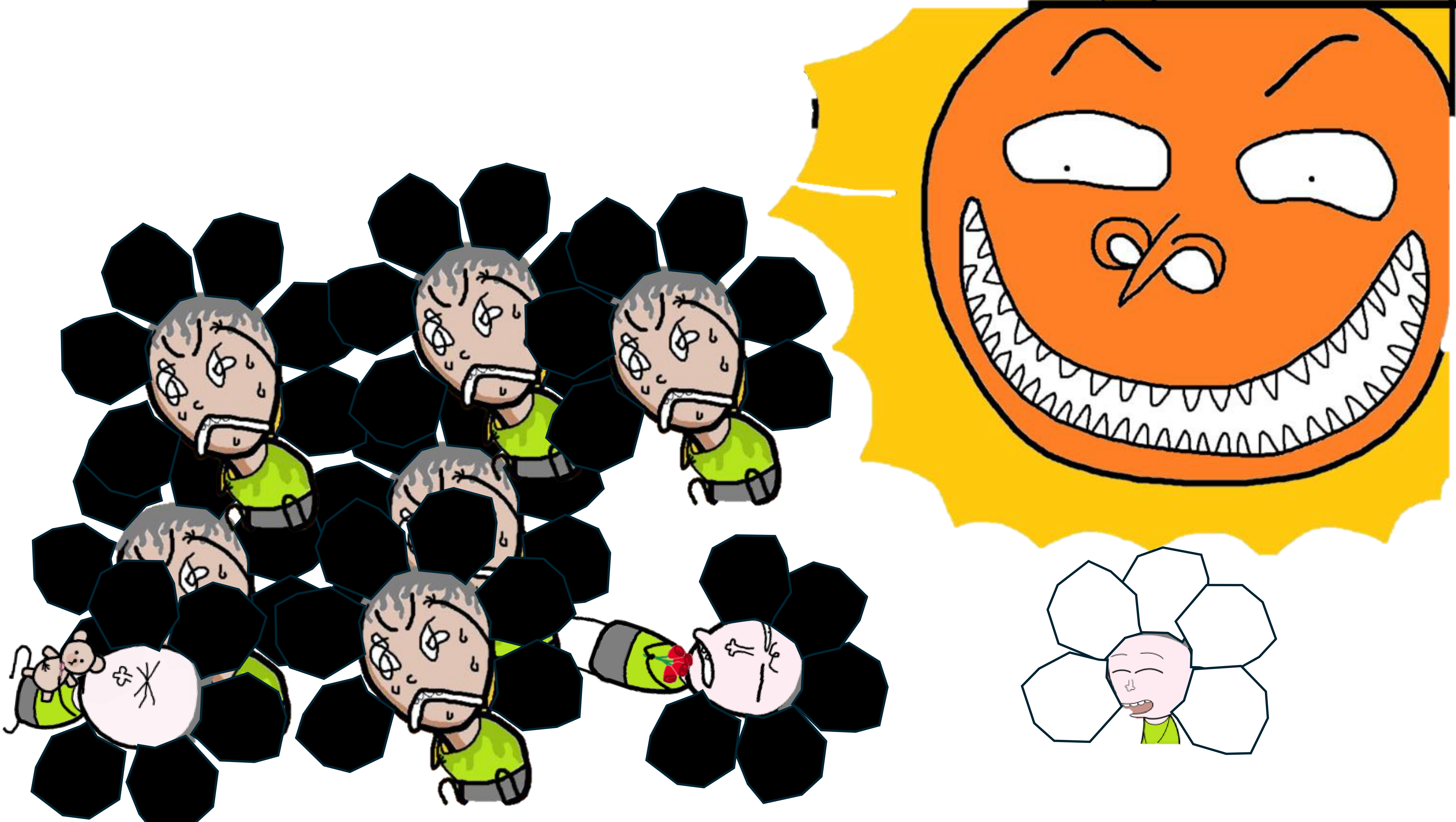


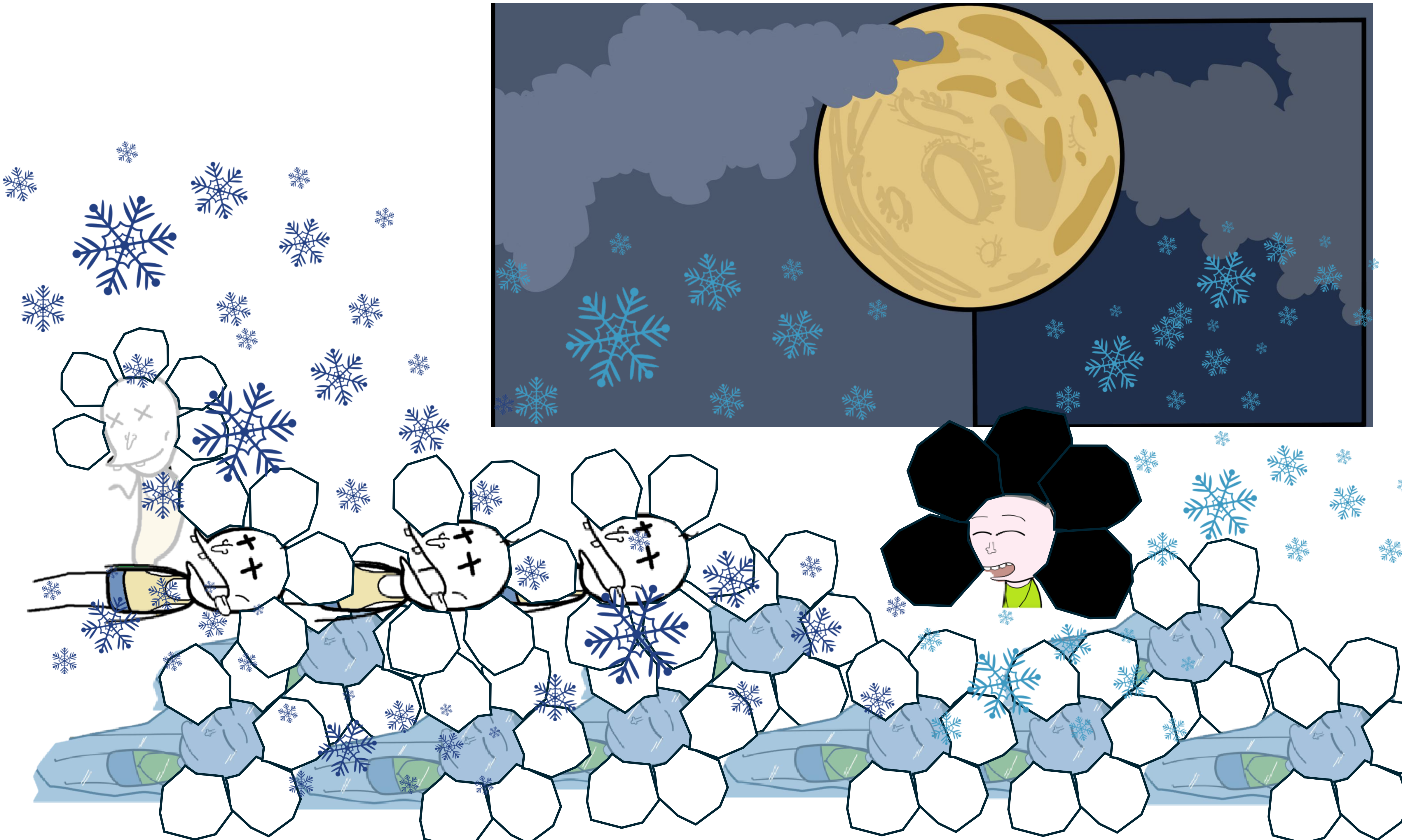

Faeries



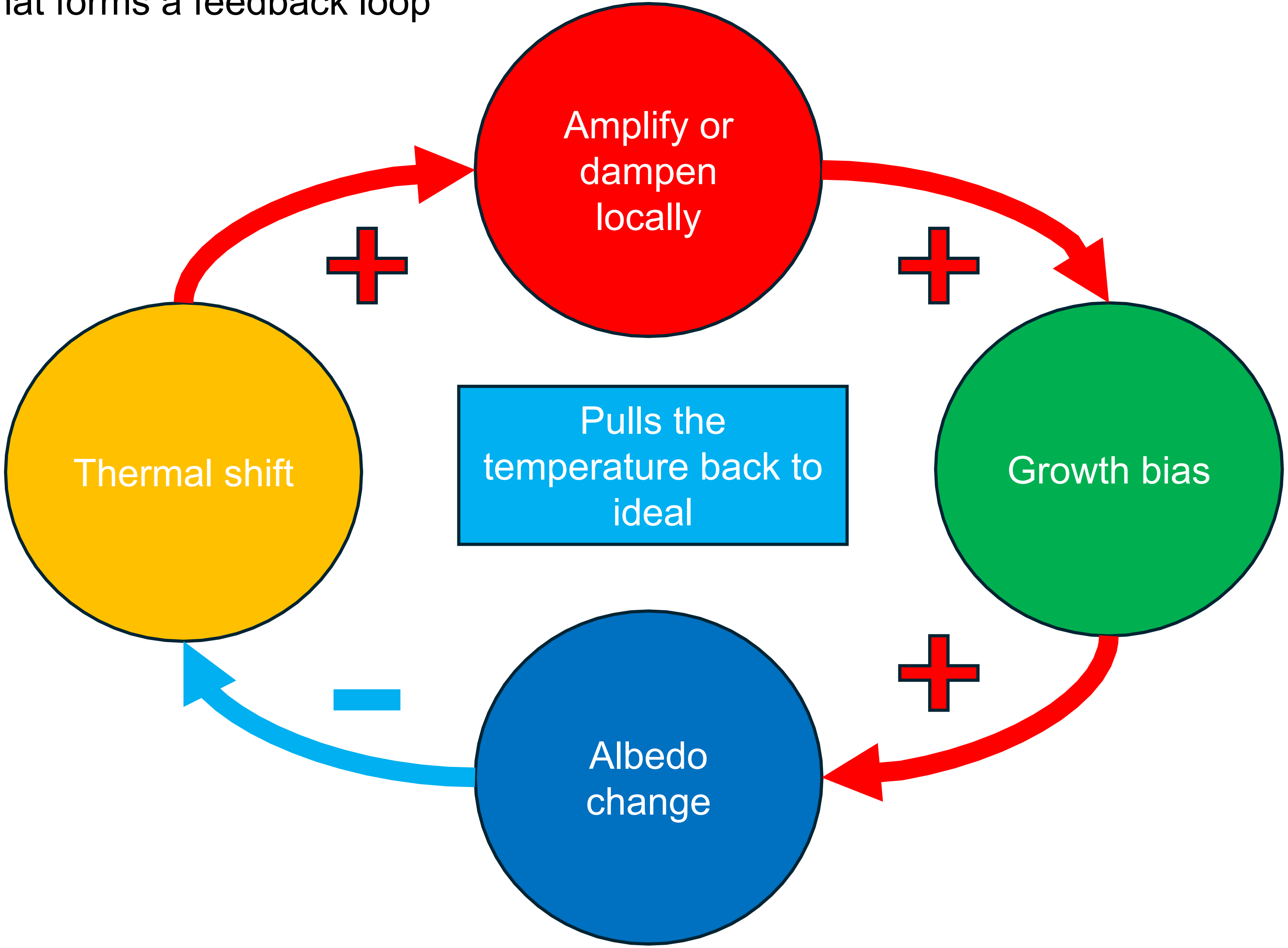








