ECLIPSE PHASE

# Astrometrics

A GM's Guide to Exoplanets

POSTHUMAN STUDIOS

# INTRODUCTION

Creating exoplanets for an *Eclipse Phase* game can be a chore, especially when you want to create several and have your players choose. While many trips through the Pandora Gates will be to one exoplanet and then back to the Sol system, a campaign focusing on gatecrashing will quickly overtax a busy Game Master.

To remedy this, the tables and steps in *Astrometrics* are provided to make designing an exoplanet or an entire extrasolar system relatively quick and easy. While the tables are presented as rolling options for creating random locations, they can also be used as reference tables for designing systems purposefully.

Whichever way this guide is used, feedback and improvements are welcomed at mephitjames@gmail.com.

## CREDITS

- Material borrowed and converted from the RTT Complicated Star System Generator for *Traveller RPG* and *GURPS Traveller*. This information was originally posted on the ***rpg.net*** wiki.
- The Hertzprung-Russel diagram on page 24 and accompanying text is from the European Space Agency.
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- Fonts used in this document are Heliotype for section headings and **Cambria** for paragraphs and tables.

# CREATING AN EXOPLANET

The classification scheme presented here is based on origin and history, making it rather long but also comprehensive and interesting.

## STEP 1: EXOPLANET GROUP

To determine planetary classifications randomly without worrying about the larger stellar system, use the following table. Note that this chart is balanced for exoplanets with Pandora gates on them. It is not at all indicative of the percentages of planet types in the galaxy.

**Table 1: Random Exoplanet Group**

| d100 Roll | Group |
|---|---|
| **00 – 19** | **Small Body Group:** Very small worlds with negligible gravity such as might be found in the Main Belt or Kuiper Belt. |
| **20 – 44** | **Dwarf Terrestrial Group:** Small, rocky worlds that have enough gravity to maintain a thin atmosphere and support tectonic processes. |
| **45 – 64** | **Terrestrial Group:** Large rocky worlds similar to Earth, Mars, and Venus. |
| **65 – 79** | **Helian Group:** These gas giants have masses between terrestrial worlds and Jovian ones. They are similar to larger gaseous worlds but have unique properties as well. |
| **80 – 94** | **Jovian Group:** These gas giants are massive and composed of either large-scale hydrogen and helium atmospheres or frozen clouds, like Jupiter, Saturn, Neptune, and Uranus. |
| **95 – 99** | **Planemo Group:** These planets are far enough out that they are barely held by the gravity of the stars they orbit, mostly found in a star's Oort Cloud. |

## STEP 2: EXOPLANET CLASS AND TYPE

Within a group, exoplanets are divided into class and then type (sometimes into subtype and rarely into divisions). Once you have found the group that the exoplanet belongs to, choose or roll on the appropriate table in the sections below to find the exact type of exoplanet you are dealing with.

# Small Body Group

These are worlds with less than 0.0001 Earth masses, and thus not massive enough to sustain hydrostatic equilibrium. Typically they are restricted to sizes ranging from a few meters to tens of kilometers across.

| Table 2: Small Body Group | | | |
|---|---|---|---|
| d100 | Type | d100 | Subtype |
| 00 – 33 | Vulcanoidal | | |
| 34 – 66 | Asteroidal | 00 – 20 | Metallic |
| | | 21 – 40 | Silicaceous |
| | | 41 – 60 | Carbonaceous |
| | | 61 – 80 | Gelidaceous |
| | | 81 – 00 | Aggregate |
| 67 – 80 | Passive Comet | 00 – 33 | Oort |
| | | 34 – 66 | Kuiper |
| | | 67 – 99 | Centaur |
| 81 – 94 | Active Comet | 00 – 33 | Active Brevis |
| | | 34 – 66 | Active Dirunitus |
| | | 67 – 99 | Active Effigia |
| 95 – 99 | Damocloid Comet | | |

## Asteroidal Class

These are the archetypical asteroids, small and irregular bodies which are often found in specific belts or fields within a solar system, although they may also be found in eccentric solar orbits.

- **Metallic Type:** Metal-rich, dense objects with a metallic content in excess of 50%. In most systems, these are the least common asteroidal bodies.
- **Silicaceous Type:** Silicate-rich bodies with a silicate content in excess of 50%. These are fairly common in most solar systems.
- **Carbonaceous Type:** Carbon-rich bodies with varying amounts of silicates and metals. They are by far the most common type of asteroid in most systems.
- **Gelidaceous Type:** Commonly called "iceteroids," these are ice-rich bodies with a frozen volatile content greater than 50%. However, unlike the Cometary Class, these bodies are in stable, relatively circular orbits which do not take them close enough to the local sun for volatile-loss.
- **Aggregate Type:** Bodies which are essentially debris piles, held together by mutual gravity; their shapes may change over time, subtly or obviously, due to gravitational flexing. Their composition may vary, but for the most part they tend to be silicate-rich.

## Cometary Class

Bodies with an ice content in excess of 50%, and which can be in orbits which carry them relatively close to their sun, causing volatile depletion and outgassing.

### Passive Type

These are Cometary bodies which remain in distant stellar orbits, or are in the slow process of having their orbits transformed into those which will take them close to the stellar primary.

- **Oort Subtype**: These are dormant bodies which never venture from the outer most regions of their sun's gravity well. Typically located in the Oort cloud, these worlds are nearly unchanged from the time of their initial formation.
- **Kuiper Subtype**: These are dormant bodies which never venture from their local sun's Kuiper belt, and remain relatively unchanged since the time of their initial formation.
- **Centaur Subtype**: Dormant bodies which have been gravitational ejected from either the Oort cloud or the Kuiper belt, and found within the outer planetary region of the system. Their orbits are gravitationally unstable, and will likely become Active Type comets.

### Active Type

These are Cometary bodies which are in orbits that take them fairly close to their stellar primary, resulting in volatile loss. These are the classical comets.

- **ActiveBrevis Subtype** Active bodies with orbits of less than 200 years Standard. They remain gravitationally bound to their stellar primary, but may still be subject to shifting orbits over hundreds of millions of years.

- **ActiveDirunitus Subtype** Active bodies with orbits greater than 200 years Standard, and remaining gravitationally bound to the primary sun.
- **ActiveEffigia Subtype** Cometary bodies in parabolic or hyperbolic orbits; that is, they pass close to their sun (or a sun) once, and are then flung out of the solar system forever.

### Damocloid Type
Cometary bodies that have lost all of their volatiles, and in appearance look quite similar to asteroids. These bodies are typically quite ancient, although some are of average age, but have been trapped within very short period orbits for most of their active lifetimes.

## VULCANOIDAL CLASS
These are rocky bodies in epistellar orbits, and marked by high metallic content. Rare, even unique mineralogical properties may develop because of their long term exposure (on the order of billions of years) to intense stellar radiation. First theoretically proposed by Charles Dillon Perrine in the mid-Twentieth Century.

# DWARF TERRESTRIAL GROUP

Worlds with masses ranging from 0.0001 to 0.15 that of Earth. Most are massive enough to sustain hydrostatic equilibrium and support geological activity due to tidal forces, although the lesser examples are only roughly spherical and tend to be geologically quiescent.

**Table 3: Dwarf Terrestrial Group**

| d100 | Class | d100 | Type | Subtype | |
|---|---|---|---|---|---|
| 00 – 20 | Protothermic | 00 – 25 | ProtoFerrinian | | |
| | | 26 – 50 | ProtoLithian | | |
| | | 51 – 75 | ProtoCarbonic | | |
| | | 76 – 99 | ProtoGelidian | | |
| 21 – 40 | GeoPassive | 00 – 20 | Ferrinian | **Lithic Subtypes** | |
| | | 21 – 40 | Lithic *(roll for subtype)* | 1 – 2 | Janian |
| | | 41 – 60 | Carbonian | 3 – 4 | Hermian |
| | | 61 – 80 | Gelidian | 5 – 6 | Vestian |
| | | 81 – 99 | Stygian | 7 – 8 | Selenian |
| | | | | 9 – 10 | Cerean |
| 41 – 60 | GeoThermic | 00 – 25 | Phaetonic | | |
| | | 26 – 50 | Apollonian | | |
| | | 51 – 75 | Sethian | | |
| | | 76 – 99 | Erisian | | |
| 61 – 80 | GeoTidal | 00 – 10 | Hephaestian | **Promethean Subtypes** | |
| | | 11 – 20 | Hebean | 1 – 2 | EoPromethean |
| | | 21 – 35 | Promethean *(roll for subtype)* | 3 – 4 | MesoPromethean |
| | | 36 – 45 | Lokian | 5 – 6 | BathyPromethean |
| | | 46 – 55 | Idunnian | 7 – 8 | AmuPromethean |
| | | 56 – 65 | Burian | 9 – 10 | ThioPromethean |
| | | 66 – 75 | Atlan | **Plutonian Subtypes** | |
| | | 76 – 90 | Plutonian *(roll for subtype)* | 1 – 3 | Europan |
| | | 91 - 99 | Tritonic | 4 – 7 | Enceladusian |
| | | | | 8 – 10 | Iapetean |
| 81 – 99 | GeoCylic | 00 – 40 | Arean *(roll for subtype)* | **Arean Subtypes** | |
| | | | | 1 – 4 | MesoArean |
| | | | | 5 – 7 | EuArean |
| | | | | 8 – 10 | Arean-Lacustric |
| | | 41 – 59 | Utgardian *(roll for subtype)* | **Utgardian Subtypes** | |
| | | | | 1 – 4 | MesoUtgardian |
| | | | | 5 – 7 | EuUtgardian |
| | | | | 8 – 10 | Utgard-Lacustric |
| | | 60 – 99 | Titanian *(roll for subtype)* | **Titanian Subtypes** | |
| | | | | 1 – 3 | Meso Titanian |
| | | | | 4 – 6 | Eu-Titanian |
| | | | | 7 – 10 | Titan-Lacustric |

## PROTOTHERMIC CLASS

Dwarf protoplanetary bodies which are still in the process of forming. Their surfaces are often partial to completely molten, and their atmospheres are typically thick with hydrogen and helium, as well as gases released by the massive geological activity; they still suffer major impact events. In general, their ages are less than between 10 and 100 million years. Prior to this, the Dwarf

Terrestrial bodies are still accreting mass at a very high rate, and after this point the surface of these worlds, though still occasionally experiencing major impacts, have largely cooled, forming that world's earliest crust.

- **ProtoFerrinian Type:** These are Dwarf Terrestrial bodies which are still in the process of forming, their surfaces extremely hot or even molten. These worlds have a very high metallic content, and will eventually cool down into iron-rich bodies. Typically, these worlds are found in orbit of high mass or high metal stars.
- **ProtoLithian Type:** These are Dwarf Terrestrial bodies which are still in the process of forming, their surfaces extremely hot or even molten. These worlds are composed primarily of silicates, and are common in most systems.
- **ProtoCarbonic Type:** These are Dwarf Terrestrial bodies which are still in the process of forming, their surfaces extremely hot or even molten. They are carbon-rich, and are fairly common, though they tend to appear more in high-massed systems.
- **ProtoGelidian Type:** These are Dwarf Terrestrial bodies which are still in the process of forming, their surfaces hot, with high instances of geological activity. However, they form in the outer regions of a solar system, and so the primary building material is water. Thus they may possess significant atmospheres and even regions of liquid water on their surfaces as well, although as the world ages and cools, the atmosphere and liquid will freeze out, while the heavier silicates and metals will have since sunk to form the body's core.

## GEOPASSIVE CLASS

These are worlds which do not sustain continuous or intermittent geological activity, and whose surfaces are largely unchanged since the early period of planetary formation.

### Ferrinian Type

These are dormant worlds composed primarily of metals, and are most commonly found orbiting F-type and earlier suns, or in high metallicity systems.

### Lithic Type

These are dormant worlds composed largely of silicates. They are common in all star systems.

