

C.S. MacCath's Physical Worldbuilding Guide

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Astronomy

The Galaxy

1. In what galaxy is this world located?
2. What is the structure and age of this galaxy?
3. What are the prominent celestial phenomena in this galaxy?
 - a. How do these phenomena interact with the sun and solar system in question?

The Sun

1. How far away is this star from Sol?
2. Where does this star fall in the main sequence of stars?
3. What is its mass?
4. What is its radius?
5. What is its temperature?
6. What is its lifespan?

The Solar System

1. How many planets are there in the solar system?
2. What are these planets comprised of?
3. What satellites orbit these planets?
4. What is the period of each planet's rotation around the sun?
5. What is the period of each satellites rotation around its planet?
6. Are there any other stable celestial bodies present in the solar system?
 - a. What are they?
 - b. Where are they placed?
 - c. How do they interact with other celestial bodies in the solar system?

The Focus Planet

1. Where is the focus planet located in relation to the other planets and satellites?
2. What is the density of this world?
3. What is the radius of this world?
4. What is the gravity of this world?
5. What is the escape velocity of this world?
6. What is the day length of this world?
7. What is the axial tilt, and therefore the seasonal variation of this world?
8. What is the mean temperature of this world?
9. What is the atmosphere of this world comprised of, and in what percentages?
10. What are the size, gravity, and orbits of the focus planet's satellites?

Solar System Chart

1. *(insert here)*

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Geology

Planetary Cooling

1. Describe how the focus planet cooled.
2. Were there asteroid impacts?
3. Was there volcanic activity?
4. What are geological conditions like today?

Land Masses and Oceans

1. Describe the land on the focus planet.
2. Map land masses and oceans on the planet.
3. *(insert maps here)*

Contour Maps

1. Draw a contour map of the focus planet.
2. Map the elevations on the planet.
3. Map major rivers and lakes.
4. *(insert maps here)*

Oceans

1. Describe the oceans on the focus planet.
2. Map continental shelves.
3. Map ocean depths.
4. *(insert maps here)*

Landscape Profiles

1. Create landscape profiles of the focus planet.
2. Take a cross section of the elevation map to show how the continents look from a side view.
3. *(insert maps here)*

Mineral Resources

1. Where are mineral resources located?
2. Which mineral resources are particularly abundant, and in which areas?
3. Which mineral resources are particularly scarce, and where can they be found?
4. Create a mineral resource map.
5. *(insert maps here)*

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Meteorology

General Planet Description

1. What sort of planet is this?
 - a. Is it earthlike?
 - i. Warmer? Colder?
 - ii. Is it drier or wetter?
2. About how much of the surface is water?
3. Does the planet have seasons?
4. Write a description of the planet's climate and weather.
 - a. Remember to include weather and tidal variations due to gravitational forces affecting the planet.
5. Draw maps to show the climate zones using relief maps previously created.
6. *(insert maps here)*

Major Air and Water Currents

1. Sketch the main air and water currents on the planet using arrows.
2. How does the heat get distributed on the planet?
3. Show air currents on a map.
4. *(insert maps here)*

Rainfall Map

1. Figure out what the rainfall on the different parts of the land masses will be.
 - a. Label the rainfall amounts with a color code.
2. *(insert maps here)*

Temperature Map

1. Start with the outline map again and use it to show temperatures ranges on different parts of the planet.
 - a. Remember to account for seasons.

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Microbiology

The Environment

1. Where did life begin on the planet?

Early Life Forms

1. Mesophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers
2. Extremophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers

Development and Adaptation of Life Forms

1. Mesophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers
2. Extremophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers

Reproduction and Survival

1. Mesophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers
2. Extremophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers

Senses and Behaviors that Enhance Survival

3. Mesophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers
4. Extremophilic
 - a. Primary Producers
 - b. Consumers
 - c. Decomposers

Current Conditions

1. Which of the above microbes still exist on the world?
 - a. Where do they live?
 - b. What is their function?
 - c. What effect do they have on other living creatures?

