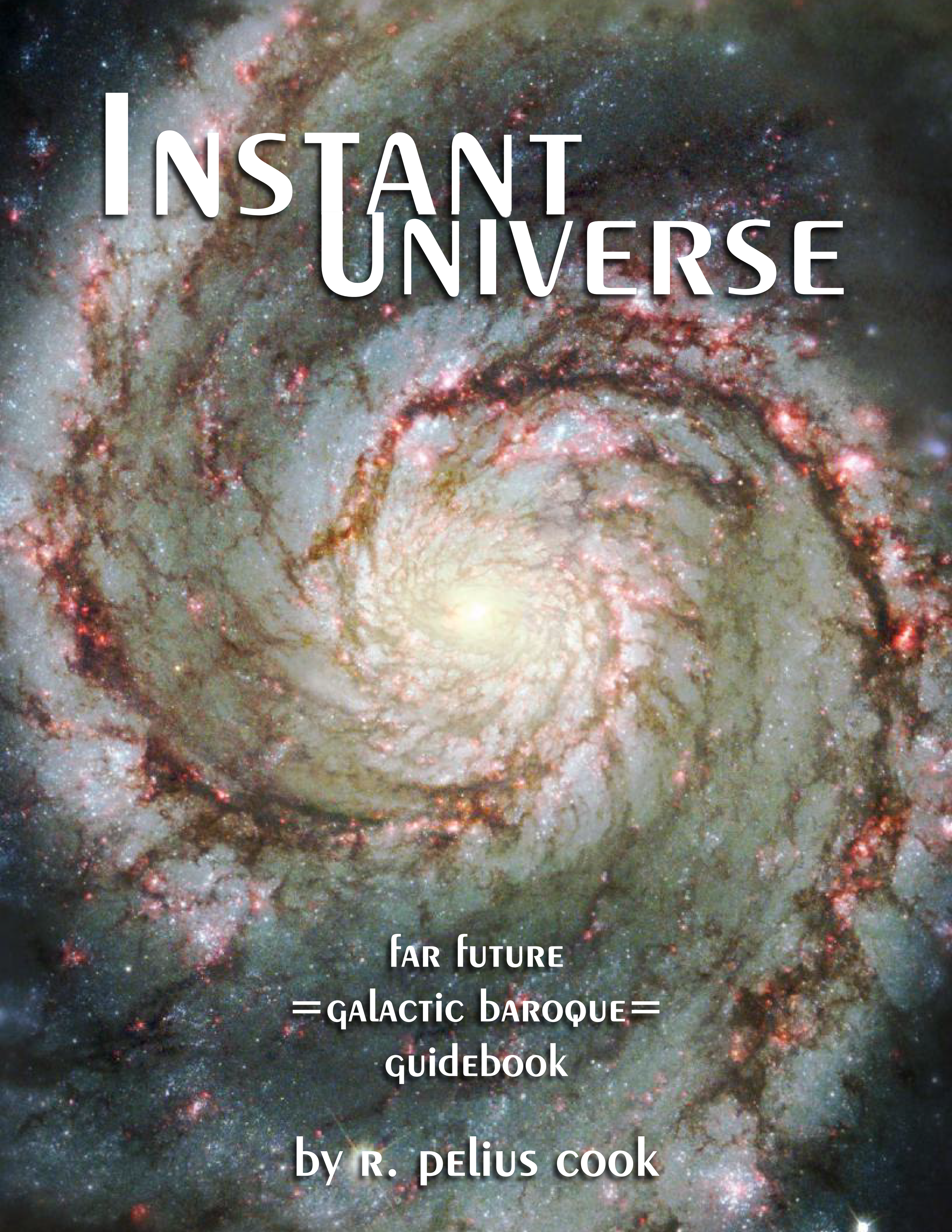

Instant Universe

far future
=galactic baroque=
guidebook

by r. pelius cook

DEDICATION

To Tiana and Angela
My best two reasons to
always keep reaching
for the stars.

=galactic baroque=
far future roleplaying

Instant universe

by r. pelius cook

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Table of contents

Finally! A star system generator that captures the vastness and variety of space, time, and technology.

Exploring strange worlds and alien civilizations is one of the most exciting aspects of science fiction. In many cases, though, these worlds are only slight variations of our own, with cultures and technology not much farther beyond our own.

=GALACTIC BAROQUE= INSTANT UNIVERSE will vastly expand your horizons. Not merely a rulebook for random solar system creation, this guide generates exotic locales at any point from the Big Bang to the end of the Stelliferous Era that better reflect where super- and ultra-advanced technology will take us.

Does humankind still live in trees or caves? Of course not! We learned to build our own habitations long ago. Likewise, *INSTANT UNIVERSE* determines technology levels of civilizations, indicating native life populations, star system development (including terraformed planets, megaengineered space colonies, and beyond), and interstellar colonization.

Writers of any genre, gamers, roleplayers, world-builders, astronomy enthusiasts, and more will find this heavily researched book both useful and fascinating. It's a great way to introduce children and novices to the wonders of the universe, too!

