



A SMALL GAME OF MUTUAL DESTRUCTION

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ABSTRACT

µ ("Micro") is a game on microbial ecology. The goal of the game is to make your own prokaryotic species to live and prosper against all odds, also by competing or collaborating with other species in the same environment.

INTRODUCTION

Microbial ecology is a scientific research field which explores how different microbial organisms (such as Bacteria) become able to populate and thrive in different ecosystems, their role in the ecosystem they inhabit and how different they can be from time to time and from place to place. In the game, each player will create a prokaryotic species of his/her own, and must then allow it to populate new places. The combined movements of all species at play will make some of them clash to compete for the same resources, while others might instead be able to join their strengths and carry on together. The game will also allow players to make their own species evolve, acquiring new traits and abilities over time.

EXPERIMENTAL PROCEDURES, RESULTS AND DISCUSSION

Material preparation

For this game, you will need:

- ∅ 40 Habitat tokens (the game provides 1 sheet of 10 Habitats);
- ∅ 80 Species tokens (the game provides 1 sheet of 20 Species);
- ∅ 12 Metabolism cards (the game provides 1 sheet of 6 Metabolism cards);
- ∅ 54 Evolution cards (the game provides 1 sheet of 18 Evolution cards);
- ∅ 1 6-sided die for each player (which will be referred to later as "1d6").

Arrange the table

Gather all players (at least 2) around the table. Make sure you have 40 Habitat tokens and gather them in a pile at the centre of the table: that represents Gaia, the whole Earth ecosystems (well, not exactly: more correctly, this game only features a portion of the marine ecosy-

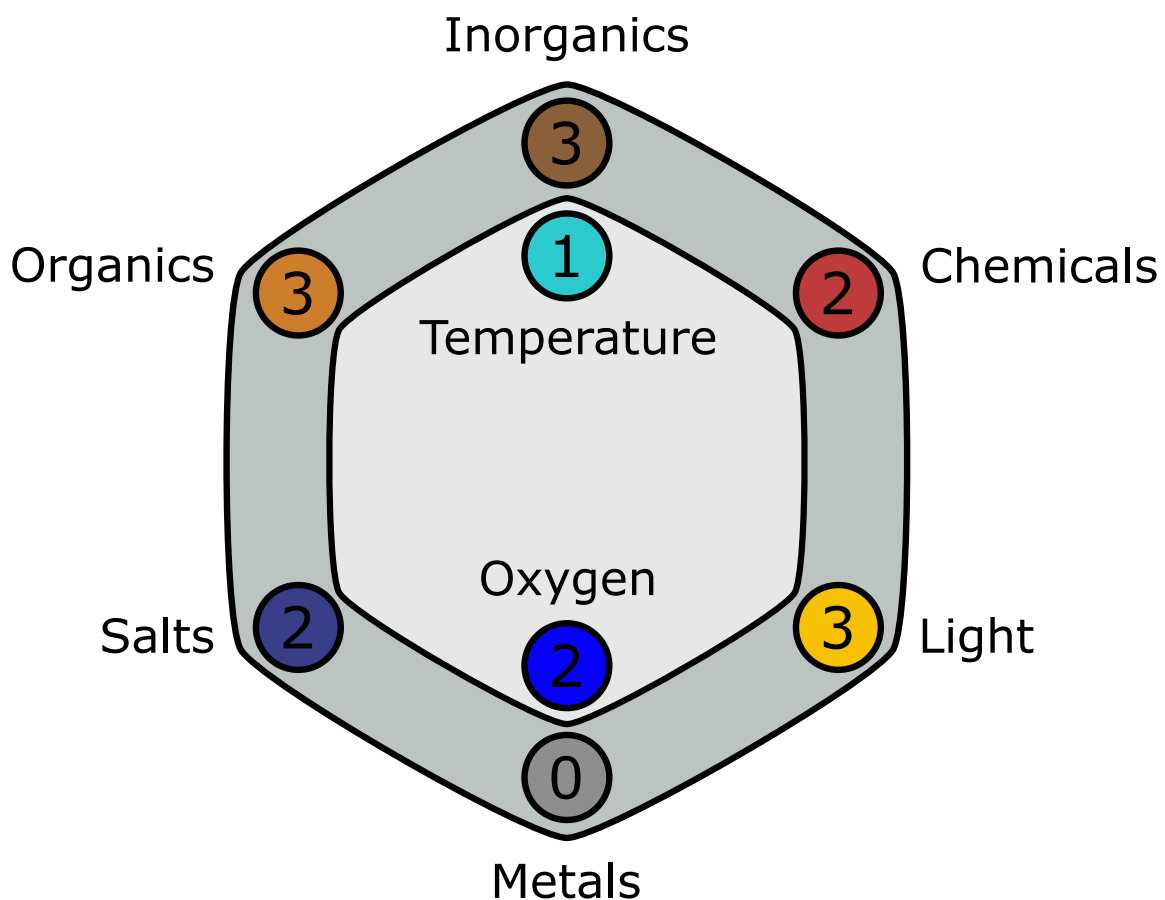
stems). Also, make sure you have 80 Species tokens: pile them according to the species depicted close to Gaia; in the game, we will refer to these piles as the Linnaeus. Gather close to them 12 Metabolism cards, which will be referred in the game as the Winogradsky Column, and 54 Evolution cards, which will be referred in the game as the Galapagos.