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Marine Botany

Marine Botanical Regions

1. Arctic
2. Sub-Arctic
3. Northern Hemispheric
4. Equatorial
5. Southern Hemispheric
6. Super-Antarctic
7. Antarctic

Marine Botanical Specifics

1. Name of plant
2. Sketch of plant & relationship to other plants in the species
 - a. One plant should be fully developed, but others in the species can be used for reference by means of this sketch
3. Evolution of plant from its early/primitive form
4. Height of plant
5. Reproduction strategies of plant
6. Environmental niches
7. Special adaptations
8. Uses for this plant in medicine, technology, etc.
9. Possible relationships between this plant and other aquatic plants/animals
 - a. Refine these relationships here and in the Marine Zoology section

Marine Zoology

Marine Zoological Regions

1. Arctic
2. Sub-Arctic
3. Northern Hemispheric
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Marine Zoological Specifics

Fish

1. Sketch the animal & name it.
2. How did it come into being?
3. How does it move?
4. What does it eat?
5. How does it reproduce?
 - a. Sketch the developmental phases of this animal.
6. What is this animal's natural environment?
7. What aquatic animals are related to this one?
 - a. Sketch these relationships.
8. What aquatic animals are ancestors to this one?
 - a. Sketch these relationships.
 - i. One animal should be fully developed, but others in the species can be used for reference by means of this sketch.

Water Mammals

1. Sketch the animal & name it.
2. How did it come into being?
3. How does it move?
4. What does it eat?
5. How does it reproduce?
 - a. Sketch the developmental phases of this animal.
6. What is this animal's natural environment?
7. What aquatic animals are related to this one?
 - a. Sketch these relationships.
8. What aquatic animals are ancestors to this one?
 - a. Sketch these relationships.
 - i. One animal should be fully developed, but others in the species can be used for reference by means of this sketch.

Sessile Creatures

1. Sketch the animal & name it.
2. How did it come into being?
3. How does it move?
4. What does it eat?
5. How does it reproduce?
 - a. Sketch the developmental phases of this animal.
6. What is this animal's natural environment?
7. What aquatic animals are related to this one?
 - a. Sketch these relationships.
8. What aquatic animals are ancestors to this one?
 - a. Sketch these relationships.
 - i. One animal should be fully developed, but others in the species can be used for reference by means of this sketch.

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Other

1. Sketch the animal & name it.
2. How did it come into being?
3. How does it move?
4. What does it eat?
5. How does it reproduce?
 - a. Sketch the developmental phases of this animal.
6. What is this animal's natural environment?
7. What aquatic animals are related to this one?
 - a. Sketch these relationships.
8. What aquatic animals are ancestors to this one?
 - a. Sketch these relationships.
 - i. One animal should be fully developed, but others in the species can be used for reference by means of this sketch.

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Marine Ecology

Marine Ecological Regions

1. Arctic
2. Sub-Arctic
3. Northern Hemispheric
4. Equatorial
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7. Antarctic

Marine Ecological Specifics

Biome	Water Plants	Water Animals	The Water Ecology Page	
Shore	Shore P	Shore A	Shore P	Shore A
Ocean	Ocean P	Ocean A	Ocean P	Ocean A
Tropical	Tropical P	Tropical A	Tropical P	Tropical A

1. **Basic Facts:** Describe conditions in the biome that you are working on. Describe the environment, whether shallow mud flats, the open ocean, deep sea volcanic vents, the rocky shore, etc. How deep is the water where your animals live? What do they eat? What temperature is the water? Is it clear or muddy with sediment?
2. **Describe the Primary Producers:** These make food from inorganic materials and energy (plants on earth) Tell the size of the organisms and describe their color and structure.
3. **Describe the Primary Consumers:** (herbivores on earth) Describe the plant eaters and tell which plants they eat. Do they have any protective mechanisms, such as protective coloration or spines?
4. **Describe the Secondary Consumers:** (carnivores on earth) These eat the plant eaters. Describe them and any special mechanisms that they may have to capture prey.
5. **More Consumers?** It is possible that you might have carnivores who prey on smaller carnivores, but this is rare. On earth we see a maximum of 5 layers in ecosystems.
6. **Diagram the Energy Pyramid:** This shows how the energy moves up in the food chain. Give an explanation of this diagram.