HOW TO CREATE AN INSTANT UNIVERSE

Proceeding in order from Galaxies to Planets, then adding details from the Civilization section, provides the most accuracy and detail of star systems and their worlds. If you only need information from a few sections, though, start wherever works best. Always feel free to pick whatever result you prefer from any of the choices. Even if you do not roll dice for this, the number ranges give a clear idea of how often such combinations are found in the universe.

INSTANT UNIVERSE is designed to work best with a full set of polyhedral dice: 4-side (d4), 6-side (d6), 8-side (d8), 10-side (d10), 12-side (d12), 20-side (d20), and 100-side or percentile dice (d100). To use any table, make a HaVoQ ROLL: Roll ALL the dice together! Match each die roll to the applicable section, add or subtract any modifiers, then make any additional rolls as required. Record the indicated results, then move on to the next section. You will find that the results of one table often affect the results of other sections.

If an indicated result is **Special**, feel free to use your imagination! Should you need a hint, though, reroll on that table and consider the new result to be an unusual or special variation of it. For duplicate results (such as for certain Peculiarities tables), consider it a more extreme variation.

STELLIFEROUS ERA

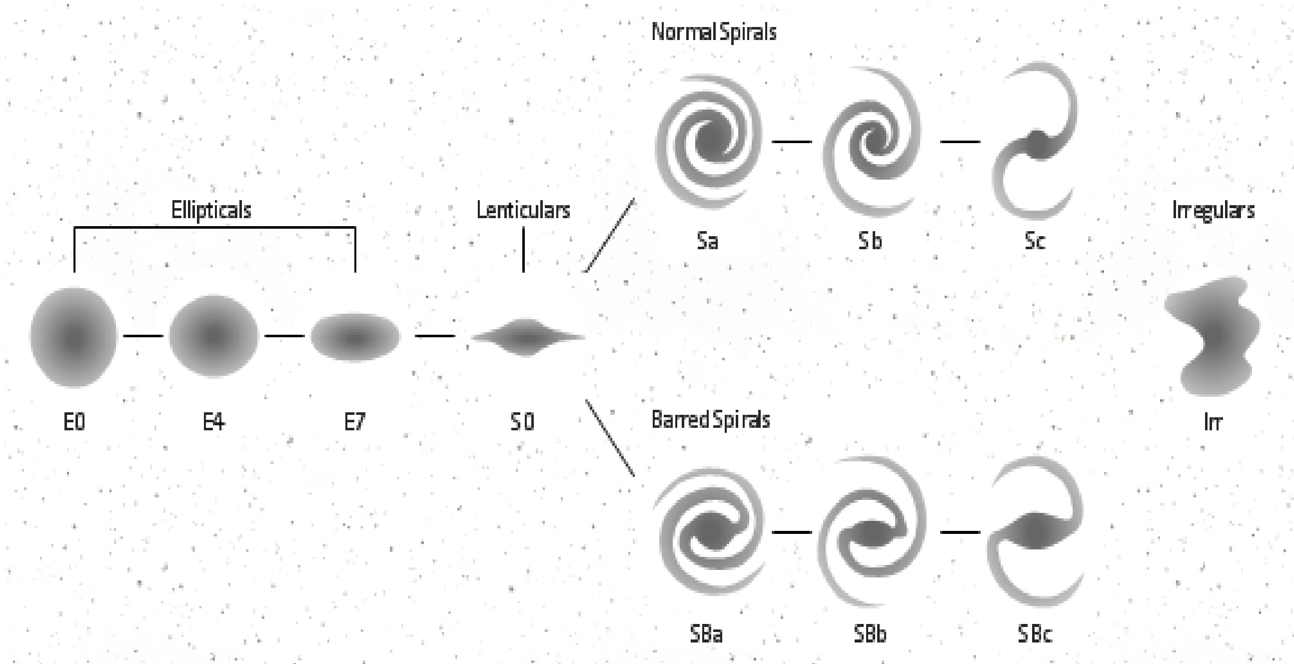
This edition of *INSTANT UNIVERSE* was published in the early Middle Stelliferous Era, but results are not limited to that point in time—any time from the first stars to the last is possible!

STELLIFEROUS ERA

PERIOD	TIME AFTER BIG BANG
Ancient Stelliferous	0.2-0.4 billion years
Early Stelliferous	0.5-4.9 billion years
Middle Stelliferous	5-49 billion years
Late Stelliferous	50-1999 billion years
End Stelliferous	2-100 trillion years

May you all enjoy exploring with this guide as much as I enjoyed compiling it.

—R. Pelius Cook



1.1 GALAXY TYPES

ROLL d4 FOR GALACTIC NEIGHBORHOOD.
ROLL d20 FOR EACH GALAXY TYPE.
ROLL d12 FOR EACH GALAXY SUBTYPE (d8: Galaxy Region).