And overall, that forms a feedback loop

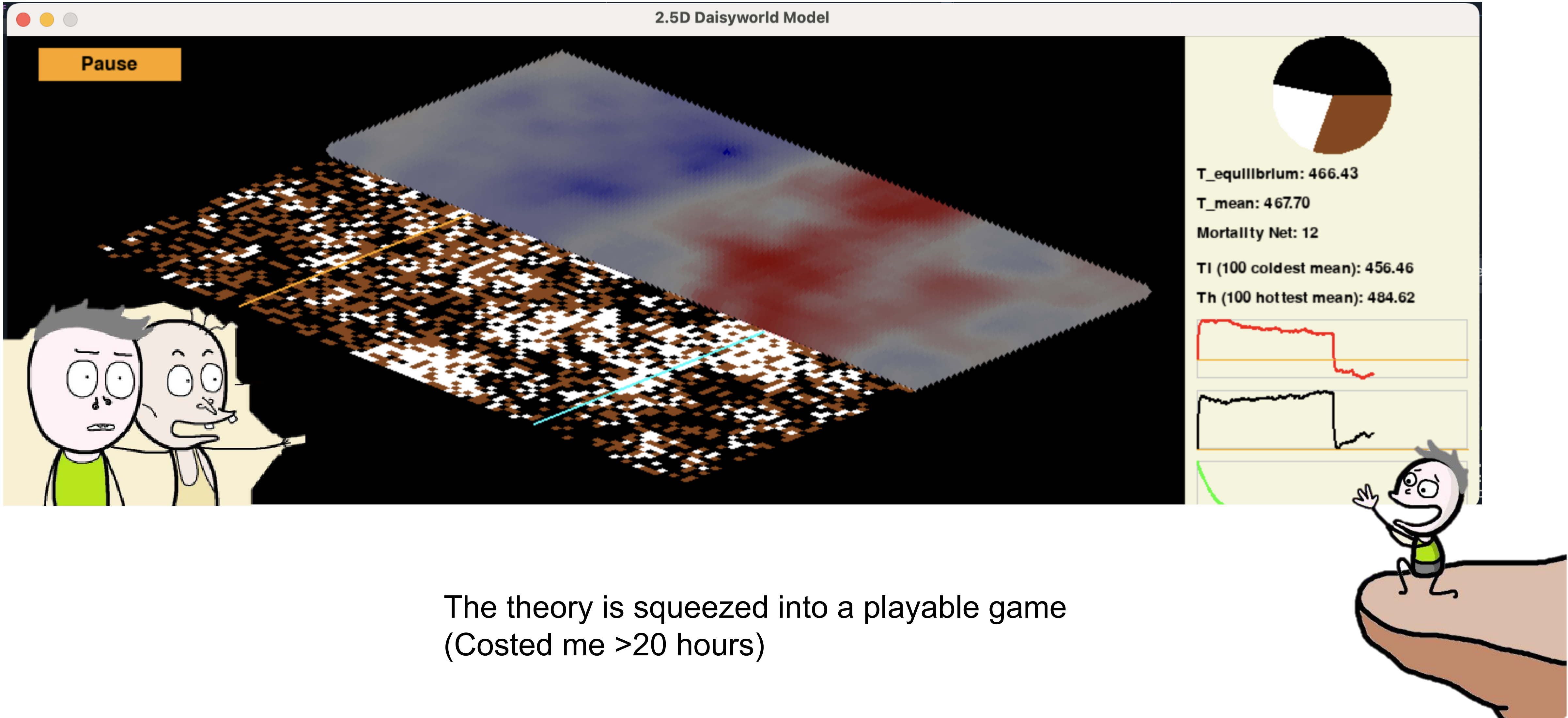