Creating a Colony

At start, each player must first draw one Metabolism card from the Winogradsky Column. This card tells the player how many Nutrients his/her starting Colony needs to survive; Nutrients are required for energy production ("Energy"), biomass production ("Biomass") and as electron donors for various reactions ("Donors"). Together, all the Nutrients required by a Colony are referred to as Resources.

Choosing the Habitat

Then, each player must pick 3 random Habitat tokens from Gaia. Each Habitat token shows a combination of features:



- ø **Chemicals**: this category encompasses a wide range of compounds, from methane to sulfides, which can provide energy sources.
- ø **Organics**: this category regards all the organic compounds that are used to build up the cells.
- ø **Inorganics**: this category contains all those compounds that are not biological in origin.
- ø **Light**: the amount of light that reaches that Habitat.
- ø **Temperature**: the temperature that characterize that Habitat.
- ø **Metals**: how much metal is contained in that Habitat.
- ø **Salts**: how much salt is contained in that Habitat.

Some of these features (**Chemicals**, **Light**, **Organics** and **Inorganics**) can be taken up by the Colonies as Nutrients. Others, such as Metals and Oxygen, can produce special effects in some cells. Metals and Salts are usually toxic for all Colonies: when the amount of each is higher than 0, Colonies need to take up a double amount of Energy Nutrients. When it's higher than 1, this amount is further doubled. If the Temperature of an environment is below 2, all Colonies in that Habitat have -1 Mobility. Nutrients are consumed at each Turn by a Colony. When no more Nutrients are available, the Colony starts dying (see below).

When a Colony takes up an amount of each Nutrient equalling the ones describes in its Metabolism card, it counts as 1 Resource is being gained. Colonies are not compelled to always take up only the amounts of Nutrients required to fill 1 Resource; conversely, they can take up any desired amount of each Nutrient at each turn.

Evolving and moving

Each player rolls 1d6 and sums 2 to the result: this number will represent the amount of Resources required by a Colony to double its mass and grow a new Generation. Each Colony is associated with a Generation, which is a score underlining how big it has become. Whenever the Colony obtains an amount of Resources equalling that required to double its mass, its player can spend 1 Resource to do one of the following.

- ø **Moving**: each Colony possesses a Mobility score of 2. This number represent the maximum number of Habitat tokens that the Colony can move through before stopping. When a Colony moves, it leaves its past

Habitat and settles onto a new one. When the player wants to move its Colonies, he/she must move the upper Colony token. The Generation of a Colony is halved when a portion of the Colony tokens is moved to a new position. You cannot move a Colony through an occupied Habitat or onto an occupied Habitat. New Colonies share the same Evolution cards of their starting Colony.

∅ **Doubling**: when a species doubles, the player must put a new Colony token on the same Habitat. When a Colony doubles up, also its Resource requirements double.

∅ **Evolving**: when a Colony evolves, its player must draw an Evolution card from the Galapagos. Each Evolution card provides special characteristics to a Colony that can be used anytime. Players can evolve single Colony on single Habitat tokens, not all their Colonies at once. Only Colonies at a Generation score higher than 1 can evolve. When a Colony evolves separately from its source Colony, it becomes a new species and is a starting Colony on its own.