1-3	Group (1d6-1 galaxies; if result is 0, neighborhood is a 1d10x10 Mpc Void with 1d4-1 galaxies.)		
	1	Intergalactic (Roll d8: 1-2 Stream, 3-7 Remnant, 8 Aura)	
	2-5	Irregular Galaxy	
		1-4	Dwarf Amorphous (Roll d8: 1 Cluster, 2-3 Association, 4-7 Group, 8 Field)
		5-9	Dwarf Spiral (Roll d8: 1-2 Nucleus, 3-7 Arm, 8 Halo)
		10-12	Dwarf Elliptical (Roll d8: 1-3 Core, 4-7 Ellipse, 8 Halo)
	6-14	Spiral Galaxy	
		1-2	Flat (Roll d8: 1 Nucleus, 2-7 Disk, 8 Halo)
		3-9	Barred (Roll d8: 1 Nucleus, 2 Bar, 3 Arm, 4-6 Disk, 7 Halo, 8 Satellite)
		10-12	Classic (Roll d8: 1-3 Bulge, 4 Arm, 5-6 Disk, 7 Halo, 8 Satellite)
	15-18	Lenticular Galaxy	
		1-2	Dwarf (Roll d8: 1 Nucleus, 2-7 Disk, 8 Halo)
		3-9	Common (Roll d8: 1-2 Bulge, 3-5 Disk, 6-7 Halo, 8 Satellite)
		10-12	Giant (Roll d8: 1-3 Bulge, 4-5 Disk, 6-7 Halo, 8 Satellite)
	19-20	Elliptical Galaxy	
		1-4	Dwarf (Roll d8: 1-4 Core, 5-7 Ellipse, 8 Halo)
		5-9	Common (Roll d8: 1-3 Core, 4-6 Ellipse, 7 Halo, 8 Satellite)
		10-12	Giant (Roll d8: 1-2 Core, 3-5 Ellipse, 6-7 Halo, 8 Satellite)
4	Cluster (2d10* galaxies; for each 1 rolled on d10, a galaxy is Dominant type.)		
	1-2	Intracluster (Roll d8: 1-3 Stream, 4-7 Exile, 8 Aura)	
	3-5	Irregular (Roll d8 Irregular table above for subtype.)	
	6-7	Spiral (Roll d8 Spiral table above for subtype.)	
	8-17	Lenticular (Roll d8 Lenticular table above for subtype.)	
	18-20	Elliptical (Roll d8 Elliptical table above for subtype.)	
	**	Dominant Elliptical Galaxy	
		1-6 Common (Roll d10: 1-2 Core, 3-4 Ellipse, 5-6 Halo, 7-8 Satellite)	
		7-8 Giant (Roll d10: 1 Core, 2-3 Ellipse, 4-6 Halo, 7-8 Satellite)	

*If d10 roll is 10, reroll and add results together.

At the largest scales, the universe is a boundless web of galaxies, gas, and dust surrounding vast bubbles of mostly empty space.

1.1 GALAXY TYPES

NEIGHBORHOOD

Major galaxies within 2 megaparsecs (or 5-10 Mpc for giant and dominant galaxies) tend to be gravitationally bound to each other.

Voids are the emptiest parts of the universe, spanning 1d10x10 Mpc diameter.

Groups are the most common distributions of galaxies.

Clusters are groups of closely packed galaxies. Intergalactic space within a cluster is filled with a superhot plasma far more massive than all member galaxies combined, plus a large population of intergalactic stars. Galaxies within many clusters are centered around an unusually large, dominant galaxy.

TYPES & SUBTYPES

Irregulars (Irr) are dwarf galaxies that do not fit clearly into any category. Protogalaxies began as irregulars, growing into, merging with, or becoming satellites of larger galaxies over time. Irregular dwarf spirals and irregular dwarf ellipticals show traits similar to spiral and elliptical galaxies, respectively, but with generally higher star formation rates than either. Amorphous irregulars are congregations of star clusters, associations, and groups without discernable order.

Dimensions: Roughly 1d6 kiloparsecs (kpc) length x 1d6 kpc width x 1d4 kpc height (about half height result for irregular spirals).

Spirals (S/SB) are disk galaxies with prominent arms rotating around a central bulge. Star formation is most active in the arms, where molecular clouds are densest. Bulges vary between the gas poor, elliptical bulge of classic spirals, the gas rich, flat nucleus of barred spirals, and the nearly nonexistent bulge of flat spirals. Although very uncommon in the early universe, barred spirals become more common than other types by the Middle Stelliferous.

Disk: Radius = 5d4 kpc; thickness equal to about 1% radius.

Lenticulars (S0) are disk galaxies common to galaxy clusters. Although initially similar to spirals, starburst conditions, mergers, and travel through the intracluster plasma depleted most star-making gas early in their history; dwarf lenticulars, which are thick, pure disk spirals, are an exception to this. Common lenticulars are often more massive than spirals, with thicker disks and extensive halos of globular clusters, and are usually dustier than ellipticals. Giant lenticulars resemble flattened ellipticals and are the largest disk galaxies.

Disk: Radius = 1/[1d4] kpc (dwarf); 5d6 kpc (common); [1d4+2] x 10 kpc (giant); Thickness equal to 1d6% (dwarf), 2d6% (common), or 3d6% (giant) of radius.