- **Janian Subtype**: These are worlds tidally locked to their sun. Silicate rich, they also possess nightside ice caps, the result of trapped volatiles either native to the world and coming from the now vanished primary atmosphere, or delivered via cometary impacts over the eons.
- **Hermian Subtype**: These are hot, silicate worlds with large metallic cores and relatively thin crusts. Early catastrophic loss of mass through major impacts early in the world's history are the typical cause for such geological configurations.
- **Vestian Subtype**: These are silicate-rich worlds with ample evidence of a geologically active past, beyond the formation process. They typically possess no atmosphere, and are quite common as moons, or within inner solar system regions which experienced extensive tidal disruption early in the system's history.
- **Selenian Subtype**: These are low metal, silicate-rich worlds, typically formed through the collision of two large bodies during the early formative period of a solar system. In such collisions, the higher massed world will absorb most of the heavy metals, while the lighter materials tend to aggregate into a separate body. As such, these worlds are most often found as moons around much larger bodies. They may also form normally within low metal systems. Those forming via collisions tend to have large amounts of evidence for a brief and active geological phase, the result of the formation of the body and subsequent major impacts. Mature Selenian worlds, however, are almost completely geologically inert, with only the occasional outgassing of volatiles that have been working their way to the surface for hundreds of millions of years. Such outgassing is very brief and locally powerful, but makes little impact on the world in general. Atmospheres are either entirely absent, or transient due to various circumstances, such as major cometary impacts or extremely rare major outgassing events.

- **Cerean Subtype** These are low metal, silicate-rich worlds which possess a significant amount of volatiles, typically in subsurface deposits or geological layers.

### Carbonian Type

These are dormant worlds largely composed of carbon, carbides, or hydrocarbon compounds.

### Gelidian Type

These are dormant worlds largely composed of ices, and are found beyond the snowline.

### Stygian Type

These are Dwarf Terrestrial worlds which have survived the movement of their primary sun off of the main sequence, and its subsequent evolution towards a stellar corpse. The surfaces of these bodies show ample evidence of transformation due to the primary's stellar evolution.

## GEOTHERMIC CLASS

These are worlds which sustain regular or intermittent geological or geothermal activity due to temperature differences caused by highly eccentric orbits.

- **Phaethonic Type:** These are metal-rich worlds which experience intense volcanism as they approach their parent sun at extreme epistellar distances. While the planetary core may not be geologically active, the surface of the world itself is the driving force behind the intermittent geology as the crust continually melts and re-cools. This Type is named after Phaethon of Greek mythology, who drove his solar chariot too close to the Earth, scorching it.
- **Apollonian Type:** These are silicate-rich worlds which experience intense volcanism as they approach their parent sun at extreme epistellar distances. While the planetary core may not be geologically active, the surface of the world itself is the driving force behind the intermittent geology as the crust continually melts and re-cools.
- **Sethian Type:** These are carbon-rich worlds which experience intense hydrocarbon volcanism as they approach their parent sun at extreme epistellar distances. While the planetary core may not be geologically active, the surface of the world itself is the driving force behind the intermittent geology as the crust continually melts and re-cools. This Type is named after Seth of Egyptian mythology, who protected the sun god Ra during his nightly journey through the underworld.
- **Erisian Type:** These are icy worlds which experience cryo-volcanism or crustal evaporation as they move in their elliptical orbit to within the snowline. This Type is named after Eris, the Greek goddess of chaos, as well as the largest example of such a body in the Sol System.

## GEOTIDAL CLASS

These are worlds that sustain continuous geological activity due to tidal flexing. The level of activity can range from nearly constant resurfacing to regular cryo-volcanic outgassing. Some of these worlds are even able to sustain clement environments suitable to the development of simple or complex life.

### Hephaestian Type

These are the most geologically active of planets, with surfaces that are almost entirely molten, and which change constantly. The entire planetary map can be utterly changed within a period less than a year Standard.

### Hebean Type

Named after Hebe, the Greek goddess of youth, these silicate-rich worlds are highly geologically active, but possess large regions of stability as well. The atmosphere can vary in thickness, with standing water typical only for those larger-massed bodies that have a high level of activity and a resulting thick atmosphere. The average age of the surface of these worlds is no more than a few million years old, much like active Terrestrial worlds.

## Promethean Type

These are silicate-rich worlds that, through a naturally balanced amount of tidal flexing, has developed a full geological cycle similar to plate tectonics. Water oceans are a part of this process, and life, even advanced multicellular biomes, can be found on these worlds. From the surface, or from orbit, these planets are indistinguishable from the Gaian worlds. However, the processes which keep them habitable are far different.

- **EoPromethean Subtype**: These worlds are roughly 800 million to 3 billion years in age, possessing a relatively warm and wet alkaline environment, with a thick atmosphere rich in carbon dioxide and methane, along with a hydrocarbon haze.. The first oceans will have formed during the earliest part of this period, as will have the earliest forms of life.
- **MesoPromethean Subtype**: These worlds are roughly 3 and 4 billion years in age, possessing a relatively warm and wet alkaline environment, with a thick atmosphere that has little or no methane, but which remains thick with carbon dioxide. Single-celled simple life forms remain dominant, although towards the end of this period the first multicellular forms will typically begin to appear. Also towards the end of this phase, these life forms will typically begin to infuse large amounts of oxygen into the atmosphere, transforming the entire biosphere.
- **EuPromethean Subtype**: These are Promethean worlds which can be characterized as being "mature", in that their biosphere is fully formed. They possess a rich nitrogen-oxygen atmosphere, and life has come to fill nearly every ecological niche possible. They remain geologically active, and have distinct divisions between terrestrial and oceanic crusts.
- **BathyPromethean Subtype**: These are Promethean worlds which have formed with a large amount of water, the result being that nearly the entire surface if covered by deep oceans. The geological cycle of the world continues normally, however, with the occasional volcanic island or microcontinent being formed before the ocean erodes it away, within only a few tens of millions of years.
- **AmuPromethean Subtype**: These are mature Promethean worlds, but they orbit at a further distance from their sun than other Promethean worlds, and have ammonia as a part of their biosphere. The oceans are heavily infused with ammonia, and the life forms present are reliant upon it as a part of their biochemical makeup. It is the presence of this ammonia which allows the surface water to remain unfrozen.
- **ThioPromethean Subtype**: These are mature Promethean worlds, but they orbit at the furthest distance possible from their sun and remain biologically viable. This is due to the presence of large amounts of methane in the makeup of the planet, from the oceans to the life forms present. However, because of the low temperatures, life may not develop into complex forms for billions of years, possibly taking longer than the main sequence lifespan of their sun.

## Lokian Type

These are the most active of carbon planets, with surfaces that are almost entirely molten, and a geology which changes on an almost yearly basis. They are carbon-analogues to Hephaestian worlds.

## Idunnian Type

Named after Idunn, the Norse goddess of youth, these carbon-rich worlds are highly geologically active, but possess large regions of stability as well. The atmosphere can vary in thickness, with standing liquid ammonia typical only for those larger-massed bodies which have a high level of activity and thus thicker atmospheres. The average age of the surface of these worlds is no more than a few million years old. They are the carbon analogues to Hebean Type worlds.

## Burian Type

These are carbon-rich worlds which, through a naturally balanced amount of tidal flexing, have developed a geological cycle similar to plate tectonics. Ammonia oceans, life, and even advanced biomes can occur on these worlds, and from the surface they are almost indistinguishable from Amunian Type worlds, though the processes which keep them habitable are quite different. They are often considered to be the carbon equivalent of Promethean worlds. Liquid water is not possible on these worlds, even when mixed with ammonia; water ice does occur, and is typically rock-hard, forming the bulk of the crust and mantle.

### Atlan Type

These are icy worlds which, through a naturally balanced amount of tidal flexing, has developed a cryo-geological cycle similar to plate tectonics. Methane oceans, methane-based life, and even advanced biomes can occur on these worlds. On the surface they are almost indistinguishable from Tartarian Type planets, but the processes which keep them habitable are far different. They are considered methane-equivalents to Promethean worlds. Liquid water is not possible beyond thermal regions on these worlds, even when mixed with methane, and instead occurs as granite-hard deposits, forming the bulk of the crust and mantle.

### Plutonian Type

These are tidally stretched icy worlds which exhibit varying degrees of cryo-volcanic and other forms of geological activity. They exist in the outer regions of solar systems, typically as moons to Jovian worlds, although independent bodies may arise as well.

- **Europan Subtype** These worlds are tidally stretched to the point of forming subsurface oceans, which can range from being a thin slushy layer less than a kilometer thick, to great liquid water oceans hundreds of kilometers deep. The surface of the planets are covered with icy crusts, often exhibiting deformations indicative of the oceans below.
- **Enceladusian Subtype** These are tidally stretched icy worlds, their surfaces smooth and relatively crater free due to outgassing of volatiles from subsurface reservoirs. Surface ridges and grooves cover much of the slowly dynamic surface, although there are more stable, cratered regions as well. The reservoirs themselves exist as isolated pockets of semi-liquid water, maintained as such by the slow tidal flexing of the world. Indeed, the tidal flexing which creates these worlds is of a type far less powerful than that which creates Europan worlds.
- **Iapetean Subtype** These are tidally stretched icy worlds, rich in carbon materials, which are marked by extensive upwellings of hydrocarbons. The surfaces of these worlds are typically quite splotchy as the ice contrasts with the extremely dark hydrocarbon sediments. Major rift zones and upwelling regions are also formed by this activity, built up into tremendously tall ridges and mountains by the deposition of the heavier materials.
- **Tritonic Type** These are tidally stretched icy worlds marked by cryo-volcanic outgassing, although most of the surface is geologically stable. The atmosphere varies in thickness, but typically is quite thin, if present at all. Standing bodies of liquid methane are possible, although rare, typically being present only near cryo-thermal regions, and when the atmosphere is thick.

## GEOCYCLIC CLASS

These are worlds which possess an active geology, but which occur on a cyclic basis, often over a span of hundreds of millions of years. The driving force behind this cycle tends to be a slow build up of geothermal energy, resulting in a short active phase following a long quiescent phase. Other mechanisms may also be responsible.

### Arean Type

These are silicate-rich worlds which typically have relatively quiescent planetary cores. Their atmospheres range from thick and volatile-laden to almost vanishingly thin. In their youth they may have begun a system of plate tectonics, but the lack of a permanent presence of liquid water on the surface quickly arrested that, leaving the surface barren. The slow build up of geological energy, however, will eventually lead to much more clement conditions, and may harbor the development of simple life, or even more complex forms if there is enough time. This movement from cold and dry to warm and wet conditions is called a Sisyphean Cycle, and can conceivably be maintained for billions of years.

- **MesoArean Subtype**: These are Arean worlds with intermittent geological activity, with periods of freezing and thawing, as well as massive and sudden floods and the growth of glaciers and ice caps.  They represent the rise to and fall from the height of geological activity in the Sisyphean Cycle.

- **EuArean Subtype:** These Arean worlds are the quiescent, cold, and dry phase of the Sisyphean Cycle.  Their surfaces are barren and will have accumulated a large number of impact craters, while their atmospheres will have largely eroded away to only a thin covering of carbon dioxide.  There may be some residual geological activity, and even pockets of extremophile life, typically deep beneath the surface, but for the most part these worlds can be considered to be "dead".
- **Arean-Lacustric Subtype:** These are Arean worlds at the height of their Sisyphean Cycle, with wet and clement surfaces.  Simple life is abundant, and on those more massive worlds where this phase lasts longer, more complex forms might develop.  The atmosphere is thick with carbon dioxide, powered by the extensive geological activity.  At its height, these worlds may be too warm for polar caps.

## Utgardian Type

These are carbon-rich worlds which have relatively quiescent cores and surfaces rich with ammonia.  Their atmospheres range from thick to only moderately so, never becoming exceedingly thin due to the distances of such worlds from their primary sun, and the ease which cold temperatures retain atmospheric gases.  The slow build up of geological activity brings these worlds from relatively dry conditions to a state where the surface is marked with liquid ammonia seas, rivers, and possibly even ammonia-based life.  This Ragnarokian Cycle alternates over tens of millions of years, sometimes hundreds of millions, and it could indeed last for billions of years.

- **MesoUtgardian Subtype:** These are Utgardian worlds with intermittent geological activity, their surfaces either slowly drying out, or marked by the thawing of ammonia reserves.  They mark the rise and fall from the height of this activity cycle, and thus can have dynamic surfaces.
- **EuUtgardian Subtype**: These are Utgardian worlds which are the quiescent and dry phase of the Ragnarokian Cycle.  Their surfaces are barren, and the lack of activity lends towards the accumulation of impact craters.  The atmospheres will have thinned somewhat due to the lack of surface activity, but because of the cold temperatures typical for their orbital position, they still remain thicker than normal, and are rich in methane.  The surface becomes dominated by Aeolian forces.  Any advanced life that had previously managed to evolve will go extinct, although the more primitive and hardy microscopic forms will remain, typically deep beneath the surface.
- **Utgard-Lacustric Subtype:** These are Utgardian worlds at the height of their activity cycle, and which are resplendent with seas and even oceans of liquid ammonia.  Their atmospheres are quite thick, and the environment is warm, relatively speaking.  Life, largely dormant before hand, will expand across the surface, and given enough time may even diversify into more advanced multicellular forms.  This phase of the cycle may last tens of millions of years, or more, largely depending on world mass and the amounts of heavy metals present.