More than 1 Resource can be spent in this fashion, but not on the same choice. For instance, a player might be interested in moving its Colony to another Habitat and evolving it at the same time, thus spending 2 Resources. The amount of Resources available to the Colony is diminished according to the amount of Resources spent in the turn.

Starting the game

After having defined his/her starting Colony, each player places the 3 Habitats in front of him/her on the table, arranging them in any fashion he/she prefers. After this step, he/she must pick a Species token from the Linnaeus and place it on one of the Habitats, taking care to place the starting Colony on a suitable Habitat (i.e. any Habitat with good amounts of the required Nutrients).

The game is organized in Turns. At each Turn, one player can do one of the following:

∅ **Double, Move or Evolve** his/her Colony: as above.

∅ **Exchange Habitats**: at any Turn, a player can pick a single Habitat token from Gaia and add it to its Habitats and put back to Gaia an unused one.

∅ **Attack a nearby Habitat**: at any Turn, a nearby Habitat occupied by

a Colony belonging to another player might be attacked. During an attack, confront the Generations of the two Colonies: that with the higher Generation score wins the attack, unless some evolutionary traits gained from the Evolution cards allow them to do something else. Both colonies lose 1 Generation: if such a score gets to 0, the Colony dies (see the related mechanism later) leaving the Habitat free for the new Colony to colonize it during a subsequent Turn.