Ellipticals (E) are spherical or ovoid galaxies that range in size from the smallest to the largest galaxies in the universe. Much like lenticulars, ellipticals deplete almost all of their gas early on, leaving aging populations of stars and almost no subsequent star formation. Dwarf ellipticals are found throughout space, often as satellites orbiting major galaxies. Common and giant ellipticals are very rare in the Early Stelliferous, growing through early, intense starburst activity and galaxy interaction in clusters; in the center of the densest clusters, dominant ellipticals cannibalize other galaxies to grow into the most massive in the universe.

Ellipse: Radius = 1/1d100 kpc (dwarf); 1d20 kpc (common); [1d4+1] x 10 kpc (giant); [5d4] x 10 kpc (common dominant); [1d4+1] x 100 kpc.

1.1 GALAXY TYPES (continued)

REGIONS

Characteristics of star systems can vary greatly depending on galactic region. For all but irregular galaxies, stars are generally oldest in the Halo and the Core, with younger generations in between. Star populations tend to grow denser toward the center of a galaxy, too—from an average of a star every cubic parsec in ellipses and disks to as many as a million or more per cubic parsec in the core and nucleus.

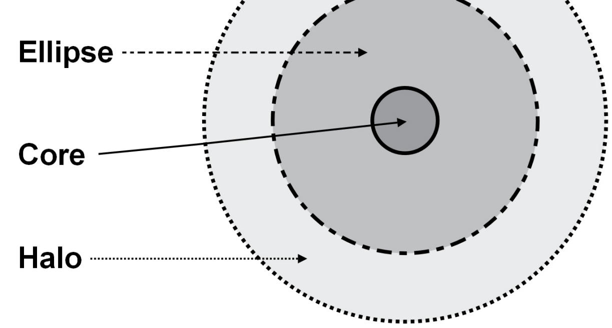
Satellite galaxies usually orbit beyond the Halo. Most galaxies have 1d10+2 satellites, but for those with larger satellite populations, consider a Halo result as a possible Satellite result instead. Roll d10:1-2 (more) or 1-5 (much more) becomes Satellite region. For galaxies with smaller satellite populations, roll d10 on any satellite region result: 1-2 (less) or 1-5 (much less) becomes Halo instead.

REGION RADIUS (Rule of Thumb)

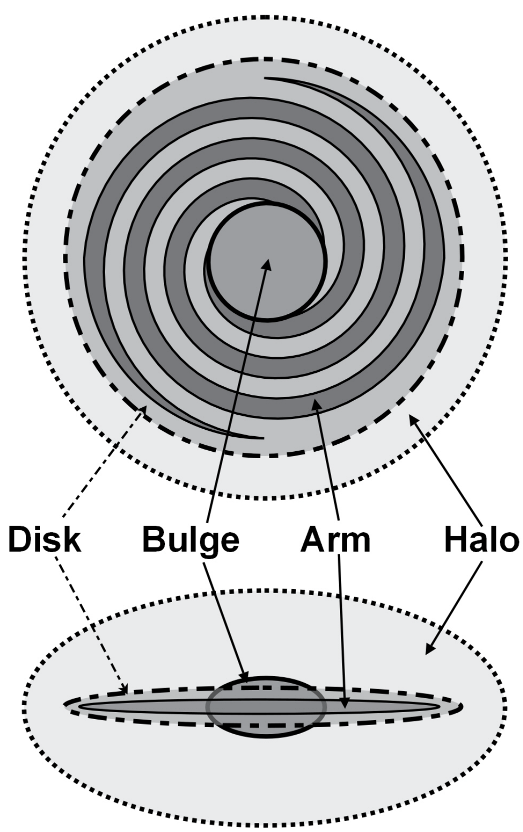
Region	Spiral	Lenticular	Elliptical
Core	--	--	x1/10
Bulge	x1/10	x1/5	--
Arm	x1/2	--	--
Disk/Ellipse	x1	x1	x1
Halo	x1.5	x2	x3

NOTE: Arm thickness is about 1/10th of disk Thickness. Halo, ellipse, core, and common spiral bulge radius is spherical around galaxy center.

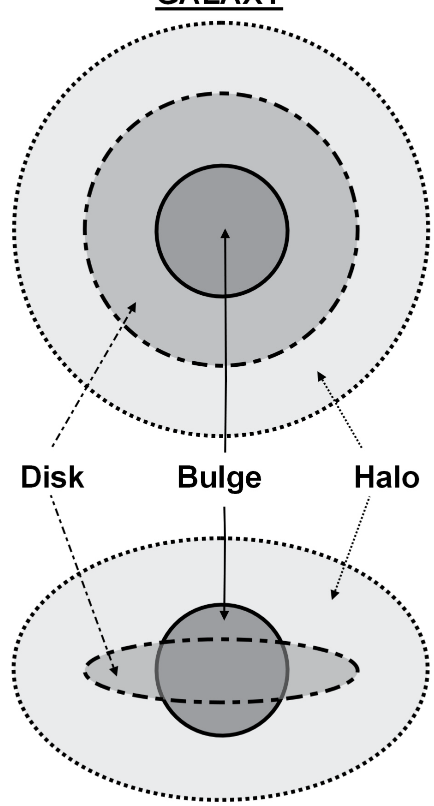
ELLIPTICAL GALAXY



SPIRAL GALAXY



LENTICULAR GALAXY



1.2 GALAXY PECULIARITIES

Active nucleus galaxies have massive central black holes accreting immense quantities of gas and dust, producing greater than typical luminosity across much or all of the electromagnetic spectrum. Jets of plasma emit from the core that extend for thousands of parsecs.