That feedback loop is a part of the big GAIA hypothesis

Not just adapting, life will reshape the environment around it for habitability

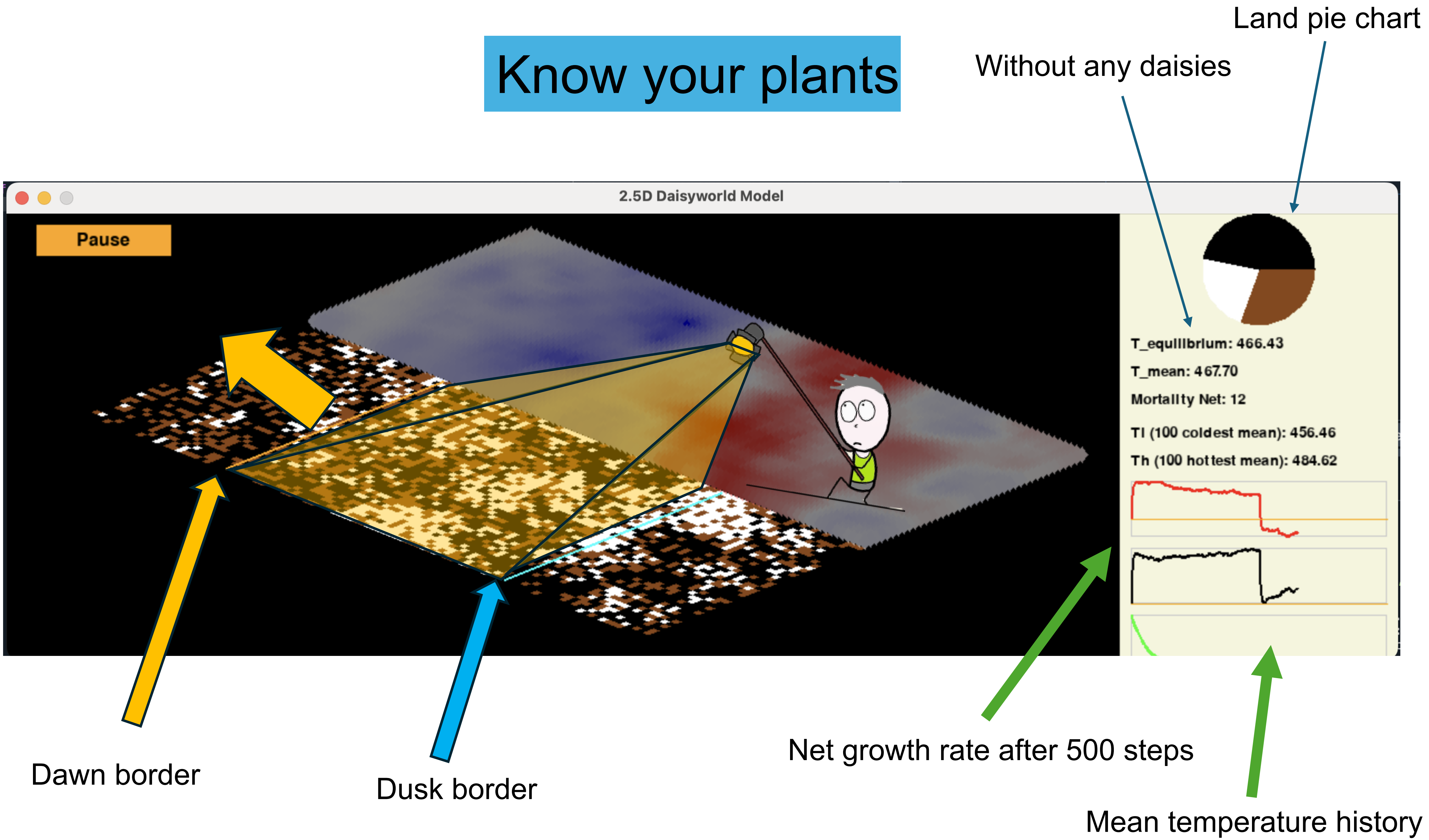
Just like we have learned about the interaction between the biosphere and the Earth