## Titanian Type

These are carbon-rich worlds which have relatively quiescent cores and surfaces rich with methane.  Their atmospheres, because it is so cold and the gases so easily retained in their distant orbital positions, are almost always thick with methane and hydrocarbons.  A greenhouse effect caused by methane is present, but largely negligible due to the distance from the parent sun.  Over time, and because of the lack of heavy geological activity, the atmosphere may slowly diminish, turning the world into a frozen body over the course of several billion years.  Only renewed activity will reform the greenhouse environment, and the seas will again thaw.  This Titanomalchian Cycle alternates over tens of millions of years, sometimes hundreds of millions, and it could indeed last for billions of years.

- **MesoTitanian Subtype**: These are Titanian worlds with intermittent geological and cryo-volcanic activity, their surfaces either drying out and freezing, or marked by the thawing of methane reserves.  These worlds mark the rise and fall from the height of this cycle, and their surfaces have the potential for being quite dynamic.

- **EuTitanian Subtype:** These are Titanian worlds which are the quiescent and dry phase of the Titanomalchian Cycle.  Their surfaces are barren, and the lack of activity lends itself towards the accumulation of impact craters.  The atmospheres will become less dynamic during this phase, but will experience relatively little loss of mass overall.  The surfaces become dominated by Aeolian forces.  Any advanced life that had managed to evolve during the active phase will likely go extinct, leaving only the more hardy extremophile forms.
- **Titan-Lacustric Subtype:** These are Titanian worlds at the height of their activity cycle, and which are resplendent with seas and even oceans of liquid methane.  Their atmospheres are quite thick with extensive hydrocarbon hazes, and the environment is warm, relatively speaking.  Life has the potential for developing into complex forms, but because of the cold environment, this is not very common.  This phase of the cycle may last tens of millions of years, or more, largely depending on world mass and the amounts of heavy metals present.

# TERRESTRIAL GROUP

These are rocky worlds ranging from 0.02 to 5.0 Earth masses. These worlds are massive enough to clear out their orbital zones and/or sustain continuous geological activity. This activity also maintains a substantial atmosphere.

**Table 4: Terrestrial Group**

| d100 | Class | d100 | Type |
|---|---|---|---|
| 00 – 10 | ProtoActive | 00 – 33 | ProtoLithic |
| | | 34 – 66 | ProtoCarbonian |
| | | 67 – 99 | ProtoGelidic |
| 11 – 20 | Epistellar | 00 – 50 | JaniLithic |
| | | 51 – 99 | Vesperian *(roll for subtype)* |
| 21 – 40 | Telluric | 00 – 50 | Phosphorian |
| | | 51 – 99 | Cytherean |
| 41 – 60 | Arid | 00 – 33 | Darwinian |
| | | 34 – 66 | Saganian |
| | | 67 – 99 | Asimovian |
| 61 – 80 | Tectonic | 00 – 40 | Gaian *(roll for subtype)* |
| | | 41 – 80 | Amunian *(roll for subtype)* |
| | | 81 – 99 | BathyAmunian |
| 81 – 99 | Oceanic | 00 – 33 | Pelagic *(roll for subtype)* |
| | | 34 – 66 | Nunnic |
| | | 67 – 99 | Teathic |

| Gaian Subtypes | |
|---|---|
| 1 | EoGaian |
| 2 | MesoGaian |
| 3-4 | EuGaian *(roll for subdivision)* |
| 5 | BathyGaian |
| 6 | Cholritic Gaian |
| 7 | AmuGaian |
| 8 | ThioGaian |
| 9 | GaianGelidian |
| 10 | Post-Gelidian |

| EuGaian Subdivisions | |
|---|---|
| 1 – 2 | Xeric Gaian |
| 3 – 4 | Campian Gaian |
| 5 – 6 | Paludial Gaian |
| 7 – 8 | Continental Gaian |
| 9 – 10 | Pelagic Gaian |

| Amunian Subtypes | |
|---|---|
| 1 – 3 | EoAmunian |
| 4 – 7 | MesoAmunian |
| 8 – 10 | EuAmunian |

| Pelagic Subtypes | |
|---|---|
| 1 – 3 | EuPelagic |
| 4 – 6 | BathyPelagic |
| 7 – 10 | Pelagic-Gelidian |

## PROTOACTIVE CLASS

These are Terrestrial protoplanetary bodies which are still in the process of forming. Their surfaces are often partial to completely molten, and their atmospheres are typically thick with hydrogen and helium, as well as gases released by the massive geological activity; they still suffer major impact events. In general, their ages are less than between 10 and 100 million years. Prior to this, the Terrestrial bodies are still accreting mass at a very high rate, and after this point the surface of these worlds, though still occasionally experiencing major impacts, have largely cooled, forming that world's earliest crust.

- **ProtoLithic Type:** These are Terrestrial bodies which are still in the process of forming, their surfaces extremely hot or even molten. These worlds are composed primarily of silicates, and are common in most systems. They retain atmospheres of varying densities, rich in hydrogen and helium.
- **ProtoCarbonian Type:** These are Terrestrial bodies which are still in the process of forming, their surfaces extremely hot or even molten. They are carbon-rich, and are fairly common, though they tend to appear more in high-massed systems. Their atmospheres are typically rich with hydrogen, helium, and primordial methane.
- **ProtoGelidic Type:** These are Terrestrial bodies which are still in the process of forming, their surfaces hot, with high instances of geological activity. However, they form in the outer regions

of a solar system, and so the primary building material is water. Thus they may possess significant atmospheres and even regions of liquid water on their surfaces as well, although as the world ages and cools, the atmosphere and liquid will freeze out, while the heavier silicates and metals will have since sunk to form the body's core.

# EPISTELLAR CLASS

These are Terrestrial planets tidally locked to their stellar primary, with surface conditions made dynamic by geological activity, and/or atmospheric dynamics.

## JaniLithic Type

These are rocky, dry, geologically active worlds with greatly varying degrees of geological activity. As such, their atmospheres are also quite varied, but typically are primarily composed of carbon dioxide.

## Vesperian Type

These are silicate worlds with continuous geological activity which may be plate tectonics, or a similar mechanism. Because of their proximity to cooler late k-type or M-type stars, they have temperatures suitable for the development of life. And while a large number of circumstances must be met for these worlds to be life bearing, circumstances which are rare, the sheer number of stars which can host these worlds makes the presence of Vesperian planets only slightly less common than Gaian worlds.

- **JaniVesperian Subtype**: These are atypical, borderline Vesperian worlds with either most of the surface water frozen out on the nightside, or the volatiles having been depleted during the planetary formation process. The native biology is sustained by the thickened atmospheres, but due to the lack of large bodies of water they suffer major climatic extremes. Most of the surface water will be located in the twilight regions, as well as the biomass.
- **EuVesperian Subtype**: These are mature Vesperian worlds which typically support lush biomes. Depending on continental configuration, and the amount of surface water, there may be a nightside ice cap of varying size and thickness. Regardless, the oceans and, to a somewhat lesser extent, the atmosphere aid in evenly distributing the heat of the sun across the globe, leaving only extreme temperatures under the sun and near the nightside polar cap.
- **BathyVesperian Subtype**: These are Vesperian worlds of high temperature and deep oceanic basins, their atmospheres quite dense. Because of this, they tend to have complete cloud cover, and a lack of any sort of nightside ice cap. The atmosphere and ocean tends to evenly distribute global temperatures, although there may be an oceanic "dead zone" near the surface directly underneath the sun. Temperatures in this region can easily reach nearly 250 degrees Fahrenheit.
- **ChloriVesperian Subtype**: These are Vesperian worlds which have biospheres that releases free chlorine through photosynthesis. Such worlds can only form when there is a high percentage of hydrogen chloride in addition to the water present. Such worlds are believed to be exceptionally rare, especially when taken with the relative rarity of Vesperian worlds themselves.

# Telluric Class

These are Terrestrial worlds whose conditions do not support a continuous hydrological cycle of any sort. They are typically subject to major resurfacing by literally cataclysmic events over the course of several hundred million years, although some worlds may continue such resurfacing at a slow but constant pace. Because of the constant geological outgassing, the atmospheres are typically quite dense, and produce major greenhouse effects.

- **Phosphorian Type**: These are the most extreme of Telluric worlds. They form much closer to their sun than other Telluric worlds, and have correspondingly higher temperatures. Because of the extreme solar heat, there is little to no cloud cover, although the atmospheres remain quite dense.
- **Cytherean Type**: These are the archetypical Telluric worlds, their trademark thick atmospheres having been formed by unrelenting geological activity and the buildup of major greenhouse

gases over hundreds of millions of years. While these worlds may form with an appreciable amount of water, the formation of this hothouse environment will eventually cause it all to evaporate and breakdown into its component atoms. Tectonic activity, which may have been in the formative stages, ceases, but the associated geology continues unabated. Eventually the build up of gases produces the incredibly dense atmosphere, while the volcanism thickens the crust, until a point is reached when volcanism may actually become rare. However, a buildup of subsurface pressure is inevitable, and every few hundred million years the surface literally melts as the molten mantle boils up. Once this pressure has been globally released, the process of thickening the crust begins once more.

## Arid Class

These are Terrestrial worlds whose conditions support a limited but continuous hydrological cycle, and quite often an accompanying biosphere. The geological activity of these worlds, coupled with the constant recycling of carbon by that activity, aids in both keeping the planet from freezing, or from evolving into a Cytherean world. Indeed, it is often the evolved biology of the planet which aids in maintaining its habitability.

- **Darwinian Type:** These are Arid worlds with less than 30% surface water coverage, and lacking any kind of plate tectonics. Most of the planet's water is locked up within its biomass, which aids in maintaining global habitability.
- **Saganian Type:** These are ammonia equivalents of Darwinian worlds, the planet's water being mixed with liquid ammonia, the biomass fully adapted and dependent on its presence.
- **Asimovian Type:** These are methane equivalents of Darwinian worlds, the planet's water being mixed with liquid methane, the biomass fully adapted and dependent on its presence. These worlds are found around the dimmer M-type dwarf stars..

## Tectonic Class

These are Terrestrial worlds whose conditions support a continuous hydrological cycle, and quite often an accompanying biosphere. The crust of these worlds are separated into thinner and heavier oceanic crust, and thicker and lighter raised continental crust.

### Gaian Type

These are silicate-rich Tectonic worlds, non-tidally locked, with a continuous geological cycle and often quite geologically active. They tend to be located around stars ranging from F8 V to K3 V, and are often in systems with one or more large outer system Jovians. They are usually attended by one or more large moons, which aids in stabilizing the planet's axial tilt, and thus supports a stable biosphere.

- **EoGaian Subtype:** These are young Gaian worlds, roughly between 800 million and 3 billion years in age, which have rich and thick carbon dioxide and methane atmospheres. The presence of such a thick atmosphere, generated largely by methanogen bacteria, creates a major greenhouse effect and a fairly active water cycle. The atmospheric methane also forms thick layers of hydrocarbons in the upper atmosphere, covering the planet in an orange haze.
- **MesoGaian Subtype**: These are Gaian worlds roughly between 3 and 4 billion years of age, with prominent microbiological ecosystems. The atmospheres of these worlds have been largely cleared of methane, although carbon dioxide remains prevalent. As the present microbiological forms of life become more complex and evolve, however, they begin to release oxygen into the atmosphere, slowly transforming the planet into a EuGaian state.
- **EuGaian Subtype**: These are mature Gaian worlds with fully developed geological, hydrological, and biological systems. Life is usually quite diverse, although there may be cases where evolution beyond simple microbial forms never occurred, simply because there was no environmental pressure to do so. However, even in these cases, the life present produces oxygen and carbon dioxide as a bi-product, making the atmosphere unique and generally friendly for non-native life forms. In short, these are the archetypical "blue marbles" that are so covetously sought after by Humankind.