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Botany

Botanical Regions

Arctic
Sub-Arctic
Northern Hemispheric
Equatorial
Southern Hemispheric
Super-Antarctic
Antarctic

Botanical Specifics

1. Name of plant
2. Sketch of plant & relationship to other plants in the species
 - a. One plant should be fully developed, but others in the species can be used for reference by means of this sketch
3. Evolution of plant from its early/primitive form
4. Height of plant
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6. Environmental niches
7. Special adaptations
8. Uses for this plant in medicine, technology, etc.
9. Possible relationships between this plant and other aquatic plants/animals
 - a. Refine these relationships here and in the Marine Zoology section

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Zoology

Zoological Regions

Arctic
Sub-Arctic
Northern Hemispheric
Equatorial
Southern Hemispheric
Super-Antarctic
Antarctic

Zoological Specifics

Evolution		
Animal in Ocean	Descendents on Land?	On Land? Why or Why not? List Important Features

Environment		
Animal	Environment	Adaptations

Table of Animal Facts					
Animal	Weight	Kilocalories Needed/Day <i>Divide by 10 for cold blooded</i>	Kilocalories <i>Estimate 50 Kcal/oz.</i>	Herbivore or Carnivore?	Hot or Cold Blooded?

1. **Environment:** This has great influence on the biome (community of living things). Decide which animals will live in the different climatic zones. How do they adapt? You should describe the environment, including temperature, rainfall, seasonal variations and the vegetation that your animals will eat.
2. **Describe the Animal:** Tell the size of the animal and describe its appearance and structure. Describe specific adaptations that make it able to survive in its environment. Tell what the animal eats and how it reproduces.
3. **Illustrations:** May be drawn or gathered from other sources. Illustrations may be diagrammatic so long as they get the concepts across.
4. **Table of Animal Facts:** Make a table. Put in the names of your animals and what they weigh. Note that there are two tables, one for warm blooded animals and one for cold blooded animals. Note which the animal is on your chart. In Column Four (Eat It Cal) multiply the animal's weight in ounces by 50 or weight in pounds by 500. This is how many calories a predator would get if it ate this animal.
5. **Diagram of Animal Species Relationships:** This is a sort of genealogical chart of the different species and how they are related to each other because of descent from a common ancestor.

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Land Ecology

Land Ecology Regions

Arctic
Sub-Arctic
Northern Hemispheric
Equatorial
Southern Hemispheric
Super-Antarctic
Antarctic

Land Ecology Specifics

Biome	Land Plants	Land Animals	The Land Ecology Page combines these Life Forms	
Desert	Desert Plants	Desert Animals	Desert Plants	Desert Animals
Grasslands	Grasslands Plants	Grasslands Animals	Grasslands Plants	Grasslands Animals
Tropical Rain Forest	Tropical Rain Forest Plants	Tropical Rain Forest Animals	Tropical Rain Forest Plants	Tropical Rain Forest Animals