Compact galaxy stars are much more densely packed than those in other galaxies of similar type. Roll d10: 1 Extremely Compact (200% density), 2-4 Very Compact (150% density), 6-10 Compact (120% density). **Expansive** galaxy stars are much less densely packed than those in other galaxies of similar type. Roll d10: 1 Extremely expansive (20% density), 2-4 Very (50% density), 5-10 Expansive (75% density).

Dusty galaxies have stars with greater metallicity. **Metal poor** galaxies have lower metallicity.

Extended halo galaxies have sizeable stellar populations outside the core and disk/ellipse, often with large numbers of globular clusters. Consider outer radius to be about 150% normal.

Gas poor galaxies have much less gas, with a concurrently slower star formation rate. **Gas rich** galaxies have much more gas, with a much faster star formation rate.

Interacting galaxies are close enough for gravity to distort each other. Star formation rates and extragalactic star populations are greater.

Younger galaxies have larger populations of hot, bright stars. **Older** galaxies generally stopped star formation long ago and have older stellar populations.

Satellites of galaxies are common, with some having far more or far less than others. Roll d10: 1 Much more, 2-4 More, 5-7 Less, 8-9 Much less, 10 None or Special.

Starburst galaxies are experiencing very high star formation rates, most often due to interaction with another galaxy.

Sub-size galaxies are 1/1d4+1 as massive. **Super-size** galaxies are 1d4+1 times more massive.

1.2 GALAXY PECULIARITIES

ROLL d100 FOR GALAXY PECULIARITIES.

Elliptical	Lenticular	Spiral	Irregular	Dwarf	Giant	Dominant	Cluster	Peculiarity
01-05	01-05	01-05	01-05	01-05	01-05	01-02	01-05	None
06-15	06-10	06-10	—	—	01-10	03-12	06-10	Active nucleus
16-20	11-15	11-15	06-10	06-20	11-15	13-15	11-15	Compact
21-25	16-35	16-25	11-15	21-22	16-20	16-20	16-20	Dusty
26-30	36-40	26-30	16-20	23-24	21-25	21-27	21-25	Expansive
31-35	41-50	31-40	—	—	26-30	28-30	26-35	Extended halo
36-55	51-60	41-45	—	25-30	31-35	31-33	36-40	Gas poor
—	—	46-50	21-40	31-40	36-40	34-35	41-45	Gas rich
56-60	61-65	51-55	41-50	41-50	41-50	36-42	46-70	Interacting
61-65	—	56-60	—	51-70	51-55	43-45	71-75	Metal poor
66-75	66-75	61-65	51-55	71-74	56-65	46-55	76-80	Older
76-83	76-80	66-75	56-60	—	66-88	56-65	81-82	Satellites
84-85	81-82	76-80	61-80	75-80	89-90	66-70	83-88	Starburst
86-90	83-88	81-85	81-85	81-90	—	—	89-90	Sub-size
91-95	89-94	86-90	86-90	91-92	91-95	71-95	91-94	Super-size
96-97	95-97	91-95	91-95	93-97	96-97	96-97	95-97	Younger
98-99	98-99	96-99	98-98	98-99	98-99	98-99	98-99	Roll twice
00	00	00	00	00	00	00	00	Special

2.1 STAR ASSOCIATIONS

NEIGHBORHOOD

Young neighborhoods begin as open clusters of 1d10*x100 stars that over millions of years drift apart into looser associations. New open clusters (less than 2 million years old) are often still surrounded by the nebula from which they formed. Most stars in these clusters are the same age.

Mature neighborhoods are mixed populations of mostly main sequence stars of varying ages and types. Age is for individual stars, not the neighborhood in general.

In **old** neighborhoods star formation has long been minimal, such as elliptical and lenticular galaxies, as well as galactic bulges and globular clusters. Age is for the general neighborhood.

Ancient stars were the first generations to be born and are typically found in the galactic halo. Age is for the general neighborhood.

EVOLUTION

Only the first stars were metal-free **paleodwarfs** (Population III). Relative to later generations, they have higher minimum and maximum masses, yet much smaller radii; below 2/5 solar mass, hydrogen fusion is not possible (red brown paleodwarf and brown paleodwarf), whereas on the other end of the spectrum sizes approaching 500 solar masses are possible. Paleodwarfs burn furiously and live extremely short lives before dying, often in spectacular hypernova explosions or collapsing into black holes. Elements heavier than hydrogen and helium were generated in the cores of the first stars, which after their deaths enriched subsequent generations of stars. Planetary systems around paleodwarfs are practically non-existent.

Subdwarfs (Population II) are metal-poor stars from the Early Stelliferous with smaller radii for a given solar mass than dwarfs. Although neither as massive nor as luminous as paleodwarfs, these stars still had higher minimum and maximum masses than those that came afterward; Brown star threshold begins below 1/8 solar mass, with the largest Blue subdwarfs in excess of 200 solar masses. Small planetary systems can form around subdwarfs.