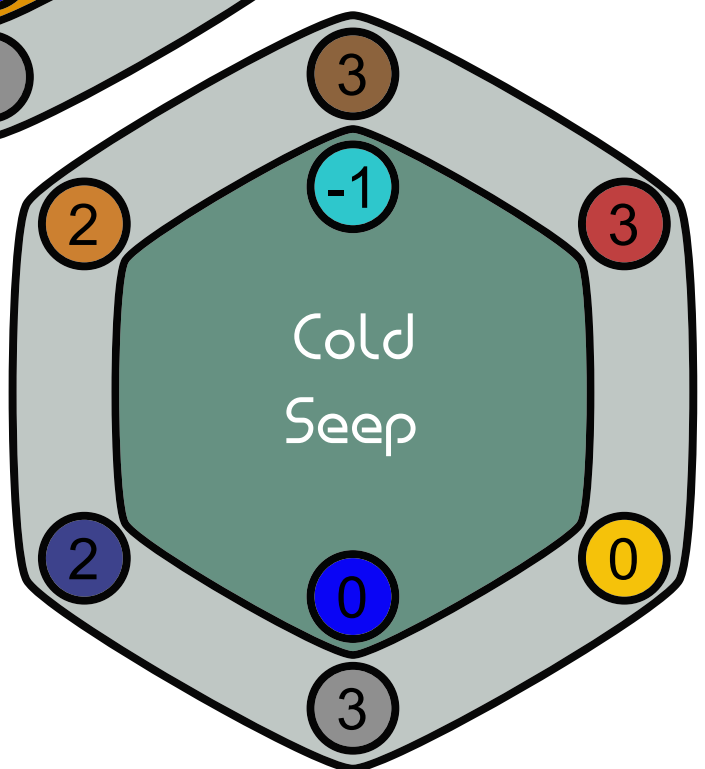
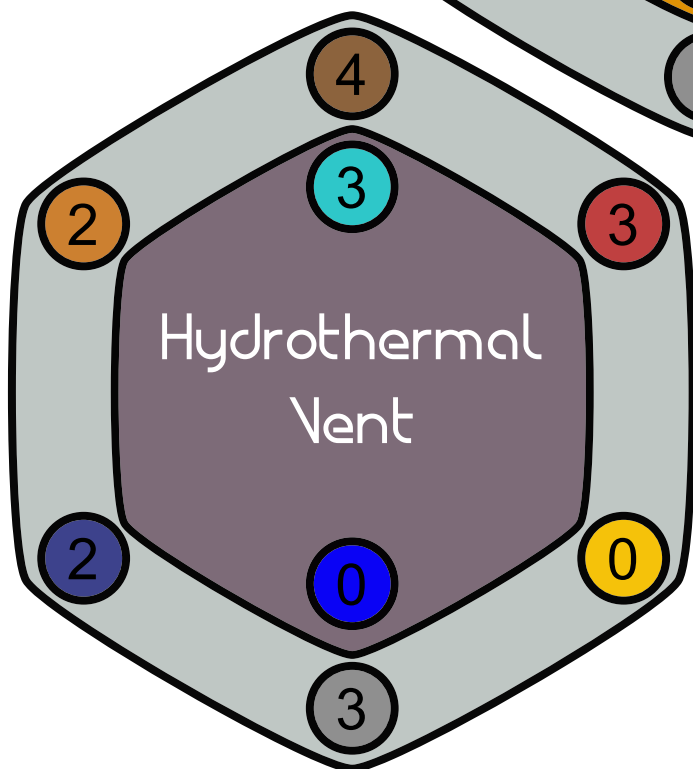
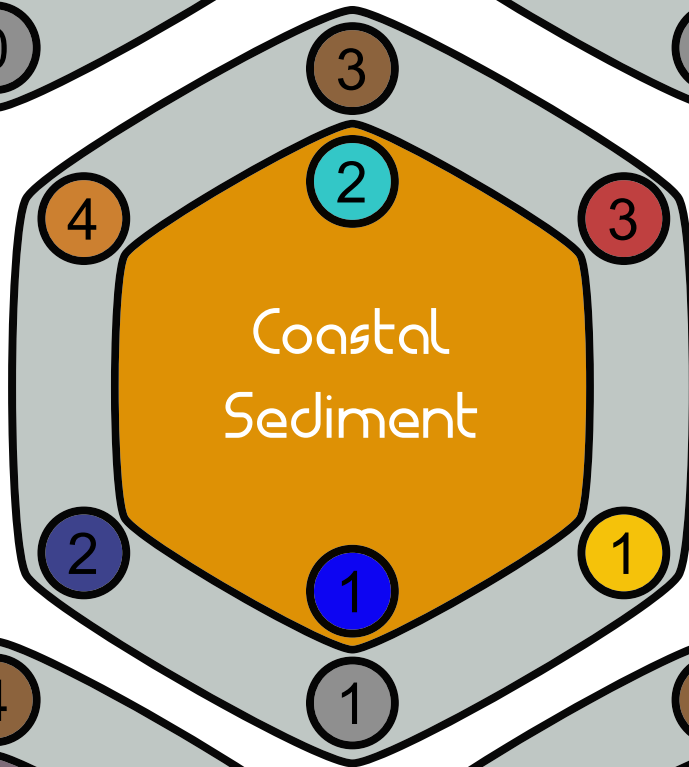
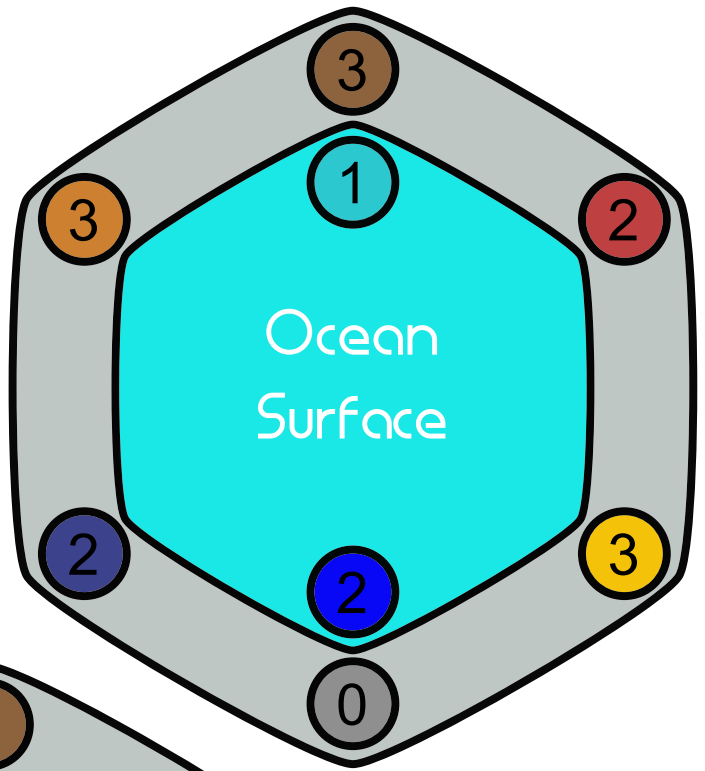
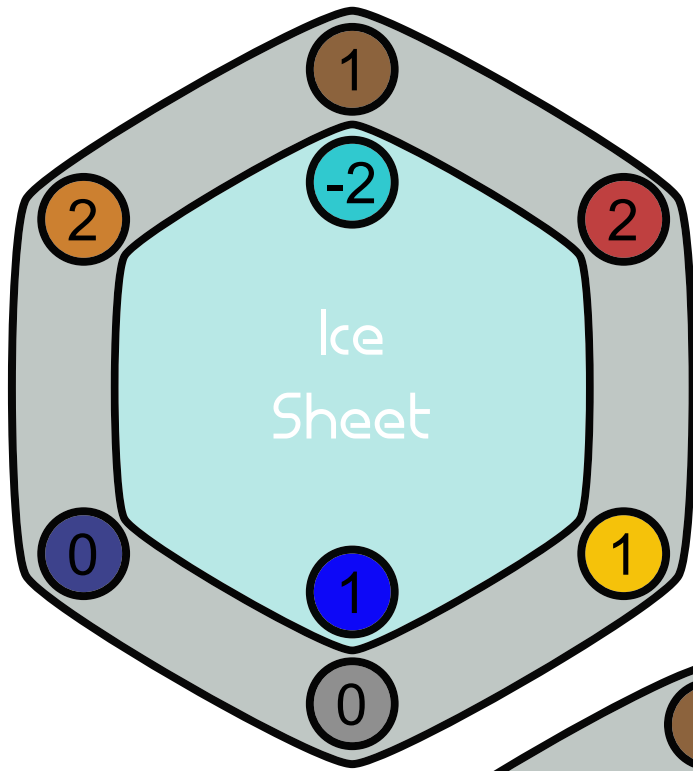
∅ **Change metabolism:** at any Turn, a player can choose to change the Metabolism of one of his/her Colonies. Should he/she choose so, he/she must put back an Evolution card in the Galapagos before doing the same with the Metabolism card in the Winogradsky Column. The new Metabolism card must be chosen randomly from the Column.