Jump into the World of Daisies

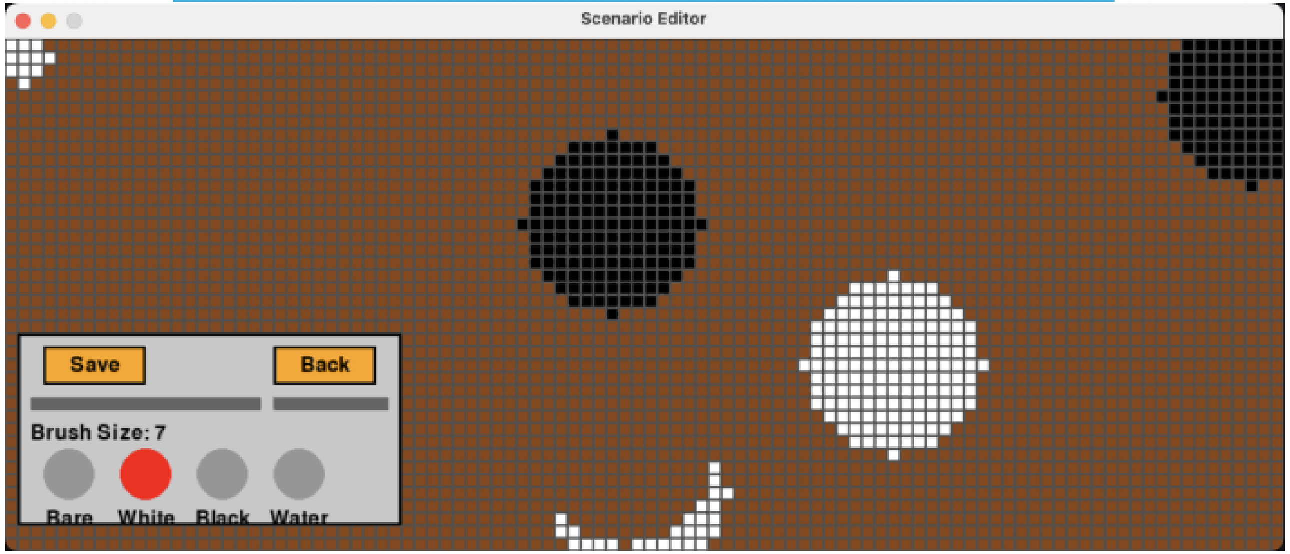


The theory is squeezed into a playable game
(Costed me >20 hours)