- **Xeric Gaian Subdivision:** These are warm and dry EuGaian worlds, with 15% or less of the surface covered by standing water. Major desert zones are common, and life tends to remain close to the small ocean and sea basins. Plate tectonics are present, but the relative scarcity of water means that this geological process moves slowly. Less water also means that less carbon dioxide is absorbed and locked away into carbonate rock; as such, the atmospheres are carbon dioxide rich and contribute to the over all higher temperatures of the worlds.
- **Campian Gaian Subdivision**: These are EuGaian worlds with 30 to 50% water coverage, their oceans and seas tending to be quite saline. Climatic extremes are common, and vast inland deserts are not uncommon. Due to the low water table, biomass and atmospheric oxygen is much lower in levels than with other Gaian worlds. The effective absence of an efficient oceanic heat transfer system makes for large temperature differences between the latitudes.
- **Paludial Gaian Subdivision:** These are EuGaian worlds with 30 to 50% water coverage, where land features tend to have low surface relief, forming extensive swamplands, lakes, lushly forested regions, and semi-open woodland. The climate is predominantly oceanic, with relatively open ocean flow and freedom for globe-spanning weather systems to keep a largely homogenous planetary temperature. Polar regions do tend towards glaciation, however. The geographical arrangement is typically due to a decrease in geological activity, and tends to be common for lower mass, older Gaian worlds.
- **Continental Gaian Subdivision:** These are EuGaian worlds with 50 to 80% water coverage, with most of the planet's water concentrated within deep ocean basins. The arrangement of continental plates can create a wide variety of climatic conditions across the globe, and these conditions change constantly as the plates continue to slowly drift over the billions of years of the planet's lifetime.
- **GaianPelagic Subdivision**: These are EuGaian worlds with over 80% water coverage, the continental plates largely submerged. The global climate is even and tends towards the temperate, although various circumstances can swing that climate to either the cold or the hot end of the spectrum. The majority of the terrestrial regions are islands or micro-continents located along rift or convergent zones.

- **BathyGaian Subtype**: These are Gaian worlds which could be regarded as cooler and relatively drier versions of BathyPelagic worlds, or very hot and high surface pressured EuGaian worlds. Superficially they are similar to true Cytherean worlds, their massive atmospheres consisting of carbon dioxide, and their surfaces concealed beneath dense cloud layers. These surfaces are under 10 to 100 bars of pressure and on the order of 200 to 400 degrees Fahrenheit, although the high pressure keeps that water from evaporating. The surface of the planet is covered by a global ocean several kilometers deep. Life is nearly always present, with more complex forms found in the deeper waters. The ocean bottom is barren and largely anoxic, but possesses its own particular set of biomes. Plate tectonics are present, but continental crust is almost entirely missing.
- **ChloriticGaian Subtype**: These are Gaian worlds which are quite rare and tend to be located around warmer G and cooler F-type stars. They typically have little or no complex surface life, with most forms remaining in marine environments. They are marked by the presence of large quantities of integrated chlorine in the environment, which is integral to any biomes present. in appearance, the oceans and clouds are somewhat greenish, while the continents tend to be a somewhat barren brown.
- **AmuGaian Subtype**: These are Gaian worlds with 15 to 85% ammonia ocean coverage and methane-rich atmospheres. Such worlds have cold climates despite the presence of a greenhouse gas, with the ammonia content in the water aiding in keeping them liquid. These worlds are typically found in orbit of cooler K and M-type suns. Life can be present on these worlds, but employs processes to balance the mixed ammonia-water chemistry of their environments.
- **ThioGaian Subtype**: These are Gaian worlds based on sulfur photosynthesis rather than oxygen photosynthesis. The protein S8, which is produced in photosynthesis, is carried to the upper

atmosphere and shields the surface from radiation, while the sulfuric acid which is also produced by this process is used to produce sulfur dioxide by plankton-like faunaforms or microbes, which is then produced by other life forms, which in turn produce carbon dioxide and hydrogen sulfide as a waste product. These are then used by the floraforms to continue the cycle. Such worlds tend to have yellowish skies, and the soil may be stained red from extensive rust deposits.

- **Gaian-Gelidian Subtype:** These are Gaian worlds which have settled into a frozen climatic equilibrium, either due to biological or orbital placement reasons. Complex life, if it develops, or remains extant, tends to be concentrated within subglacial seas. However, if such a world has entered into this state after the evolution of complex life, then that life will have most likely gone extinct. The atmospheres are oxygen-deprived and nitrogen-rich. The air is usually devoid of major cloud formations, and with Aeolian forces being dominant, the land areas will likely be barren of ice as past glaciers will no longer have the means to grow, and their surface areas will be desiccated by the wind.
- **Post-Gelidian Subtype:** These are Gaian worlds which have begun to lose large amounts of surface water, typically due to the beginning of their sun's evolution off of the main sequence. Early stages of this Subtype are worlds with dense, cloud-covered, water-rich atmospheres. Often, plant life will undergo an explosion of diversity and growth. Later examples of these worlds will be largely desert, with very restricted and highly saline seas located in the lowest elevations. Life, if it remains, will be microbial extremophiles.

## Amunian Type

These are carbon-rich worlds, and thus deprived of water, silicates, and other oxygen-bearing compounds. They are rich in carbides, hydrocarbons, and other carbon compounds. The soils of these particular worlds are also rich in nitrogen. Life on these worlds forms not in water, then, which is rock-hard at the temperatures involved, but in liquid ammonia. These worlds are found around M and K-dwarf suns, as the ultraviolet flux of anything greater would break down the planetary supply of ammonia. The term Amunian is derived from the Egyptian god Amun, from which the word 'ammonia' comes from.

- **EoAmunian Subtype** These are young Amunian worlds, having an atmosphere of gaseous ammonia, methane, and small amounts of water droplets. As the planet ages and cools, these components will be broken down into nitrogen, carbon monoxide, and a hydrocarbon 'tar' that will rain down on the surface. Ammonia oceans will condense on the surface during this period, and the earliest forms of life will develop. These organisms will be acidophilic due to the presence of dissolved water, but they will begin converting the present oxygen into sulfur dioxide as a part of their metabolic processes.
- **MesoAmunian Subtype** These are Amunian worlds which have cooled, their atmospheres composed almost entirely of nitrogen and carbon monoxide. The primitive life present will begin to use a hydrogen-methane cycle, thus increasing the amount of methane within the atmosphere. Cycles which incorporate nitrogen and carbon monoxide will also be used and eventually incorporated into the growing planetary ecology. As levels of methane increase the planet will once again begin to warm.
- **EuAmunian Subtype** These are Amunian worlds which are often considered to be ammonia analogues of Gaian worlds. They possess plate tectonics, a dynamic climate, and sometimes an advanced biosphere. There are, however, differences in climate, hydrology, meteorology, and geology, all of which are significant. They are colder than Gaian worlds, forming beyond the habitable zone of their sun, but still receive enough energy to melt ammonia. Because ammonia ice is more dense than liquid ammonia, polar caps are located beneath the polar oceans. In appearance they are greener than Gaian worlds, because of the gases involved, and their atmospheres tend to be dense and rich in nitrogen, with significant amounts of methane and hydrogen.
- **BathyAmunian Subtype** These are Amunian worlds with much stronger greenhouse effects than EuAmunian worlds. The atmospheres are very dense that retain large amounts of carbon monoxide and 'humid' with ammonia. These worlds are capable of supporting liquid ammonia at higher temperatures because of the greater atmospheric pressure. These atmospheres may

contain significant amounts of volcanic and possibly sulfuric gases, depending on the inherent geological activity of the planet. Large portions of the extant biomass will be located in the upper atmosphere, where it is cooler, as well as within the oceans and seas. Such organisms are considered to be extremophiles by the standards of the rest of the planet. The extreme worlds, highest in pressure, can actually support liquid ammonia at temperatures which are more common on EuGaian worlds.

### Tartarian Type

These are worlds rich in methane and carbon compounds. Life on these worlds forms not in water, which is rock hard at the temperatures involved, but in liquid methane. These worlds are found around dimmer suns, or in the outer regions of Solar-type suns.

- **EuTartarian Subtype:** These are Tartarian worlds which are often considered to be methane analogues of Gaian worlds. They possess plate tectonics, a dynamic climate, and sometimes an advanced biosphere. There are, however, differences in climate, hydrology, meteorology, and geology, all of which are significant. They are colder than Gaian worlds, forming beyond the habitable zone of their sun, but still receive enough energy to melt methane, and their atmospheres tend to be dense and rich in nitrogen, with significant amounts of methane and hydrogen.

## Oceanic Class

These are Terrestrial worlds whose conditions support a continuous hydrological cycle with a global ocean that is tens of kilometers deep, many of which support advanced biospheres. The geological processes involved tend to be more related to Telluric or Arid than Tectonic worlds.

### Pelagic Type

These are geologically active silicate worlds covered with a global ocean. They are typically found around warm K to cool F-type suns.

- **EuPelagic Subtype** These are Pelagic worlds with hundreds of times the water found on EuGaian worlds. The atmospheres are oxygen rich due to several ocean-related factors. Some worlds have an oxygen content in excess of 90%.
- **BathyPelagic Subtype** These are Pelagic worlds with the highest amounts of water, their global oceans tens to hundreds of kilometers deep, their atmospheres extremely dense. The surface temperature can reach into the hundreds of degrees Fahrenheit, but the intense atmospheric pressure keeps the ocean liquid, and also serves to keep it from boiling away. Indeed, the surface evaporation and re-condensation is so high that the demarcation line between ocean and atmosphere is difficult to determine.
- **PelagicGelidian Subtype** These are Pelagic worlds with their crusts frozen over due to a variety of reasons, most often a dimming sun. Tidal or subsurface geological stresses often create cracks in the global ice coverage, allowing a thin atmosphere of oxygen and nitrogen to form. Were it not for constant replenishment from these rifts, the atmosphere would desiccate within a few million years.

### Nunnic Type

These are geologically active worlds covered in global oceans of liquid ammonia.

### Teathic Type

These are geologically active worlds covered in global oceans of liquid methane.

# HELIAN GROUP

These are worlds with 3 to 17 Earth masses, enough to retain helium atmospheres.

| Table 5: Helian Group | | | |
|---|---|---|---|
| d100 | Class | d10 | Type |
| 00 – 33 | Panthalassic | | |
| 34 – 66 | Nebulous | 1 – 5 | GeoNebulous |
| | | 6 – 10 | CryoNebulous |
| 67 – 99 | GeoHelian | 1 – 2 | Halcyonic |
| | | 3 – 4 | Hyoperionic |
| | | 5 – 6 | Thetusean |
| | | 7 – 8 | Metusean |
| | | 9 – 10 | Solarian |

## GEOHELIAN CLASS

These are Helian worlds with masses ranging from 3 to 15 times that of Earth, and which lack a layer of liquid or super-condensed volatiles, having either expended them long ago, or never having had them to begin with. Older, more stable regions may be heavily cratered, but much of the surface of these worlds tends to be geologically young.

- **Halcyonic Type:** These are silicon-rich GeoHelian worlds in tight solar orbits, their masses ranging from 5 to 15 times that of Earth. There is substantial surface volcanic activity, and though the atmosphere is quite dense, it is relatively cloudless due to the extremely high temperatures. The surface is thus visible from space, but still partially obscured by the sheer thickness of the atmosphere, which from space appears as a blue haze, especially pronounced along the limb of the planet.
- **Hyperionic Type:** These are silicate-rich GeoHelian worlds with masses ranging from 5 to 13 times that of Earth. There is substantial surface volcanic activity, and a large greenhouse effect which is slightly off-set by a cloudy atmosphere of yellowish sulfuric acid or water clouds. The surface is extremely hot, and well outside the range for life.
- **Thetusean Type:** These are carbon-rich GeoHelian worlds in tight solar orbits, their masses ranging from 5 to 15 times that of Earth. There is substantial surface volcanic activity, and the atmosphere is quite dense and thick with dark clouds of hydrocarbon soot. The surface is extremely hot due to a combination of a very strong greenhouse effect and the low albedo of the hydrocarbon clouds.
- **Metusean Type:** These are carbon-rich GeoHelian worlds with masses ranging from 4 to 13 times that of Earth. There is substantial surface volcanic activity, and a large greenhouse effect which is slightly off-set by a cloudy atmosphere of white water, brown ammonium hydrosulfide, or cream-colored ammonia clouds. The surface is extremely hot, and well outside the range for life, although there may be lakes or even oceans of thick hydrocarbon tar.
- **Solarian Type:** These are carbide-rich GeoHelian worlds in tight solar orbits, their masses ranging from 5 to 15 times that of Earth. There is substantial surface volcanic activity, and though the atmosphere is quite dense, it is relatively cloudless due to the extremely high temperatures. The surface is thus visible from space, but still partially obscured by the sheer thickness of the atmosphere, which from space appears as a reddish haze, especially pronounced along the limb of the planet.
- **Thean Type:** These are ice-rich GeoHelian worlds with masses ranging from 3 to 10 times that of Earth, and are located beyond the snowline of their solar system.