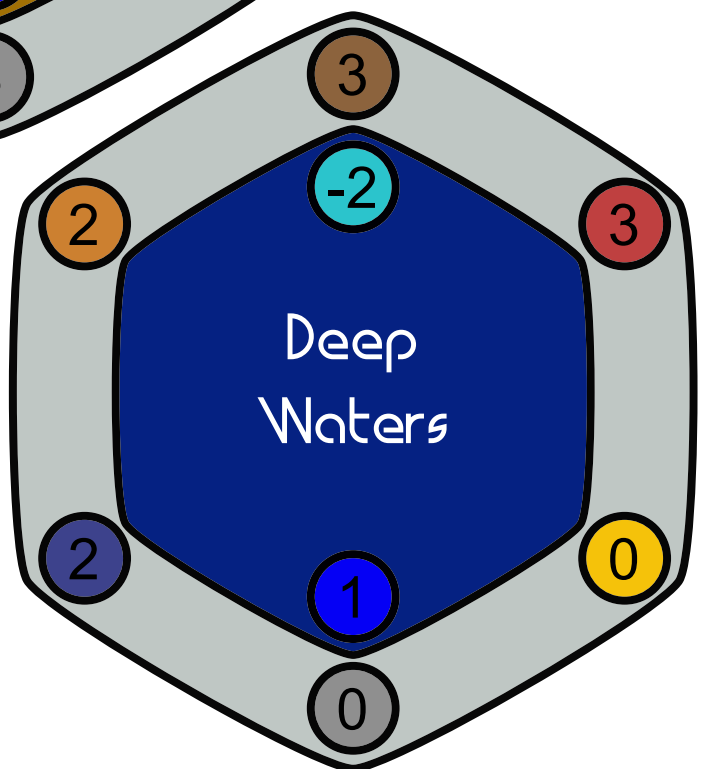
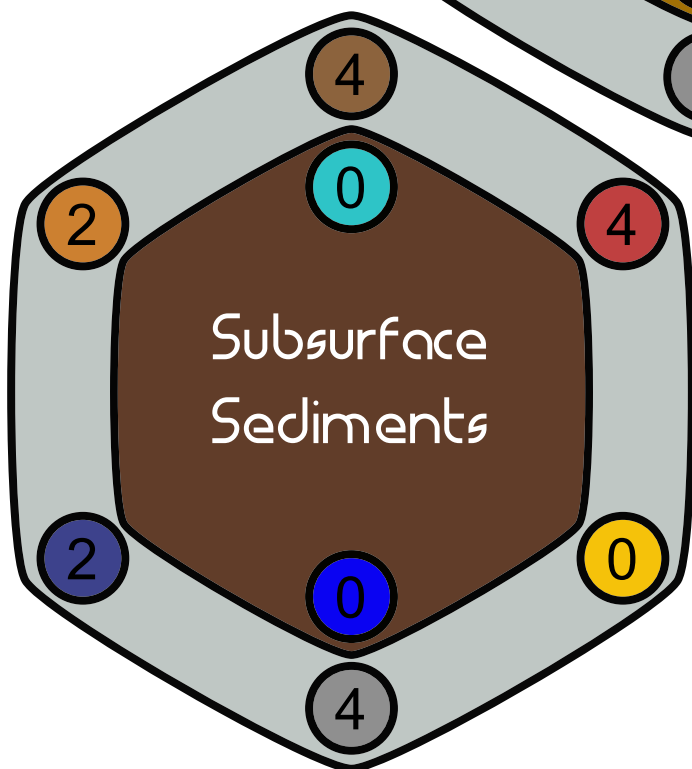
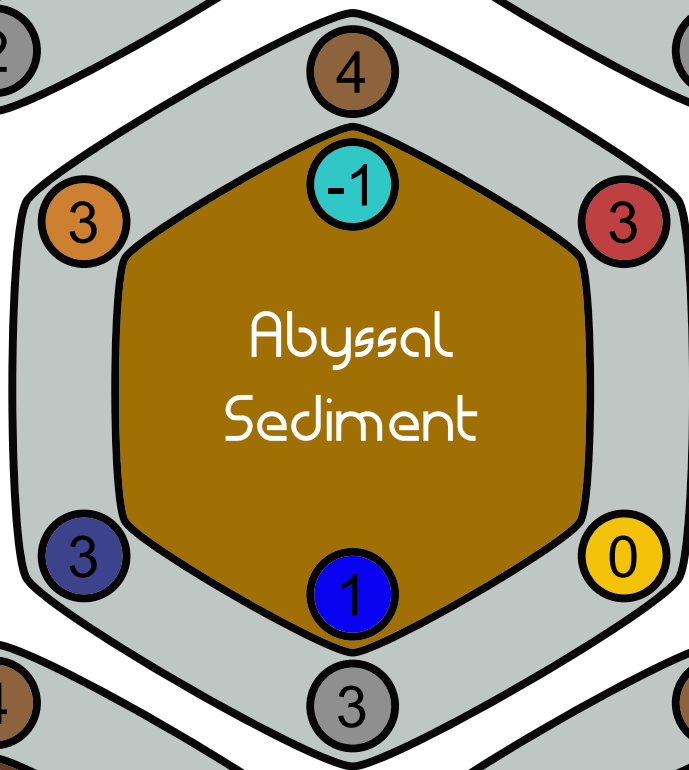
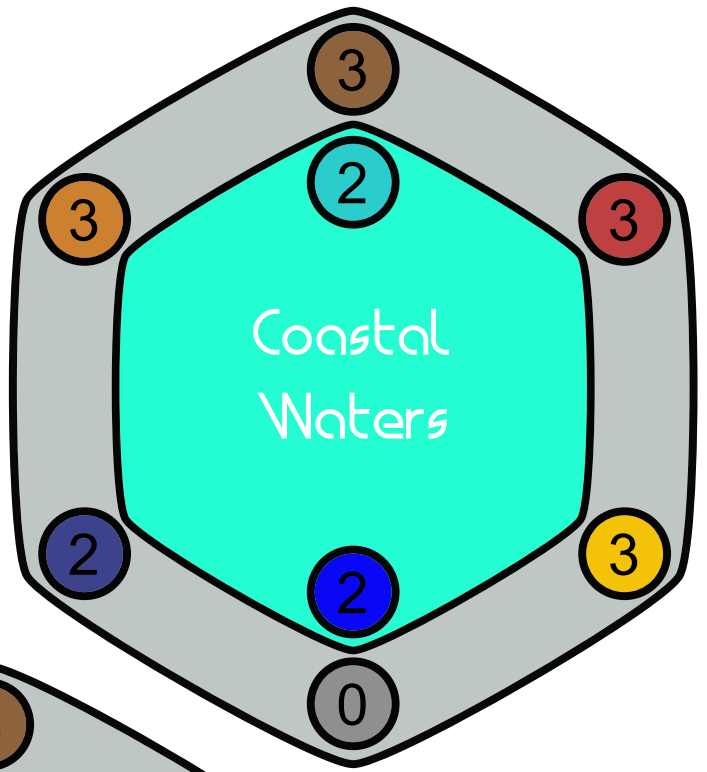
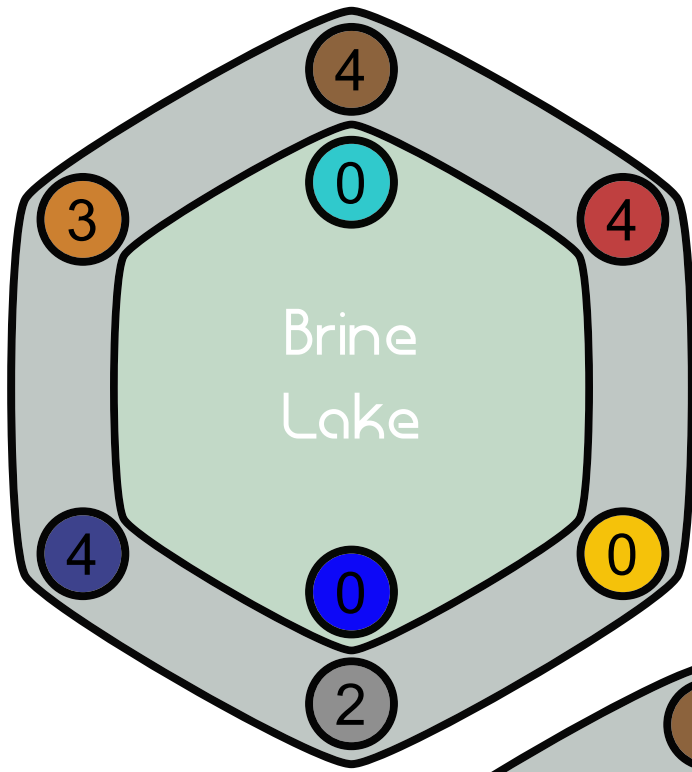
When a Colony cannot use the Nutrients available, it consumes half of its Generations in that Turn. When it reaches 1, and still cannot use the available Nutrients, it dies. When a Colony dies, it releases a number of Nutrients per kind (i.e. Energy, Donors and Biomass) equalling the maximum Generation score reached by the Colony.