1. **Basic Facts:** Describe conditions in the biome that you are working on. Describe the environment, whether desert, grasslands, tropical rain forest, mountains, etc. How deep is the water where your animals live? What temperature is the water? What do they eat?
2. **Describe the Primary Producers:** These make food from inorganic materials and energy (plants on earth) Tell the size of the organisms and describe their color and structure.
3. **Describe the Primary Consumers:** (herbivores on earth) Describe the plant eaters and tell which plants they eat. Do they have any protective mechanisms, such as protective coloration or spines?
4. **Describe the Secondary Consumers:** (carnivores on earth) These eat the plant eaters. Describe them and any special mechanisms that they may have to capture prey.
5. **More Consumers?** It is possible that you might have carnivores who prey on smaller carnivores, but this is rare. On earth we see a maximum of 5 layers in ecosystems.
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Sentient Alien Life

The Seven Qualifications for Life

How does the alien race fulfill the seven qualifications for life? They are as follows:

1. Organized - Living things are made of atoms and molecules that are organized into cells. The cells in an organism can be either uniform or specialized for various functions. The cells can be further organized into tissues, organs and systems. Living things on Earth are quite diverse as to their organization and complexity.
2. Homeostatic - Living things carry out functions that keep them in a constant, relatively unchanging state called homeostasis. For example, your body has systems that keep your body temperature constant -- you shiver if you're cold, sweat if you're hot.
3. Reproduces - Living things make copies of themselves, either exact copies (clones) by asexual reproduction or similar copies by sexual reproduction.
4. Grows/develops - Living things grow and develop from smaller and/or simpler forms. For example, a human begins life as a fertilized egg, developing into an embryo, fetus and then a baby. The baby subsequently grows into a toddler, adolescent and adult.
5. Takes in energy from the environment - Staying in a relatively constant, organized state violates the second law of thermodynamics, which states that the degree of disorder (entropy) of all objects increases. For a living organism to maintain organization, it must take in, process and expend energy. The way humans and other animals do this is by eating food and extracting energy from it.
6. Responds to stimuli - Living things respond to changes in their environment. For example, if a stimulus causes you pain, you respond by moving away from that object. If you place a plant near a well-lit window, the branches or shoots grow toward the light (phototropism). For protection, some animals change color to blend in with their surroundings (camouflage).
7. Adapted to its environment - The characteristics of a living thing tend to be suited for its environment. For example, the fins of a dolphin are flat and adapted for swimming. The wing of a bat has the same basic structure as the bones in a dolphin's fin, but has a thin membrane that enables flight.

Ground Rules For Alien Life

1. Alien life would be based on some type of chemistry (eliminating the sci-fi concept of pure-energy beings).
2. Solvent - On Earth, the solvent for all of our biochemicals is liquid water. Other chemicals could be solvents as well, such as ammonia, methane, hydrogen sulfide or hydrogen fluoride.
3. Temperature - Alien life may require temperatures at which its solvent can remain liquid.
4. Pressure - Alien life may require environmental pressures (and temperatures) that allow solvents to exist in three states of matter (solid, liquid, gas).
5. Energy source - Living things require energy to remain organized. This energy may come from a star or from chemical or geothermal energy (as in hydrothermal vents and hot springs). On any alien world, there would have to be some source of energy to sustain life.