## NEBULOUS CLASS

These are Helian worlds with masses ranging from 3 to 15 times that of Earth. Their atmospheres are extremely dense and support a layer of super-condensed volatiles.

- **GeoNebulous Type** These are Nebulous worlds with masses ranging from 5 to 15 times that of Earth. These are extremely hot worlds composed primarily of silicates, their thin crusts riddled with tectonic activity. This activity may be of the degree that there are entire lakes or seas of magma. Within a matter of years, the surfaces of these worlds can be completely turned over. The atmospheres are thick and dense, supporting a massive greenhouse effect and sometimes comprising up to 10% of the planet's mass.

- **CryoNebulous Type** These are Nebulous worlds with masses ranging from 4 to 10 times that of Earth. These worlds form beyond the snowline and are composed of a roughly equal mixture of ice and rock. Due to their mass their crusts are thin and riddled with cryovolcanic activity, which serve to keep their surfaces fairly smooth. The atmospheres are thick and dense, sometimes comprising up to 10% of the planetary mass.

## PANTHALASSIC CLASS

These are Helian worlds with masses ranging from 3 to 13 times that of Earth. They are actually best described as aborted gas giants, having initially begun their formation beyond their solar system's snowline. However, tidal dragging caused by interactions with the accretion disk caused them to migrate inward of the snowline, where their growth was slowed or halted due to the sudden lack of abundant icy materials (which swiftly feed the growth of Jovian worlds). However, being composed of largely icy materials, they develop tremendously deep oceanic surfaces and thick atmospheres of water, hydrogen, and oxygen.

# JOVIAN GROUP

These are worlds with masses ranging from 10 to 4,000 times that of Earth, an equivalent of 0.03 to 13 times that of Jupiter. They have thick hydrogen and helium envelopes, which have given them the nickname of 'gas giants'. Their cores are composed of rock and ice, and can themselves range from less than an Earth mass to several.

| Table 6: Jovian Group | | | |
|---|---|---|---|
| **d100** | **Class** | **d10** | **Type** |
| 00 – 22 | Dwarf-Jovian | 1 – 3 | Osirian |
| | | 4 – 5 | Brammian |
| | | 6 – 7 | Khonsonian |
| | | 8 – 10 | Saturnian |
| 23 – 44 | MesoJovian | 1 – 5 | Junic |
| | | 6 – 10 | Jovic |
| 45 – 66 | Super-Jovian | 1 – 5 | SuperJunic |
| | | 6 – 10 | SuperJovic |
| 67 – 88 | SubJovian | 1 – 3 | Sokarian |
| | | 4 – 6 | Poseidonic |
| | | 7 – 10 | Neptunian |
| 89 – 99 | Cthonian | | |

## SUBJOVIAN CLASS

These are Jovian worlds with masses ranging from 0.03 to 0.48 times that of Jupiter. While they have the typical dense atmosphere of hydrogen and helium, a large portion of their mass is taken up by a large ice and rock core. Some of these worlds will possess a compressed liquid water oceanic mantle.

- **Sokarian Type**: These are SubJovians in tight solar orbits whose upper atmospheres are largely filled with silicate clouds. Extreme examples may actually be too hot to support upper cloud layers at all.
- **Poseidonic Type**: These are SubJovians which orbit within the snowline, and which possess large amounts of water vapor in their atmospheres.
- **Neptunian Type**: These are SubJovians which orbit beyond the snow line, often marked by relatively quiet upper atmospheres, overlain by a methane haze, lending a blue to green color to the planet. Near upper atmospheric layers may be quite volatile, however, being driven more by the internal heat of the planet than by any solar energy received.

## DWARF-JOVIAN CLASS

These are Jovian worlds with masses ranging from 0.06 to 0.8 times that of Jupiter. The greatest portion of their masses are concentrated within their gaseous envelopes, but they still have a low enough gravity to swell from stellar heating. The more massive examples will have layers of liquid metallic hydrogen or helium surrounding their cores.

- **Osirian Type**: These are DwarfJovians in tight solar orbits whose upper atmospheres are largely filled with silicate clouds. Extreme examples may actually be too hot to support upper cloud layers at all.
- **Brammian Type**: These are DwarfJovians which orbit within the snowline, and have large amounts of water within their atmospheres. Of all the Jovians to be found in this orbital region, these are the most likely to develop atmospheric-based life, although it rarely evolves past simple microbial forms.
- **Khonsonian Type:** These are DwarfJovians which orbit just outside of the snowline, and thus have a low instance of water within their atmospheres. However, they are ammonia-rich, and their upper atmospheres are highly altered by the presence of ammonia-based life.
- **Saturnian Type**: These are DwarfJovians which orbit beyond the snowline, and which possess dynamic atmospheres, though they are often obscured by methane and ammonia.

## MESOJOVIAN CLASS

These are Jovian worlds with masses ranging from 0.7 to 2.5 times that of Jupiter. The greatest portion of their masses are concentrated within their gaseous envelopes, and they have high cloud surface gravities. There are layers of metallic liquid hydrogen surrounding their planet-sized cores, which are composed of metals, carbon, and ices. The atmospheres of these worlds are almost always turbulent and lacking any haze layer of consequence.

- **Junic Type**: These are MesoJovian worlds in tight solar orbits whose upper atmospheres are largely filled with silicate clouds.  Extreme examples may actually be too hot to support upper cloud layers at all.
- **Jovic Type**: These are MesoJovian worlds which orbit beyond the snowline, and which possess dynamic atmospheres.

## SUPER-JOVIAN CLASS

These are Jovian worlds with masses ranging from 2.5 to 13 times that of Jupiter; this is enough mass to compress their cores into electron-degenerate matter.  Despite their great masses, the sizes of these worlds rarely extend much beyond that of Jupiter; the notable exceptions are those which experience atmospheric expansion from extreme solar heating.

- **SuperJunic Type:** These are SuperJovian worlds in tight solar orbits whose upper atmospheres are largely filled with silicate clouds.  Extreme examples may actually be too hot to support upper cloud layers at all.
- **SuperJovic Type:** These are SuperJovian worlds which orbit beyond the snowline, and which possess dynamic atmospheres.

## CHTHONIAN CLASS

These are Jovian worlds with masses ranging from 0.015 to 0.24 times that of Jupiter.  They are the exposed cores of Jovian worlds which have lost their gaseous envelopes through solar evaporation.  This typically occurs to older Jovians in tight solar orbits, or Jovians that have been greatly affected by the evolution of their primary sun.

# PLANEMO GROUP

These are planetary-massed objects which are not gravitationally bound to any star, and are found in the deeps of interstellar space. Some such worlds may have formed naturally without a sun, while others were gravitationally ejected from their home systems.

| Table 7: Planemo Group | |
|---|---|
| **d100** | **Type** |
| 00 – 20 | Hauhetean |
| 21 – 40 | Nyxian |
| 41 – 60 | Stevensonian |
| 61 – 80 | Kauketean |
| 81 – 99 | Odyssian |

- **Hauhetean Class:** These are Planemo worlds which retain their hydrogen and helium primary atmospheres, but whose masses are not great enough to maintain an internal geology.
- **Kauketean Class:** These are Planemo worlds which maintain an atmosphere dense enough to create scorching surface conditions through trapped geothermal heat. However, they are not massive enough to be considered Odyssian worlds.
- **Nyxian Class:** These are Planemo worlds which are not massive enough to retain their primary hydrogen-helium atmospheres. Some such worlds have a secondary atmosphere formed by volcanic outgassing, if they are massive enough to maintain such activity.
- **Odyssian Class:** These are Planemo worlds which retain massive hydrogen-helium envelopes. They are, essentially, rogue gas giants.
- **Stevensonian Class:** These are Planemo worlds which maintain a dense atmosphere which traps heat from internal geological activity, which creates pockets of habitability on the surface. Some such worlds are heated to an extent that the entire surface may be habitable.

# STEP 1: STELLAR SYSTEM

Stellar systems can be one star with planets orbiting or multiple stars orbiting each other with planets in complex orbits around them. For that matter, they can also be complex clouds of debris around newly-formed stars or blasted husks of planets surrounding an old and dying star.

| Table 1: Star Systems | |
|---|---|
| **d100** | **Number of Stars** |
| 01 – 50 | Single |
| 51 – 80 | Binary |
| 81 – 00 | Trinary |

To start building an exoplanet, you need to start with the stellar system it can be found in. Roll 1d100 and consult **Table 1** to see how many stars are found in the system. In binary or trinary systems, one star will be the larger, "primary" star and the other(s) will be smaller, "companion" stars. Stars evolve and change according to a pattern called the Main Sequence. The majority of stars in the galaxy fall along this trend (illustrated on the famous Hertzprung-Russel diagram on the next page) but others are more massive and cooler than others of the same luminosity (Giants and Supergiants) while others are less massive and dimmer than others of the same temperature (Dwarf Stars).

| Table 2: Stellar Classification | |
|---|---|
| **d100** | **Spectral Type** |
| 01 – 06 | O, B, or A |
| 07 – 13 | F |
| 14 – 20 | G |
| 21 – 30 | K |
| 31 – 75 | M |
| 76 – 90 | L or T |
| 90 – 91 | C or S |
| 92 – 97 | D |
| 98 | Neutron Star |
| 99 | Black Hole |
| 00 | Exotic Star |

*This is for Main Sequence primary stars in a system. Add 2d10 to the roll to determine each companion's type.*

Stars are classified using the letters *O, B, A, F, G, K,* and *M* with the letters *L* and *T* reserved for red dwarfs and Brown Dwarfs respectively. To determine the spectral type of the primary star in the system, roll 1d100 and consult **Table 2: Stellar Classification**. If the primary has any companions, they will tend to be farther along the Main Sequence due to losing mass to their larger neighbor. Roll 2d10 and add it to your roll for the primary star's classification to determine the stellar type of the companion(s).

Brief descriptions of each type of star can be found below.

- **O-Type and B-Type Stars:** The hottest and brightest of stars, these stars tend to bathe their systems in harsh ultraviolet radiation. Many of them are also supergiants, burning through their cores very quickly and leaving the Main Sequence behind. They tend to be in star-rich areas as they have little time to move farther away during their short lives. *Example:* Rigel (β Orionis).
- **A-Type Stars:** The most common naked eye stars, they are the brightest and hottest of those that follow the Main Sequence. They are young and have considerable radiation, as well as a pure bluish-white light. *Examples:* Vega (α Lyrae), Deneb (α Cygni).
- **F-Type Stars:** Bright and hot stars, F-Types are nonetheless calmer than hotter stellar types. Transhumans still need radiation shielding to survive on the surface of any planets but they are