Dwarf stars (Early Population I) are most common throughout the Middle Stelliferous Era. Red dwarfs as light as 1/12 solar mass are possible, as are Blue stars in excess of 100 solar masses. Planetary systems commonly form around such stars.

NOTE: Since “blue dwarf” and “white dwarf” refer to post-main sequence phases of stellar life cycles, Blue star and White star are the terms used for main sequence dwarf stars of those color classes.

Superdwarf (Late Population I) are metal-rich stars with subgiant dimensions. Higher metallicity means Red superdwarfs can be a light as 1/16 solar mass, but heavy Blue stars rarely attain masses beyond 50 Ms. Superdwarfs have an ideal elemental balance that moderates their fusion reactions, allowing them to remain main sequence much longer than any other generation of stars. Planetary systems are extensive, with larger bodies.

Hyperdwarf stars (Population 0) are bloated, helium dominant, and metal-heavy. Excessive metallicity causes these stars to struggle to sustain fusion, greatly reducing main sequence lifespans. Although stars greater than 25 solar masses are rare in this generation, the Brown dwarf threshold falls to 1/25 solar mass. Planets around hyperdwarfs are far more massive, numerous, and resource rich than those around other stars.

2.1 STAR ASSOCIATIONS

ROLL d8 FOR STELLAR NEIGHBORHOOD.

1 or less	Young (Neighborhood Age: 1d10**x100 million years)
2-7	Mature (Star Age: 1d10 billion years†)
8-11	Old (Star Age: Stelliferous Year/d10*)
12 or more	Ancient (Star Age: Stelliferous Year - [1d10-1] billion years)

*For every 10 rolled, reroll d10 and add the results together (cumulative)

**For every 1 rolled, reroll d10 and divide result by another 10 (cumulative).
For every 10 rolled, reroll and add the results together (cumulative).

†If age of the Stelliferous Era is less than Middle, use Ancient age formula.

NOTE: Galaxy Region modifies the d8 result.

Halo/Aura	+5	Core	+2	Disk	+1	Arm	-2
Satellite	+3	Bulge	+2	Nucleus	-1	Association	-3
Stream	+3	Ellipse	+1	Bar	-2	Cluster	-5

ROLL d10 FOR STELLAR EVOLUTION.

Less than -10	Paleodwarf
-10 to 2	Subdwarf
3-9	Dwarf
10-20	Superdwarf
21 or more	Hyperdwarf

NOTE: Age of the Stelliferous Era determines stellar evolution.

Ancient	-10	Middle	+0	End	+5
Early	-5	Late	+2		

NOTE: Apply all relevant factors to modify stellar evolution.

Dominant galaxy	+2	Dusty galaxy	+1	Disk	-1	Void	-5
Starburst galaxy	+2	Bar	+1	Ellipse	-2	Halo	-5
Nucleus	+2	Core	+1	Satellite galaxy	-2	Aura	-10
Giant galaxy	+1	Sub-size galaxy	-1	Metal-poor galaxy	-5	Stream	-5
Super-size galaxy	+1	Younger galaxy	-2	Diffuse galaxy	-1		
Arm	+1	Dwarf galaxy	-2	Intergalactic region	-10		

STELLAR DISTRIBUTION

Region	Stars (cubic parsec)
Aura	[1d4]/20
Halo	[1d4]/10
Stream	[1d4]/5
Thick Disk/Outer Ellipse	[1d4]/3
Thin Disk/Inner Ellipse	[1d4]/2
Arm/Cluster	1d4
Inner Disk	1d8
Bar	1d20
Outer Bulge/Nucleus/Core	1d100
Inner Bulge/Nucleus/Core	5d100
Center/Globular Cluster	1d1000

2.2 STAR SYSTEMS

STAR CLASS

Blue stars (Class O/B) are the most massive and luminous of all stars. Almost never found outside of the open clusters from which they were born, their powerful radiation sculpts and ionizes the surrounding nebula. Almost all form multi-star systems, but the few solitary examples often have immense circumstellar disks with hundreds (if not thousands) of major protoplanetary objects. Only the smallest Blue stars last long enough for complete planetary system formation and none last long enough to give much chance for native life to begin. They grow into supergiants at the end of their short main sequence lifespans before going supernova, leaving a neutron star remnant; the most massive of all Blue stars expand into hypergiants that soon collapse into black holes.

White stars (Class A) are larger and more luminous than most other stars, but longer-lasting than the brighter Blue stars. Although most have stellar companions, extensive planetary systems of large planets can form from the massive amount of material surrounding solitary ones. With a main sequence lifespan of a few billion years, though, any native lifeforms that might arise rarely evolve beyond simple forms before the star bloats into a bright giant, then blows off most of its mass except for the degenerate matter at the core which becomes a White dwarf.

Yellow stars (Class F/G), with their moderate mass and luminosity, live longer than the brightest stars, plus have enough dust and gas to form planetary systems. Although the main sequence phase is not as long as Orange or Red stars, it is long enough for native life to develop and possibly evolve into complex forms. Like White stars, Yellow stars swell into giants, then shed their outer layers, leaving White dwarfs.