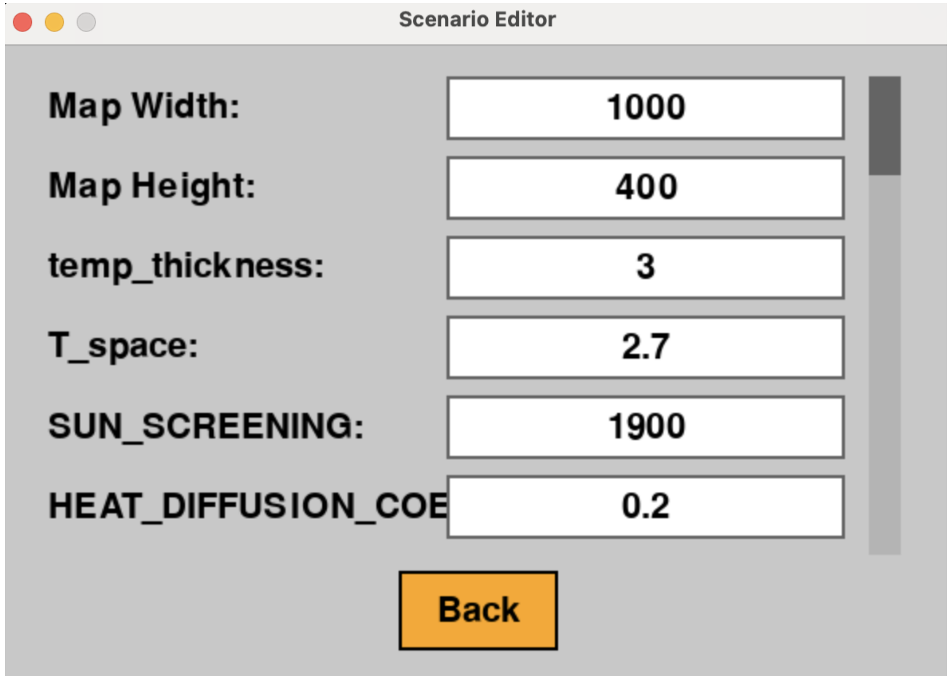
Know your plants



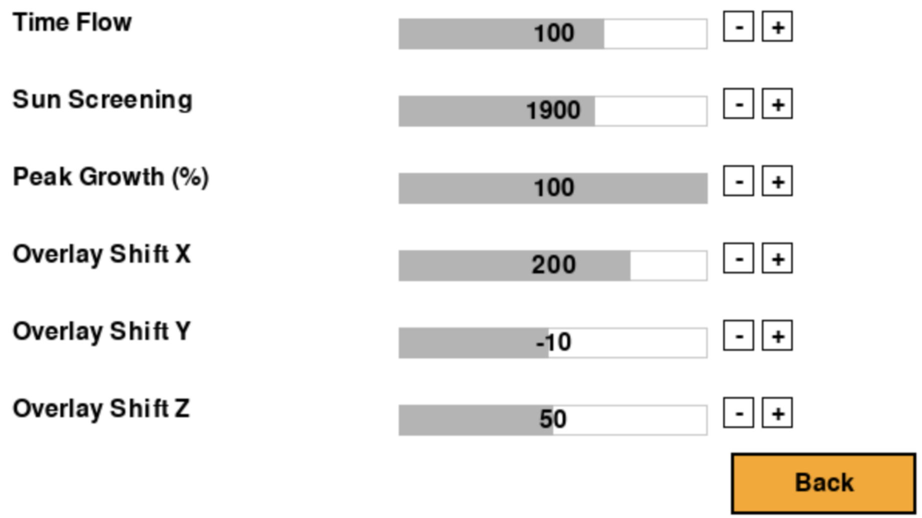
Plant whatever you want



Create a world of your choice

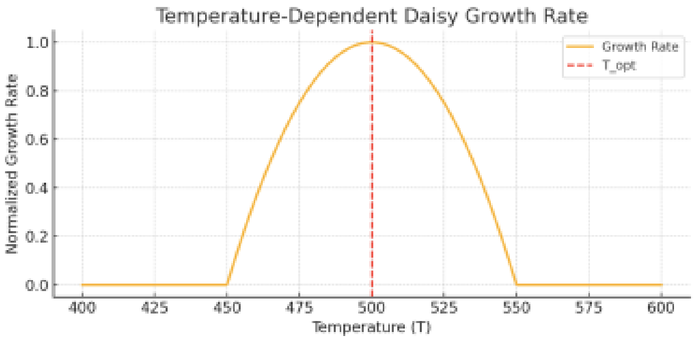


Change your world as you like



Realistic physics

$$P_{\text{grow}} = \text{SPREAD\_CHANCE} \times \frac{\text{peak\_growth}}{100} \times \left[1 - \left(\frac{T_{\text{local}} - T_{\text{opt}}}{T_{\text{tol}}}\right)^2\right]$$

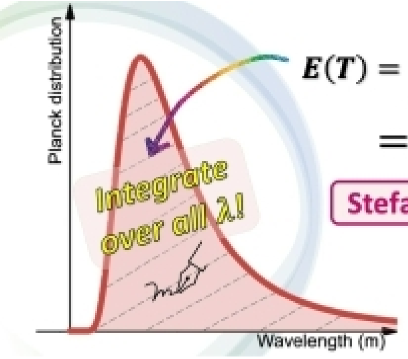



```
avg_heated = total/count if count else heating[y][x]
loss = self.COOLING_COEFFICIENT * (temp_grid[y][x]**4 - self.T_space**4)
new_temp[y][x] = temp_grid[y][x] + dt * (
    self.HEATING_RATE * (avg_heated - loss)
)
```

Heat Equation

$$u_t = D\,u_{xx}$$

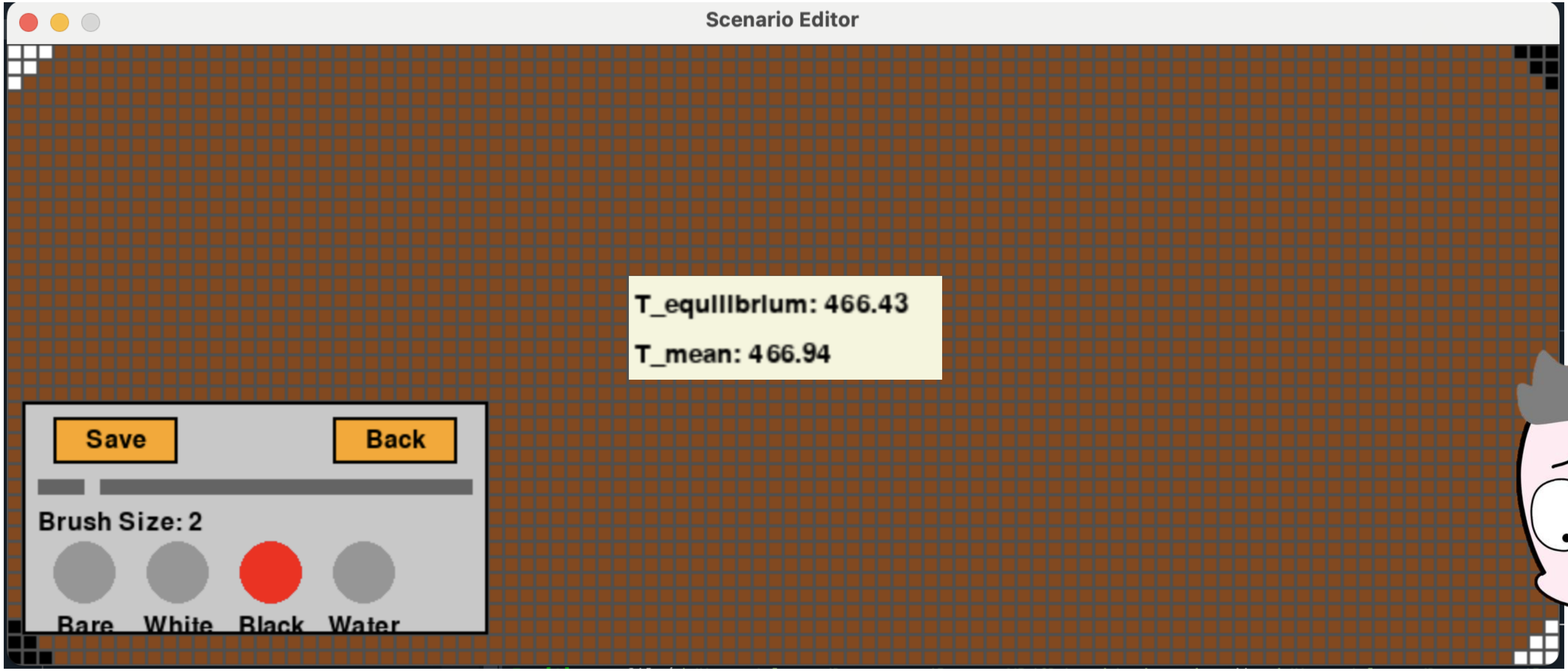
```
else heating[y][x]
(temp[y][x]**4 - self.T_space**4)
```