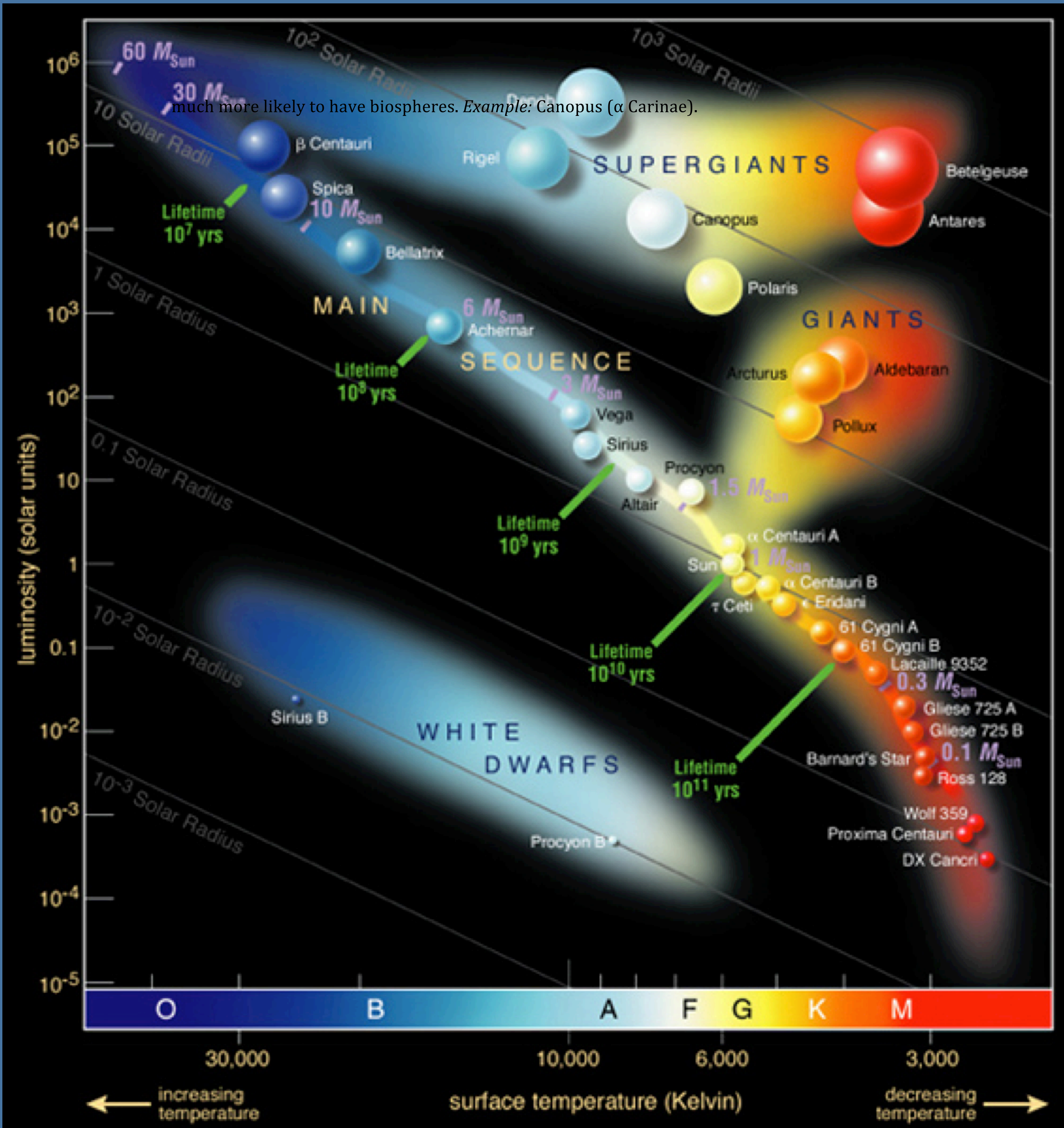
## SolArchive: Naming Stars

Stars often have names from historical sources (such as those named in Greco-Roman legend or those catalogued by Arabic astronomers) and others have nicknames and colloquial titles (such as the Dog Star or the Barnard's Star). These names make it easier to remember the stars, but they aren't the most precise naming system.

Since the 17th century, astronomers have preferred to name stars for the constellation they are found in (using the Latin possessive case) and the order of brightness (designated by a Greek letter).

This leads to names like Alpha Centauri (the brightest star in the Centaur constellation) , Beta Orioni (the second-brightest star in Orion and better known as Rigel), and Gamme Pegasi (the third-brightest star in Pegasus). For particularly dim stars, Roman lettering is used after the Greek alphabet first lower-case and then upper case (so z Carinae is brighter than A Carinae but they are both much, much dimmer than Omega Carinae).

much more likely to have biospheres. *Example:* Canopus (α Carinae).




## Hertzprung-Russel Diagram

In the Hertzprung-Russell diagram the temperatures of stars are plotted against their luminosities. The position of a star in the diagram provides information about its present stage and its mass. Stars that burn hydrogen into helium lie on the diagonal branch, the so-called main sequence. Red dwarfs like Barnard's Star lie in the cool and faint corner. Barnard's Star has itself a temperature of about 3 000 Kelvins and a luminosity which is 0.04% that of the Sun. When a star exhausts all the hydrogen, it leaves the main sequence and becomes a red giant or a supergiant, depending on its mass (Barnard's Star will never leave the main sequence since it burns so little hydrogen). Stars with the mass of the Sun which have burned all their fuel evolve finally into a white dwarf (left low corner).

- **G-Type Stars:** These are the most familiar stellar systems to transhumans since the Earth's Sun is a G-Type star. This broad category takes up a significant portion of a star's time in the Main Sequence, although this phase is actually extremely *unstable* and therefore short for supergiants. Habitable zones are similar to the Sol system (for one-star systems) and the age of the system and low radiation levels both mean that life is much more likely. *Examples:* Sol, Alpha Centauri
- **K-Type Stars:** The orange light of these stars is similar in many ways to that produced by G-Types (low frequency and so less harmful radiation) but many transhumans describe conditions on orbiting planets as feeling like "constantly evening." This is normally a relatively short phase for a star, although it can be longer for K-Type giants and supergiants. *Examples:* Pollux (β Geminorum), Arcturus (α Boötis; giant).
- **M-Type Stars:** These stars are by far the most common in the galaxy, representing about 76% of the Main Sequence stars in the volume within 15 light years of Earth. Most of these, however, are red dwarfs which will eventually cool further to be L-, T-, C-, or S-Type stars. A number of others, though, are red giants and supergiants who make up for their low energy-output with sheer volume. Because stars swell towards the end of their lives, M-Types will be much, much larger than when they were G-Type stars, meaning that formerly inhospitable planets are now thawed and comfortable while formerly pleasant planets are now burned husks if not within the star itself. *Examples:* Proxima Centauri (red dwarf), Antares (α Scorpii; supergiant) Betelgeuse (α Orionis; giant).
- **L-Type or T-Type Stars:** Brown dwarf stars (the hotter of which are called red dwarfs) are small and cool bodies, some of them even too small to support fusion of any appreciable amount. Any stellar systems with brown dwarf primaries will probably eventually collide into a Main Sequence star of a more impressive stellar class. Any planets surrounding a brown dwarf will be very poorly lit and extremely cold: even the close planets will be similar to living in the Outer System. L-Types are the hotter type, with significant metal compounds in their spectra, and T-Types are the cooler ones, also frequently called "methane stars."
- **C-Type and S-Type Stars:** These dim, cool stars are the remains of red giants near the end of their lives. C-Types (called carbon stars and at one point designated R- and N-Types) have an excess of carbon in their atmospheres that result in a deep, ruby-red color. By contrast, the slightly hotter S-Type stars have spectra dominated by zirconium at the expense of carbon, leading to lighter red colors though much dimmer than M-Types. Both of these stellar types are still giants but they have begun to retract meaning that the close planets have been baked and sterilized and are now in the process of being frozen as the star's energy runs out for good.
- **D-Type Stars:** Whereas brown dwarfs are cool and barely-burning cinders, white dwarf stars are bright and hot despite being small. For close planets they can have plenty of light and heat but those conditions fall off fairly quickly with increasing orbits. They are much more common as companion stars, however. *Example:* Sirius B, Procyon B.
- **Black Hole:** The infamous danger of deep space, these are the collapsed remnants of stars that have reached the end of their lifespans. The mass of the stellar remnant is so compacted that it's effectively infinitely dense, resulting in the pinpoint phenomenon called a singularity which warps space around it enough to prevent everything, including light, from escaping.
- **Neutron Star:** When a star collapses and its mass isn't sufficient to produce a black hole, the result instead is a superdense body composed entirely of neutrons (as the electrons and protons are forced together). When they spin, the poles emit beams of electromagnetic radiation and the cycling signal is detected as a pulsar.
- **Exotic Stars:** Before travel through Pandora Gates, these were only theoretical bodies. However, Pathfinder researchers have released data confirming that at least one system has been discovered (though the encounter destroyed the probe). These compact stars are composed of exotic matter including quarks (as in the case of the confirmed system), preons (theoretical sub-quark particles), and even antimatter.

# STEP 2: SYSTEM AGE

The age of the star system determines a lot about what gatecrashers might expect to find there. Stars will age, dim, and collapse given time, leading to severe changes for the planets orbiting them and changing conditions for gates located in that system.

Starting with the stellar type your determined in the last step, roll the age of your system and consult **Talble 3** to see how the star has evolved.

- **O-, B-, and A-Type Stars** will be 1d10 / 2 billion years old.
- **F- and M-Type Stars** will be 1d10 billion years old. For an M-Type star with companions, add +2 for each companion star.
- **G- and K-Type** will be 1d10+3 billion years old.
- **L-, T-, C-, and S-Types as well as Black Holes, Neutron Stars and Exotic Stars** will be 1d10+5 billion years old. The maximum age is 13.5 billion years, the age of the universe.

These rolls will give you ages in line with a 21st century understanding of stellar evolution, but don't feel tied to it. First of all, scientists might have a very different view of things in the post-Fall era. Even things as fundamental as the age of the universe could be called into question with a new observation or test and there are sure to be a lot of those as transhumanity moves out into the solar system.

**Table 3: Age of Stellar System**

To determine the system's age, roll 2d10. This will give the age in billions of years; use this to determine the system's luminosity class and final spectral type.

| Stellar Class | Age | Final Type |
|---|---|---|
| **O- or B-Type** *1d10 / 2 billion years* | Age ≤ 2 | **O-Ia to O-Ib:** Bright supergiant. |
| | Age = 2 | **B-Ib:** Bright blue supergiant. |
| | Age ≥ 3 | **M-Ib:** Red supergiant. |
| **A-Type** *1d10 / 2 billion years* | Age ≤ 2 | **A-V:** Bright white main-sequence star. |
| | Age = 3 | **Roll 1d10** |
| | | ***1-3*** **F-IV:** White-yellow subgiant. |
| | | ***4-5*** **K-III:** Orange giant. |
| | | ***6-10*** **D:** White dwarf. |
| | Age ≥ 4 | **D:** White dwarf. |
| **F-Type** *1d10 billion years* | Age ≤ 5 | **F-V:** White-yellow main-sequence star. |
| | Age = 6 | **Roll 1d10** |
| | | ***1-5*** **G-IV:** Yellow subgiant. |
| | | ***6-10*** **M-III:** Red giant. |
| | Age ≥ 7 | **D:** White dwarf. |
| **G-Type** *1d10 + 3 billion years* | Age ≤ 8 | **G-V:** Yellow main-sequence star. |
| | Age = 9-10 | **Roll 1d10** |
| | | ***1-3*** **K-IV:** Orange subgiant. |
| | | ***4-10*** **M-III:** Red giant. |
| | Age ≥ 11 | **D:** White dwarf. |
| **K-Type** *1d10 + 3 billion years* | | *Automatically K-V* |
| **M-Type** *1d10 billion years* *+2 for each companion star* | Age = 1-7 | **M-V:** Red main-sequence. |
| | Age = 8-10 | **M-Ve:** Hot red main-sequence. |
| | Age = 11+ | **L:** Brown dwarf. |
| **D, L, T, C, S, Black Holes, Neutron Stars, and Exotic Stars** *1d10 + 5 billion years* | | *Type Unchanged.* |

Secondly, gatecrashing is not about heading out into a neat and tidy universe to find things that confirm one's understanding of physics and astronomy. Things are weird out there, starting with the gates themselves, and finding a star that older than the universe or a white dwarf star only 500 million years old are just par for the course really.

**Table 4: Luminosity Classifications**

| Class | Description | Class | Description |
|---|---|---|---|
| 0 or Ia+ | Extremely luminous supergiants | II | Bright giants |
| Ia | Luminous supergiants | III | Normal giants |
| Iab | Intermediate luminous supergiants | IV | Subgiants |
| Ib | Less luminous supergiants | V | Main-Sequence Stars |

A special luminosity class only for red stars is Ve. An M-Ve star is a main sequence star with hydrogen emission lines, meaning that it is still fusing hydrogen even though it is nearing the end of its life. These are brighter and hotter than M-V stars, though still relatively dim compared to other main-sequence stars.

## Companion Stars

| Table 5: Companions | |
|---|---|
| **d10** | **Companion Orbits** |
| 1 – 3 | Tight Orbit |
| 4 – 6 | Close Orbit |
| 7 – 8 | Moderate Orbit |
| 9 – 10 | Distant Orbit |

Binary and trinary systems are collections of multiple stars all of the same age. You don't need to roll for the age of the companion stars, just use the same age as the primary star. You'll use the stellar classification from Step 1, however, for the companions meaning that you'll usually end up with different results with the same age.

The important part for the character of the system as a whole is the orbit of the companions. Rather than being specific with distances (which can be worked out later if strictly necessary) you just want to know if the companion star is close to it's primary, far away, or something in the middle. Roll 1d10 and consult **Table 5** for the size of the orbit. Tight or close orbits (depending on the size difference between the two stars) might mean that the larger primary is pulling material out of its companion (growing bigger and leading to a fan of plasma called an accretion disk) while a distant orbit might mean that they are effectively two solar systems that just happen to be close enough to fly a conventional spaceship between easily.