Orange stars (Class K) are small, stable stars, most of which possess planetary systems without additional stellar companions. Not nearly as resource-rich as larger stars, planets orbiting Orange stars tend to be smaller and gas giants are less common. A long main sequence life gives native life a better chance than most anywhere else to develop.

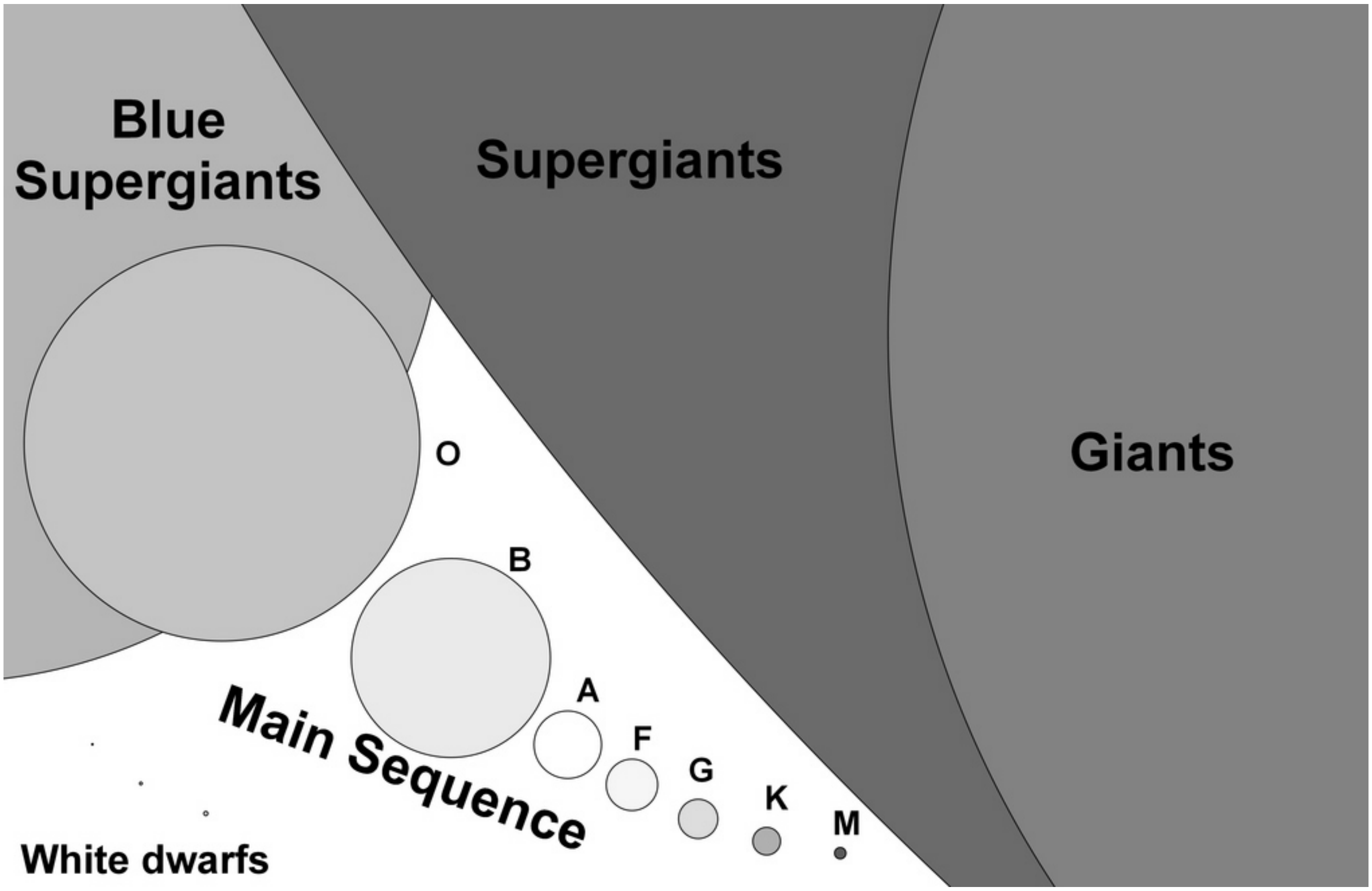
Red stars (Class M) are the smallest, dimmest, and by far most common of all stars in the universe. They take billions of years to reach main sequence, remain stable for trillions of years afterward, then most grow into subgiants before finally dying out as White dwarfs. However, the least massive never become giants; instead, they increase in temperature and luminosity to become Blue dwarfs before degenerating into White Dwarfs. This longevity advantage for native life to form is strongly mitigated by the variability of these stars and tidal-locking common to their moderate zone planets.

Brown stars (Class L/T) are substars of typically less than 1/12 solar mass. Unlike hot stars, these never fuse hydrogen into helium, instead burning deuterium (and lithium in the most massive types) for the first few million years before fusion ends and the brown dwarf slowly cools. Planetary systems more closely resemble gas giant satellite systems. Unless in an ideal orbit around a Red or larger star, native life is improbable given their extremely short main sequence window, although colonies could be possible.