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6. Complex molecules - Living things on Earth are organized and made of complex, carbon-based molecules that carry out biochemical functions. Carbon is a versatile atom that can form bonds with up to four other atoms, in many shapes, to make molecules. Although not as versatile as carbon, silicon can also form up to four bonds with other atoms and has been proposed as a basis for molecules of alien life (silicon-carbon hybrid molecules have also been proposed). It is likely that alien life forms would have some type of complex molecule to carry out similar functions.
7. Informational molecule - In Earth organisms, deoxyribonucleic acid (DNA) is a complex molecule that carries genetic information and directs the formation of other molecules in order for life to reproduce and function. Because a characteristic of life is that it reproduces, it seems likely that alien life forms would also have some type of informational molecule.
8. Alien beings that are larger than microbes would have some equivalent of cells. As an organism gets larger, its internal volume (cubic function) grows faster than its surface area (square function). This places a limit on the organism's size; because substances from the outside of the organism must pass into and throughout the organism by diffusion, which depends upon large surface areas, short distances and differences in concentrations. As an organism grows larger, the distance to its center increases and diffusion gets slower. To maintain workable diffusion distances, an organism must have many small cells instead of one large cell. So, an alien would be multi-celled if it were larger than a microbe. (We would not expect to find a light-years wide, single-celled organism like that portrayed in the original Star Trek episode "The Immunity Syndrome.")
9. Alien life would evolve and adapt to its surroundings by the theory of evolution as previously explained.
10. The physiological make-up of a multi-celled alien would be most suited to its environment. Organ systems would be adapted to environmental conditions such as temperature, moisture and gravity.
11. The alien would have some way of bringing solids, liquids and gases inside its body, distributing them to every cell and removing waste products (equivalents of heart, blood vessels and kidneys, for instance).
12. The alien would be able to take in energy from its surroundings, extract the energy and eliminate wastes.
13. The alien would have senses (such as sight, sound, touch) to obtain information from the environment and respond to stimuli (while we use vision as our primary sense, this may not be true of aliens). They would also have some type of brain or nervous system to process information.
14. The alien would have some means of reproduction, either sexual or asexual.
15. Alien organisms would probably have similar ecological structures to life on Earth.
16. Population sizes would be limited based on the predominance of food, predators, disease and other environmental factors.
17. Alien life forms would exist in food chains and food webs in their native environment, like life on Earth. Producers will make food, consumers will eat producers and/or other consumers and decomposers will recycle atoms and molecules from dead organisms back into the environment.
18. Alien life forms will be integrated with their habitats and ecosystems, like life on Earth.

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Alien Physiology

1. Are the aliens carbon-based, silica-based, or based on something else?
2. Trace the evolutionary process of the alien from the more basic life-form designs you created for your planet to the form it takes now.
3. Is the alien an animal, vegetable, mineral, or something else? What evolutionary processes contributed to this appearance?
4. Is the alien race wholly corporeal / non-corporeal? Can they take corporeal / non-corporeal form at will?
5. Can the alien race take more than one corporeal form? Can it adapt the way a chameleon does? Can it copy the physical features of other races?
6. What is the standard for height and weight of the alien race?
7. How much variance occurs among individual aliens?
8. What are the standard hair, skin, eye, fur, and scale colors of the alien race?
9. Are there albinos and the like?
10. Describe the internal organs of the alien, and how these function together.
11. Are there any specific organs that facilitate adaptation to the alien race's environment? (i.e. does the alien have an organ that filters out toxins from the air?)
12. Is it bipedal, tripedal, etc? Is it a swimmer, a walker, a flyer?
13. How does the alien perambulate? Can it fly, jump really far, burrow, teleport, etc,
14. Does it have hands or feet? How many fingers or claws does it have? Does it have suction pads? Does it have a tail?
15. How strong is the alien race overall in comparison to humans?

The Senses

1. How is its eyesight? Does it see infrared or ultraviolet?
2. How is its hearing? Strong or weak compared to humans?
3. How is its sense of touch?
4. How is its sense of taste?
5. How is its sense of smell?
6. Are there any other senses? What are the characteristics of those?

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Life Cycle and Diet

1. How do the aliens reproduce?
2. How are the aliens born? How long is gestation?
3. How long do they live? How do they die?
4. What kinds of birth defects are common? What kinds of birth defects are uncommon?
5. What diseases and disorders are common, and in what stages of the life cycle do they manifest? How many of these are purely physical? How many are psychological? How many are both?
6. What foods groupings are necessary for alien survival, and in what quantities?
7. How much water and / or other solvent does the alien need, and how often?

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Primary Tools

World Builders

Elizabeth Viau

<http://www.world-builders.org>

Fantasy Worldbuilding Questions

Patricia Wrede

<http://www.sfw.org/writing/worldbuilding1.htm>

Language Construction Kit

Mark Rosenfelder

<http://www.zompist.com/kit.html>