# Step 3: Planetary System Generation

This is where the main focus of the game will be so it's worth taking your time to make interesting and detailed planets. Start big: what sort of orbit does the planet occupy? Like the final stellar type of a star, this process starts with the stellar type to see what's reasonable. Keep this in mind and consult **Table 6** for each of the three orbital zones. Because conditions depend greatly on the star that the planet is orbiting, zones tend to be measured in solar radii (0.005 AU for the Sun).

| Table 6: Number of Planets | |
|---|---|
| *Epistellar Orbits* | • Dwarf stars (D, L, T, C, and S), black holes, neutron stars, and exotic stars: 0 planets.<br>• M-V Stars: 0-1 planets<br>• All Others: 0-2 planets<br>• If Tight Companion is present, automatically 0 planets. |
| *Inner Zone Orbits* | • 1d10 / 2 planets<br>• M-V Stars have a -1 modifier<br>• L-Type Stars instead roll 1d10 / 4<br>• If Close Companion is present, automatically 0 planets. |
| *Outer Zone Orbits* | • 1d10 / 2 planets<br>• M-V and L-Type Stars have a -1 modifier<br>• If Moderate Companion is present, automatically 0 planets. |

- **Epistellar Orbits** are those planets orbiting extremely close to their stars, generally within 100 radii. Usually they have had their atmospheres blasted away (like Mercury) or it's in the process of being removed by stellar winds. At this distance, even low-energy stars can put out deadly amounts of radiation. If a star expands at the end of its life (into a M-V red giant) this typically destroys all close planets.
- **Inner Zone Orbits** were classically thought to contain only rocky planets like Earth, Mars, and Venus. Since the discovery and cataloging of exoplanets, however, it has been seen that many other systems have gas giants in their Inner Zone. This zone is generally agreed to be between 100 radii and 1,000 radii but the actual distances are subject to a lot of variation from system to system.
- **Outer Zone Orbits** are the undisputed home of gas giants, both the great, energetic storm systems of Jupiter and Saturn as well as the icy clouds of Uranus and Neptune. Farther out are icy clouds which form the Kuiper Belt in transhumanity's home system. Those stars with companions in Distant Orbits will have fewer icy bodies in these orbits because they have another energy source relatively nearby to melt and disperse comets and iceteroids.

Companion stars can disrupt all of this, however. If a primary has a companion in a Tight Orbit, that will sweep the Epistellar Orbital zones of planets and the same is true of Inner Zone and Outer Zone orbits with Close and Moderate Companions respectively. Distant Companions have enough room to host their own planetary system and should use **Table 6** independently of their primary star to see what is orbiting that companion.

Once you know how many planets are in each orbital zone, roll 1d10 for *each orbit* and consult **Table 7** to see what is in that orbit. A follow up roll of 1d10 will give even more details.

**Table 7: Orbital Contents**

| d10* | Type | | |
|---|---|---|---|
| 0 – 2 | Asteroid Belt | 1 – 4 | All members are small bodies. |
| | | 5 – 8 | Most members are small bodies but there is one dwarf planet. |
| | | 9 – 10 | Most members are small bodies but there are 1d10 / 2 dwarf planets. |
| 3 – 4 | Dwarf Planet | 1 – 5 | No major satellites |
| | | 6 – 8 | One dwarf planet as binary companion |
| | | 9 – 10 | Multiple dwarf planet companions (1d10 / 2) |
| 5 – 7 | Terrestrial Planet | 1 - 4 | No major satellites |
| | | 5 – 6 | One dwarf planet satellite |
| | | 7 - 8 | Multiple dwarf planet satellites (1d10 / 2) |
| | | 9 - 10 | Small terrestrial planet companion. |
| 8 | Helian Planet 1d10 – 5 Satellites | 1 - 5 | All satellites are dwarf planets |
| | | 6 – 8 | One of the satellites is a terrestrial planet, the rest are dwarf planets. |
| | | 9 – 10 | Several of the satellites of the terrestrial planets, the others are dwarf planets. |
| 9 - 10 | Jovian Planet 1d10 / 2 Satellites | | **Satellites** |
| | | 1 – 7 | All satellites are dwarf planets. |
| | | 8 | One satellite is a terrestrial planet and the others are dwarf planets. |
| | | 9 | Several of the satellites are terrestrial planets and the others are dwarf planets |
| | | 10 | One of the satellites is a Helian planet, and the others are dwarf planets. |
| | | | **Ring Systems** |
| | | 1 – 7 | Minor ring system only. |
| | | 8 – 10 | Complex ring system. |

* L-Type Stars have a -1 modifier.

## STEP 4: WORLD TYPES

If the star is type III or D, the first 1d10 / 2 orbits (counting outward) were directly affected by the star's expansion. Any planets in those orbits are automatically of a particular type:

- All Dwarf Planets become Stygian.
- All Terrestrial Planets become Acheronian.
- All Helian Planets become Asphodelian.
- All Jovian Planets become Cthonian.

**Table 8: World Types**

**Dwarf Planet**

| Epistellar* | | Inner Zone* | | Outer Zone* | |
|---|---|---|---|---|---|
| 1 – 5 | Rockball | 1 – 7 | Rockball | 1 – 7 | Snowball |
| 6 – 9 | Meltball | 8 – 10 | GeoCyclic | 8 – 10 | Rockball |
| 10 | Roll 1d10 | 11 | Meltball | 11 | Meltball |
| 1 – 5 | Hebean | 12 | Roll 1d10 | 12 | Roll 1d10 |
| 6 – 10 | GeoTidal | 1 – 7 | Hebean | 1 – 5 | Hebean |
| | | 8 – 10 | GeoTidal | 6 – 8 | GeoCyclic |
| | | | | 9 – 10 | GeoTidal |

* **Modifiers:** Asteroid Belt Members -2; Helian Satellite +1; Jovian Satellite +2.

**Terrestrial Planets**

| Epistellar | | Inner Zone | | Outer Zone* | |
|---|---|---|---|---|---|
| 1 – 6 | JaniLithic | 1 – 4 | Telluric | 1 – 7 | Arid |
| 7 – 8 | Vesperian | 5 – 6 | Arid | 8 – 10 | Tectonic |
| 9 – 10 | Telluric | 7 – 8 | Oceanic | 11 - 12 | Oceanic |
| | | 9 – 10 | Tectonic | | |

* **Modifiers:** Satellite +2

**Helian Planets**

| Epistellar | | Inner Zone | | Outer Zone |
|---|---|---|---|---|
| 1 – 8 | Helian | 1 – 7 | Helian | Automatically Helian |
| 9 – 10 | Asphodelian | 8 – 10 | Panthalassic | |

**Jovian Planets**

| Epistellar | | Inner Zone | Outer Zone |
|---|---|---|---|
| 1 – 8 | Jovian | Automatically Jovian | Automatically Jovian |
| 9 – 10 | Cthonian | | |

# WORLD CHARACTERISTICS

The characteristics of exoplanets are often shorthanded for convenience. Use the following codes with the world classes in the next section.

| Code | Average Size & Surface Gravity | Code | Average Size & Surface Gravity |
|---|---|---|---|
| 0 | ≤800 km, neg. gravity | 7 | 11,200 km, 0.9g |
| 1 | 1,600km, 0.05g | 8 | 12,800 km, 1.0g |
| 2 | 3,200 km, 0.15g | 9 | 14,400 km, 1.25g |
| 3 | 4,800 km, 0.25g | 10 | ≥16,000 km, ≥1.4g |
| 4 | 6,400 km, 0.35g | 11 – 14 | Helian Sizes |
| 5 | 8,000 km, 0.45g | 15 | Jovian Sizes |
| 6 | 9,600 km, 0.70g | Y | Asteroid Belt |

| Code | Atmosphere | Code | Atmosphere |
|---|---|---|---|
| 0 | Vacuum | 8 | Dense Breathable |
| 1 | Trace | 9 | Dense Tainted |
| 2 | Very Thin Tainted | A | Exotic |
| 3 | Very Thin Breathable | B | Corrosive |
| 4 | Thin Tainted | C | Insidious |
| 5 | Thin Breathable | D | Super-High Density |
| 6 | Standard Breathable | G | Gas Giant Envelope |
| 7 | Standard Tainted | | |

| Code | Hydrosphere | Code | Hydrosphere |
|---|---|---|---|
| 0 | ≤5% (Trace) | 7 | ≤75% (Earth) |
| 1 | ≤15% (Dry/Tiny Ice Caps; Mars) | 8 | ≤85% (Water World) |
| 2 | ≤25% (Small Seas/Ice Caps) | 9 | ≤95% (No Continents) |
| 3 | ≤35% (Small Oceans/Large Ice Caps) | 10 | ≤100% (Total Coverage) |
| 4 | ≤45% (Wet) | 11 | Superdense (Deep Oceans) |
| 5 | ≤55% (Large Oceans) | X | Intense Volcanism (Molten Surface) |
| 6 | ≤65% | G | Gas Giant Core |

| Code | Biosphere | Code | Biosphere |
|---|---|---|---|
| 0 | Sterile | 7 | Small Macroscopic Life |
| 1 | Building Blocks (amino acids, or equivalent) | 8 | Large Macroscopic Life |
| 2 | Single-Celled Organisms | 9 | Simple global ecology (terrestrial life as well as ocean) |
| 3 | Producers (Forming atmosphere) | 10 | Complex Global Ecology |
| 4 | Multi-Cellular Organisms | 11 | Proto-Sapience |
| 5 | Complex Single-Celled Life (Nucleic cells or equivalent) | 12 | Full Sapience |
| 6 | Complex Multi-Cellular Life (Microscopic animals) | 13 | Trans-Sapience (Current level of transhumanity) |

# WORLD TYPE CATEGORIES

## ACHERONIAN

*Terrestrial Group, Telluric Class, Acheronian Type.*

These are worlds that were directly affected by their primary's transition from the main sequence; the atmosphere and oceans have been boiled away, leaving a scorched, dead planet.

| Trait | Code |
|---|---|
| Size | (1d10 / 2) + 4 |
| Atmo | 1 |
| Hydro | 0 |
| Bio | 0 |

## ARID

*Terrestrial Group, Arid Class, Darwinian / Saganian / Asimovian Types.*

These are worlds with limited amounts of surface liquid, that maintain an equilibrium with the help of their tectonic activity and their biosphere.

| Trait | Code |
|---|---|
| Size | 1d10 / 2 (reroll < 5) |
| Atmo | If Bio = 3+ and Water Chemistry then 1d10 (reroll 1 or 10). Otherwise Atmo = 0 |
| Hydro | 1d10 / 4 |
| Bio | See Below |

### Arid Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10 | Chemistry | Type | Age Mod |
|---|---|---|---|
| 1 – 6 | Water | Darwinian | +0 |
| 7 – 8 | Ammonia | Saganian | +1 |
| 9 – 10 | Methane | Asimovian | +3 |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age ≥ 1d3 + modifier | 1d10 / 4 |
| If Age ≥ 4 + modifier | 1d10 + 2* |
| Otherwise | 0 |

* *Modifier:* For dwarf star systems, -3.

## ASPHODELIAN

*Helian Group, GeoHelian Class, Asphodelian Type.*

These are worlds that were directly affected by their primary's transition from the main sequence; their atmosphere has been boiled away, leaving the surface exposed.

| Trait | Code |
|---|---|
| Size | (1d10 / 2) + 10 |
| Atmo | 1 |
| Hydro | 0 |
| Bio | 0 |

## CTHONIAN

*Jovian Group, Cthonian Class.*

These are worlds that were directly affected by their primary's transition from the main sequence, or that have simply spent too long in a tight epistellar orbit; their atmospheres have been stripped away.

| Trait | Code |
|---|---|
| Size | G |
| Atmo | 1 |
| Hydro | 0 |
| Bio | 0 |

## GEOCYCLIC

*Dwarf Group, GeoCyclic Class, Arean / Utgardian / Titanian Types.*

These are worlds with little liquid, that move through a slow geological cycle of a gradual build-up, a short wet and clement period, and a long decline.

| Trait | Code |
|---|---|
| Size | 1d10 / 2 |
| Atmo | d10*: 1 – 5 → Result 1; 6 – 10 → Result A. * For dwarf stars, -2 modifier. |
| Hydro | 1d10 + Size – 5* <br> * If Atmosphere 1, additional -4. |
| Bio | See Below |

### GeoCyclic Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10 | Chemistry | Type | Age Mod |
|---|---|---|---|
| 1 – 5 | Water | Arean | +0 |
| 6 – 7 | Ammonia | Utgardian | +1 |
| 8 – 10 | Methane | Titanian | +3 |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age ≥ 1d3 + modifier, and Atmo 1 | 1d10 – 8 |
| Age ≥ 1d3 + modifier, and Atmo A | 1d10 / 4 |
| If Age ≥ 4 + modifier, and Atmo A | 1d10 + Size - 6 |
| Otherwise | 0 |

## GEOTIDAL

*Dwarf Group, GeoTidal Class, Promethean / Burian / Atlan Types.*

These are worlds that, through tidal-flexing, have a geological cycle similar to plate tectonics, that supports surface liquid and atmosphere.

| Trait | Code |
|---|---|
| **Size** | (1d10 +2) -1 |
| **Atmo** | If biosphere is ≥ 3 and the world has water chemistry (see below) then atmosphere is 1d10 + Size -5 (minimum 2, maximum 9) *Otherwise:* A |
| **Hydro** | 1d10 |
| **Bio** | See Below |

### GeoTidal Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | Type | Age Mod |
|---|---|---|---|
| 1 – 6 | Water | Promethean | +0 |
| 7 – 10 | Ammonia | Burian | +1 |
| 11 – 12 | Methane | Atlan | +3 |

| *Modifiers | |
|---|---|
| **Star** | **Modifier** |
| Brown Dwarf | +2 |
| Epistellar Orbit | -2 |
| Outer Zone Orbit | +2 |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age ≥ 1d3 + modifier | 1d10 +4 |
| Age ≥ 4 + modifier | 1d10 + 2 |
| Otherwise | 0 |

* *Modifier:* Dwarf star, -3.