CONCLUSION

The game ends when either:

- ∅ No more Habitats can be drawn from Gaia;
- ∅ No more Evolutionary cards can be drawn from the Galapagos;
- ∅ Only a single player is left in the game.





PSYCHROPHYLE

When Temperature is below 0, you count as having +1 Energy. When Temperature is above +1, you count as having -1 Energy per turn.

THERMOPHILE

When Temperature is above +1, you count as having +1 Energy. When Temperature is below 0, you count as having -1 Energy.

TOXIC

At each turn, you can emit a wave of toxic chemicals that slows the growth of other species in all nearby Habitats. They count as having -2 Biomass in the following turn. To use this card, you need to have acquired at least 1 Energy in the previous Turn.

GENE SHUFFLE

You can spread particles that carry your genes. If your population has at least 3 Generations, roll 1d6: this is the number of particles spread from all sides of your Habitat token up to a number of other tokens equal to your Mobility score.

METAL-LOVER

You can use 1 Metal for Energy instead of your usual Energy Nutrient. Also, you can use your regular amount of Energy Nutrients to survive at any concentration of Metals.

SPORIGENOUS

Instead of doubling, you can form a Spore. Spores remain in the Habitat you formed them even if your Colony has gone extinct there. You can rejuvenate them at any time, restarting the colonization of the Habitat by growing a new starting Colony.

FILAMENTOUS

You grow in filaments, that allow you to take up +1 Resources per turn. You have -1 Mobility, though. Also, you count as having +1 Generations when attacking another nearby Colony.

EXUDATING

At each turn, you exude 1 Organics to all Habitats nearby. These make up a network that blocks other Colonies in all nearby Habitats, zeroing their Mobility score.

GLIDING

You can actively move wherever you want, gaining +1 Mobility. Also, you can freely move through occupied Habitats.

BIOFILM

You live in a biofilm, which covers all your Habitat token. This biofilm prevents other Colonies from attacking your Habitat. Also, if you draw a "Phage attack!" card, you must put it back in the Galapagos without feeling its effect. However, you have Mobility -1.

PIGMENTS

You can produce pigments which allow you to generate energy from other sources. Choose an Energy Nutrient you should not be able to use: starting from now, you can use it along with your regular Energy nutrient.

SYNTROPHY

Whenever a nearby Colony of your choice moves, it carries a clone of your Colony with it, occupying the same Habitat. They sum up their Generations when they attack or are attached but only use the Generations of the older one for the rest of the rules.

COMPETENCE

You can acquire the same Evolution cards of a nearby extinct Colony and add them to your own traits. If you move a fraction of the Colony to a new Habitat, you can choose to only bring with it a part of all the traits belonging to its starting Colony.

ANAEROBE

When Oxygen is lower than 2, you can use your regular amount of Energy Nutrients to survive. Also, if the Chemicals are above 1, you can freely use them as either Donor Nutrients or Energy Nutrients in place of your regular Energy and Donor Nutrients.

AEROBE

When Oxygen is higher than 1, you can use your regular amount of Energy Nutrients to survive. Also, If you acquire +1 Energy, you can lower by 1 (minimum 1) the amount of Resources required to double your Generation.

HALOPHYLE

When Salts are higher than 0, you can use your regular amount of Energy Nutrients to survive. Furthermore, when you grow a new Generation, you get harder: you count as having +1 Generations when attacking or being attacked.

PHAGE WARFARE

You have blocked a phage attack, and now can use that phage to kill off another Colony. If you sacrifice half the Generation of this Colony, the ones nearby will die. You cannot use this card if you have only 1 Generation.

PHAGE ATTACK!

You're attacked by a virulent phage! The Colony which got this card dies. Put the card back in the Galapagos.

HETEROTROPHY

Energy: 1 **Organics**/turn

Biomass: 1 **Organics**/turn

Donors: 1 **Organics**/turn

Special: you can attack one nearby Colony if it has less Generations than you every turn. If you do it, you eat 1 of its Generation and gain 1 Resource.

PHOTOLITHOAUTOTROPHY

Energy: 1 **Light**/turn

Biomass: 1 **Inorganics**/turn

Donors: 1 **Inorganics**/turn

Special: you add +1 Oxygen to your Habitat every turn. Also, you can uptake +1 **Light** in a turn to produce +1 Biomass.

FERMENTATION

Biomass: 1 **Organics**/turn

Donors: 1 **Organics**/turn

Special: you add +1 **Organics** and +1 **Chemicals** to your Habitat every turn.

CHEMOLITHOAUTOTROPHY

Energy: 1 **Chemical**/turn

Biomass: 1 **Inorganics**/turn

Donors: 1 **Inorganics**/turn

Special: you add +1 **Organics** to your Habitat every turn. Also, you can uptake +1 Oxygen in a turn to produce +1 Biomass.

MIXOTROPHY

Draw the Heterotrophy card and a second one, then put this card back in the Winogradsky Column.

CHEMOORGANOAUTOTROPHY

Energy: 1 **Chemical**/turn

Biomass: 1 **Organics**/turn

Donors: 1 **Inorganics**/turn

Special: you add +1 **Chemicals** to your Habitat every turn. Also, you can uptake +1 **Organics** in a turn to produce +1 Biomass.