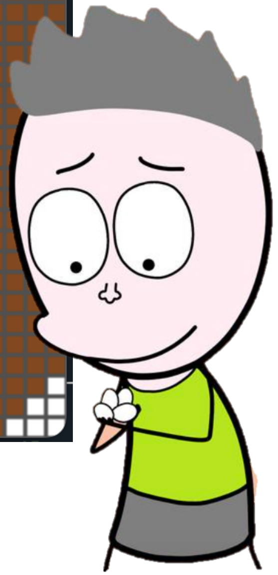


$$E(T) = \int_0^\infty \rho(\lambda, T)\, d\lambda = \sigma \cdot T^4$$

Stefan-Boltzmann

Let's see how the plants cope with colder conditions.





THE END

Thank you for listening

References:

Characters images source:
https://www.facebook.com/nhatrongngo.newversion
The brown planet image source:
https://www.pngegg.com/en/png-wgkil
Snowfall png:
https://pngtree.com/so/blue-snow
The GAIA hypothesis:
Lovelock, J.E., Margulis, L. (1974). Atmospheric homeostasis by and for the biosphere: The Gaia hypothesis. Tellus. https://doi.org/10.1111/j.2153-3490.1974.tb01946.x
Original Daisyworld:
Lovelock, J.E., Watson, A.J. (1983). Biological homeostasis of the global environment. Tellus.
https://doi.org/10.1111/j.1600-0889.1983.tb00031.x
The heat equation:
https://www.youtube.com/watch?v=KpQTkHCfioY
The Boltzmann law:
https://www.youtube.com/watch?v=V-Ex7PbsBPM
Platform:
Anaconda Software Distribution [Internet]. Anaconda Documentation. Anaconda Inc.; 2020. Available from: https://docs.anaconda.com/
Pygame Community. (2000–2025). *Pygame* (Version 2.6.1) [Computer software]. https://www.pygame.org

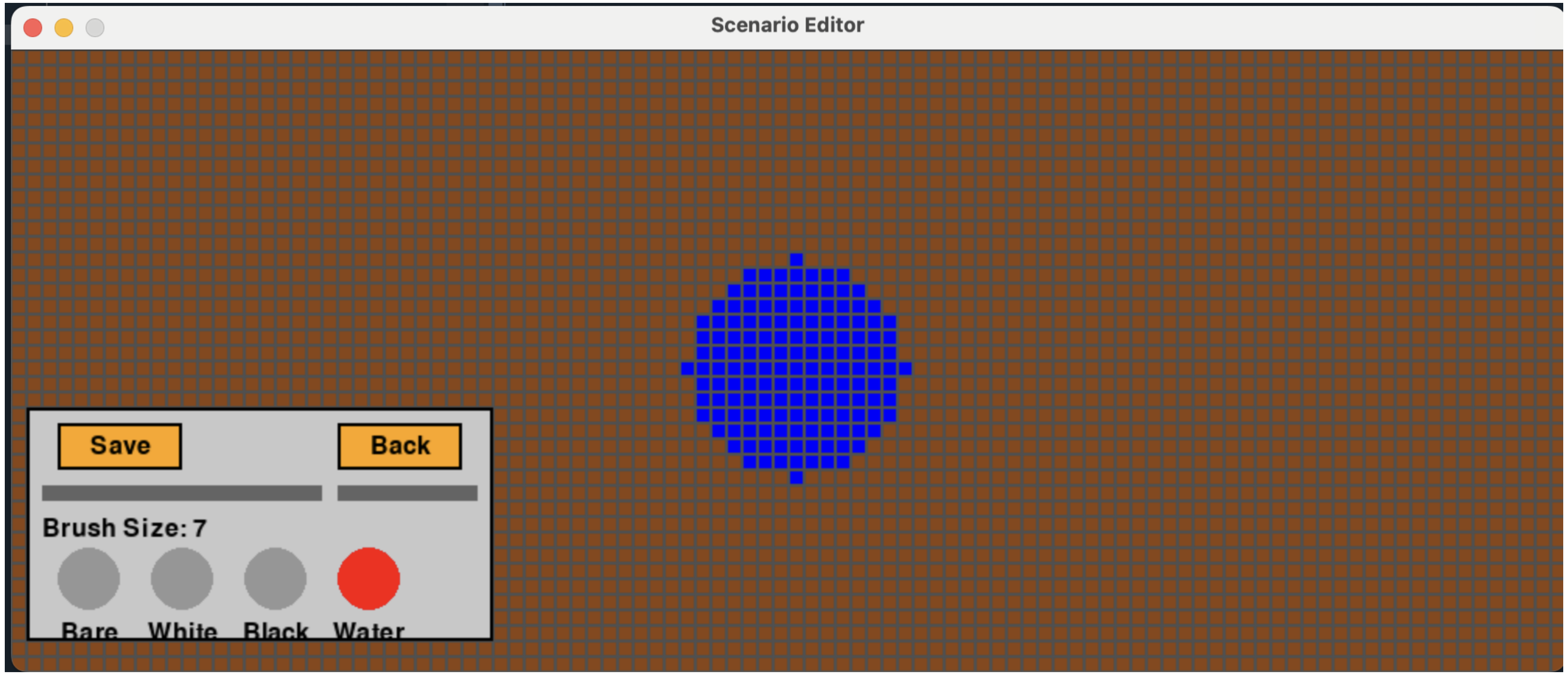
References:

The 5 spheres that shape the Earth:
https://saullosdhs.weebly.com/interactions-of-earth-systems.html
Other daisies world models:
Punithan, Dharani Kim, Dong-Kyun McKay, Robert. (2011). Daisyworld in Two Dimensional Small-World Networks. Communications in Computer and Information Science. 258. 167 − 178.10.1007/978 − 3 − 642 − 27157 − 119.
E. Cheynet (2025). DaisyWorld with greenhouse effect (https://github.com/ECheynet/DaisyWorld/releases/tag/v1.0) GitHub. Retrieved March 25, 2025.

APPENDIX

1. What water do?

Nothing, I planned to develop a full water cycle, but that would take me 20 or more hours, and I am nowhere near fre



2. Configurable parameters explanation

map_width
Width of the simulation “world” in pixels. Controls how many cells fit horizontally and the overall window/grid size.
map_height
Height of the simulation “world” in pixels. Controls how many cells fit vertically and the overall window/grid size.
temp_thickness
Vertical exaggeration factor for the temperature overlay. Affects how tall the colored “heat” bars sit above each tile.
T_space
Reference (ambient) temperature used in the radiative cooling term

SUN_SCREENING
Incoming solar flux (think “solar constant”) that, combined with albedo, drives the daytime heating rate.
HEAT_DIFFUSION_COEFFICIENT
Not used, a part of the old code.
HEATING_RATE
Fractional rate at which cells adjust toward their solar-heated temperature each time step.
INITIAL_TEMPERATURE
Starting temperature (K or arbitrary units) assigned to all non-water cells at simulation start.

2. Configurable parameters explanation

ALBEDO_BLACK
Reflectivity of black daisies (low albedo → absorb more light → heat up more).
ALBEDO_WHITE
Reflectivity of white daisies (high albedo → reflect more light → heat up less).
ALBEDO_BARE
Reflectivity of bare ground.

ALBEDO_WATER
Reflectivity of water cells (used to treat oceans).
HEAT_RETENTION
Not used, a part of the old code, replaced by influence level, heating/cooling rate, along with heat diffusion coefficient
T_OPTIMAL
Ideal local temperature for daisy growth. Growth rate peaks when local T ≈ T_OPTIMAL.
T_TOL_LOW
Temperature tolerance below T_OPTIMAL that defines how quickly growth falls off when too cold.
T_TOL_HIGH
Temperature tolerance above T_OPTIMAL for how quickly growth falls off when too hot.
SPREAD_CHANCE
Base probability that an empty cell colonizes if it has daisy neighbors (scaled by local growth rate).
DEATH_CHANCE
Probability that an existing daisy dies each step.

2. Configurable parameters explanation

COOLING_COEFFICIENT
Coefficient in the Stefan–Boltzmann-style radiative cooling term, multiplied with d(T**4)

CUM_MOR_NET
How many past time-steps of birth/death net you keep in memory for the cumulative-mortality graph.
DAY_BORDER_SPEED
Speed at which the day–night terminator (dawn/dusk line) moves across the grid.
DAY_PERIOD
Replaced by DAY_BORDER_SPEED.
THRESHOLD
Small floor used in the temperature-to-color mapping to avoid divide-by-zero or overly-steep gradients.
THRESHOLD_TMID
Convergence threshold for the equilibrium-temperature solver (compute_equilibrium_temp).
MAX_ITERS_TMID
Maximum iterations for the equilibrium-temperature solver before giving up.
INFLUENCE_LEVEL
Neighborhood radius for both daisy spread and heat diffusion:

- 1 → 4-way (N/E/S/W)
- 2 → 8-way (including diagonals)
- > 2 → circular neighborhood

2. Configurable parameters explanation

overlay_shift_x
Horizontal pixel offset to shift the heat-overlay layer relative to the world grid.
overlay_shift_y
Vertical pixel offset to shift the heat-overlay layer.
overlay_shift_z
“Gap” (in pixels) between stacked isometric layers when drawing the heat overlay.

3. How to run the game?

Extract DAYNIGHT_PACKED.zip

Before running the simulator, ensure you have Python 3.8+ installed. Then install the single required package:

```
pip install pygame
```

From your terminal or command prompt, navigate to the directory containing `main.py` and run:

```
python main.py
```

This will open the main menu.

4. What parameters can be changed mid simulation?

The solar constant
The peak growth rate
The speed of the simulation
The position of the temperature overlay

5. How do I change those?
Click Pause (Or Space)
Click God’s Brush