## HEBEAN

*Dwarf Group, GeoTidal Class, Hebean*

These are highly active worlds, due to tidal flexing, but with some regions of stability; the larger ones may be able to maintain some atmosphere and surface liquid.

| Trait | Code |
|---|---|
| **Size** | 1d10 / 2 |
| **Atmo** | 1d10 + Size -10 *If 2+, change to A.* |
| **Hydro** | 1d10 + Size -9 |
| **Bio** | 0 |

## HELIAN

*Helian Group, GeoHelian / Nebulous Classes.*

These are typical Helian or "subgiant" worlds – large enough to retain helium atmospheres. ***See also Panthalassic***.

| Trait | Code | |
|---|---|---|
| **Size** | 1d10 + 5 (reroll on <10) | |
| **Atmo** | D | |
| **Hydro** | **d10** | **Code** |
| | 1 – 4 | 0 |
| | 5 – 7 | 1d10 |
| | 8 – 10 | X |
| **Bio** | 0 | |

## JANILITHIC

*Terrestrial Group, Epistellar Class, JaniLithic Type.*

These worlds, tide-locked to the primary, are rocky, dry, and geologically active.

| Trait | Code | |
|---|---|---|
| **Size** | 1d10 / 2 | |
| **Atmo** | **d10*** | **Result** |
| | 1 – 5 | 1 |
| | 6 – 10 | A |
| **Hydro** | 0 | |
| **Bio** | 0 | |

## JOVIAN

*Jovian Group. If life-bearing, is most likely DwarfJovian Class, Brammain / Khonsonian Types.*

These are huge worlds with helium-hydrogen envelopes and compressed cores; the largest emit more heat than they absorb.

| Trait | Code | |
|---|---|---|
| Size | G | |
| Atmo | G | |
| Hydro | G | |
| Bio | d10* | Results |
| | 1 – 8 | No Life |
| | 9+ | Possible Life (see below) |
| | * *Modifier:* Inner Zone +3 | |

If the planet might possibly have life, consult the age of the system.

| Requirements | Bio |
|---|---|
| Age ≥ 1d10 roll | 1d10 / 4 |
| Age ≥ 7 | 1d10 +2* |
| Otherwise | 0 |
| * *Modifier:* For dwarf stars -3. | |

If there is life, roll on the following table to determine the chemistry.

| d10 | Chemistry | Type |
|---|---|---|
| 1 – 5 | Water | Brammian |
| 6 – 7 | Ammonia | Khonsonian |
| * *Modifiers:* Brown dwarf +1, epistellar orbit -2, outer zone orbit +2. | | |

## MELTBALL

*Dwarf Group, GeoThermic Class, Phaethonic / Apollonian / Sethian Types, or GeoTidal Class, Hephaestian / Lokian Types.*

These are dwarfs with molten or semi-molten surfaces, either from extreme tidal flexing, or extreme approach to a star.

| Trait | Code |
|---|---|
| Size | 1d10 +2 |
| Atmo | 1 |
| Hydro | X |
| Bio | 0 |

## OCEANIC

*Terrestrial Group, Oceanic Class, Pelagic / Nunnic / Teathic Types, or Tectonic Class, BathyGaian / BathyAmunian / BathyTartarian Types.*

These are worlds with a continuous hydrological cycle and deep oceans, due to either dense greenhouse atmosphere or active plate tectonics.

| Trait | Code |
|---|---|
| Size | (1d10 +2) + 5 |
| Atmo | See Below |
| Hydro | 11 |
| Bio | See Below |

### Oceanic Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | Type | Age Mod |
|---|---|---|---|
| 1 – 9 | Water | Pelagic or BathyGaian | +0 |
| 10 – 11 | Ammonia | Nunnic or BathyAmunian | +1 |
| 12 – 14 | Methane | Teathic or BathyTartarian | +3 |
| ***Modifiers** | | | |
| **Star** | | **Modifier** | |
| K-V | | +2 | |
| M-V | | +4 | |
| L- or N-Star | | +5 | |
| Outer Zone Orbit | | +2 | |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age ≥ 1d3 + modifier | 1 |
| Age ≥ 4 + modifier | 1d10 + 2* |
| Otherwise | 0 |
| * *Modifier:* For dwarf stars, -3. | |

### Oceanic Atmospheres

If the biosphere step above resulted in a water chemistry, then the atmosphere code is 1d10 + Size – 4. Otherwise, roll on the following table using the modifiers listed.

| Atmosphere Roll | |
|---|---|
| **1d10*** | **Code** |
| 1 – 2 | 1 |
| 3 – 7 | A |
| 8 – 10 | C |
| ***Modifiers** | |
| **Star** | **Modifier** |
| K-V | +2 |
| M-V | +4 |
| L- or N-Star | +5 |
| Outer Zone Orbit | +2 |

## PANTHALASSIC

*Helian Group, Panthalassic Class.*

These are massive worlds, aborted gas giants, largely composed of water and hydrogen.

| Trait | Code |
|---|---|
| **Size** | (1d10 +2) + 10 |
| **Atmo** | 1d10 + 5 (max D) |
| **Hydro** | 11 |
| **Bio** | See Below |

### Panthalassic Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | | Age Mod |
|---|---|---|---|
| 1 – 10 | *Roll 1d10 on the subtable* | | |
| | 1 – 7 | Water | +0 |
| | 8 – 9 | Sulfur | +0 |
| | 10 | Chlorine | +0 |
| 11 – 13 | Methane | | +1 |
| 14 – 15 | Methane | | +3 |
| ***Modifiers** | | | |
| | **Star** | | **Modifier** |
| | K-V | | +2 |
| | M-V | | +4 |
| | L- or N-Star | | +5 |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age ≥ 1d3 + modifier | 1d10 + 4 |
| Age ≥ 4 + modifier | 1d10 + 2 |
| Otherwise | 0 |

## ROCKBALL

*Dwarf Group, GeoPassive Class, Ferrinian / Lithic / Carbonian Types.*

These re mostly dormant worlds, with surfaces largely unchanged since the early period of planetary formation.

| Trait | Code |
|---|---|
| **Size** | (1d10 +2) |
| **Atmo** | 0 |
| **Hydro** | 1d10 + Size – 9<br>*Modifiers:* Brown dwarf +1, Epistellar -2, Outer Zone +2 |
| **Bio** | 0 |

## SMALL BODY

*Small Body Group.*

These are bodies too small to sustain hydrostatic equilibrium; nearly all asteroids and comets are small bodies.

| Trait | Code |
|---|---|
| **Size** | 0 (or Y for an entire asteroid belt) |
| **Atmo** | 0 |
| **Hydro** | 0 |
| **Bio** | 0 |

## SNOWBALL

*Dwarf Group, GeoPassive Class, Gelidian Type, or GeoThermic Class, Erisian Type, or GeoTidal Class, Plutonian Type.*

These worlds are composed of mostly ice and some rock. They may have varying degrees of activity, ranging from completely cold and still to cryo-volcanically active with extensive subsurface oceans.

| Trait | Code | |
|---|---|---|
| **Size** | (1d10 +2) | |
| | **1d10** | **Results** |
| **Atmo** | 1 – 6 | 0 |
| | 7 – 10 | 1 |
| | **1d10** | **Results** |
| **Hydro** | 1 – 6 | 11 (entirely frozen) |
| | 7 – 10 | 1d10 (subsurface oceans) |
| **Bio** | See Below | |

### Snowball Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | Age Mod |
|---|---|---|
| 1 – 10 | Water | +0 |
| 11 – 13 | Ammonia | +1 |
| 14 – 15 | Methane | +3 |
| *Modifiers | | |
| Star | | Modifier |
| Brown Dwarf | | +2 |
| Outer Zone Orbit | | +2 |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| If subsurface oceans and Age < 1d6 + modifier | 1d10 – 7 |
| If subsurface oceans and Age ≥ 1d6 + modifier | 1d10 + Size - 6 |
| Otherwise | 0 |

# STYGIAN

*Dwarf Group, GeoPassive Class, Stygian Type. These are worlds that were directly affected by their primary's transition from the main sequence; they are melted and blasted lumps.*

| Trait | Code |
|---|---|
| **Size** | 1d10 – 5 |
| **Atmo** | 0 |
| **Hydro** | 0 |
| **Bio** | 0 |

# TECTONIC

*Terrestrial Group, Tectonic Class, Gaian / Amunian / Tartarian Types.*

These are worlds with active plate tectonics and large bodies of surface liquid, allowing for stable atmospheres and a high likelihood of life.

| Trait | Code |
|---|---|
| **Size** | 1d10 + 5 (minimum 5) |
| **Atmo** | See Below |
| **Hydro** | 1d10 |
| **Bio** | See Below |

## Tectonic Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | Type | Age Mod |
|---|---|---|---|
| 1 – 9 | *Roll 1d10+2 on the subtable below.* | | |
| 3 – 8 | Water | Gaian | +0 |
| 9 – 11 | Sulfur | ThiGaian | +0 |
| 12 | Chlorine | Chloritic Gaian | +0 |
| 10 – 13 | Ammonia | Amunian | +1 |
| 14 – 15 | Methane | Tartarian | +3 |
| * *Modifier:* Dwarf star -3. | | | |

This will help you determine the final Biosphere value.

| Requirements | Bio |
|---|---|
| Age < 4 + modifier | 1d10 / 4 |
| Age ≥ 4 + modifier | 1d10 + 2* |
| Otherwise | A |
| * *Modifier:* For dwarf stars, -3. | |

## Tectonic Atmospheres

If the biosphere step above resulted in a water chemistry, then the atmosphere code is 1d10 + Size – 5 (minimum 2, maximum 9). Otherwise, roll on the following table using the modifiers listed.

| Requirements | Bio |
|---|---|
| If biosphere ≥ 3 and water chemistry | 1d10 + Size – 5 |
| If biosphere ≥ 3 and sulfur or chlorine chemistry | B |
| Otherwise | A |

# TELLURIC

*Terrestrial Group, Telluric Class, Phosphorian / Cytherean Types.*

These are worlds with geoactivity but no hydrological cycle at all, leading to dense runaway-greenhouse atmospheres.

| Trait | Code | |
|---|---|---|
| **Size** | 1d10 + 5 (minimum 5) | |
| **Atmo** | C | |
| **Hydro** | **1d10** | **Result** |
| | 1 – 6 | 0 |
| | 7 – 10 | F |
| **Bio** | 0 | |

# VESPERIAN

*Dwarf Group, Epistellar Class, Vesperian Type.*

These worlds are tide-locked to their primary, but at a distance that permits surface liquid and the development of life.

| Trait | Code |
|---|---|
| Size | 1d10 + 5 (minimum 5) |
| Atmo | If biosphere ≥ 3 and water chemistry then 1d10 + Size – 5 (minimum 2, maximum 9)<br>If biosphere ≥ 3 and chlorine chemistry then B<br>Otherwise A |
| Hydro | 1d10 |
| Bio | If Age < 3 then 1d10 / 4<br>If Age ≥ 4 then 1d10 + 2<br>Otherwise 0 |

## Vesperian Biospheres

The biosphere potential of these worlds is difficult to establish and some consideration is needed to make sure they are realistic. To start with, roll 1d10 to determine the world's type.

| d10* | Chemistry | Age Mod |
|---|---|---|
| 1 – 9 | Water | |
| 10 | Chlorine | +3 |