A Late Stelliferous evolution is the frozen star: A brown hyperdwarf between 1/16 and 1/24 solar mass that fuses hydrogen in its core, but has a surface temperature cool enough for water ice clouds to form in its atmosphere. Such a star would be a thousandth as luminous as the dimmest Red star, but would have an exponentially longer main sequence lifespan.

2.3 STAR SIZE

Luminosity of a star mainly depends upon its mass and there is variation within each star class. A dim star is less massive than a standard star, both of which are less massive and luminous than a bright star. This also affects the time a star remains on the main sequence.



2.2 STAR SYSTEMS

ROLL d20 FOR STAR CLASS (Roll d8: solar mass).

1 or less	White star (If neighborhood under 2 billion years, roll d20 again for subtype.)
	1 Blue star (1d8*+3)
	2-20 White star (2 solar mass)
2-3	Yellow star (1 solar mass)
4-8	Orange star (½ solar mass
9-19	Red star (1/[1d8*+3])
20 or more	Stellar Remnant (Roll progenitor star type with the following table and die.)

Under 2 billion years old: Blue star only.
2-4.9 billion years old: Roll White star subtype with d4.
5-9.9 billion years old: Roll White star subtype with d8.
10-199 billion years old: Roll Star Type with d8.
Over 200 billion years old: Roll Star Type with d20.

ROLL d6 FOR SYSTEM TYPE.

1 Planet, 2-6 Multi-star
1-2 Planet, 3-6 Multi-star
1-3 Planet, 4-6 Multi-star
1-4 Planet, 5-6 Multi-star
1-5 Planet, 6 Multi-star

*If d8 roll is 8, reroll d8 and add results together (open-ended).

NOTE: Stellar Neighborhood age can modify the d20 roll result.

Under 10 million years old	-2	50-99 billion years old	+6	20-49 trillion years old	+18
10-999 million years old	-1	100-199 billion years old	+8	50-100 trillion years old	+19
1 billion years old	+0	200-499 billion years old	+10	100+ trillion years old	+20
2-4 billion years old	+1	500-999 billion years old	+12		
5-9 billion years old	+2	1 trillion years old	+14		
10-14 billion years	+3	2-4 trillion years old	+15		
15-19 billion years old	+4	5-9 trillion years old	+16		
20-49 billion years old	+5	10-19 trillion years old	+17		

2.4 PLANET SYSTEM

Stable planet systems more easily form around solitary stars. Early stars have little dust with which to form major bodies, but as metallicity increases so does the number of major bodies. A planet system begins as a gas-rich circumstellar disk (protoplanetary disk) from which planets accrete, a process that lasts about 1d10x10 million years. Any leftover material orbits the star in belts and clouds; in systems without giant or larger planets, the dust-rich circumstellar disk can remain (debris disk).

When most stars enter their post-main sequence lives, they bloat into giants hundreds of times larger in diameter, engulfing inner planets and affecting the orbits of farther ones. At the end of this phase, the giant star's tenuous outer atmosphere is blown off, forming a planetary nebula and leaving a core of hot degenerate matter called a White dwarf. This process further disrupts planet orbits and pollutes the system with gas and dust. A second generation of planetary formation can begin, creating exotic planets types such as helium planets and even carbon monoxide gas planets.

A sufficiently massive star will die as a supernova, obliterating whatever planets remained after the supergiant phase, and a dense, intensely magnetic Neutron star will remain. Dust and gas may remain after this, forming a new, often carbon-rich protoplanetary disk from which new planets might form.

Should a star collapse into a black hole, however, all bets are off.

2.5 MULTI-STAR SYSTEM

Many stars, especially massive ones, orbit each other as binary stars. Powerful gravitational interactions between binaries can induce significant eccentricity in their orbits. To determine the closest (periapsis) and farthest (apoapsis) distances a secondary star gets to its primary star, use the following formulae:

Periapsis: [1 - Eccentricity] x Orbital distance
Apoapsis: [1 + Eccentricity] x Orbital distance

Aside from the orbital zones inhabited or crossed by stars (forbidden orbits), stable planet orbits are possible in binary systems. For planets that orbit around both stars (circumbinary bodies), forbidden orbits are all zones from apoapsis inward to the primary star. Forbidden orbits for circumstellar bodies orbiting the primary star are all zones from periapsis outward.

Circumstellar bodies around the secondary star of a binary are affected by the secondary's orbit around and mass relative to the primary star. Maximum planet orbital distance for the secondary star = [Apoapsis - Periapsis]; forbidden orbits are all zones beyond this maximum.

2.3 STAR SIZE

ROLL d8 FOR STAR SIZE (except Blue and Red Stars)

1	Bright (+20% mass)
2-4	Standard
5-8	Dim (-20% mass)

2.4 PLANET SYSTEM

ROLL d12† FOR PLANET SYSTEM TYPE.

Under -2	Empty system (no major bodies)	
1 to -2	Circumstellar disk (1d4* major bodies; if roll is 1, reroll d4.)	
	1	No major bodies
	2-4	One major body
2-4	Small system (1d4+2 major bodies)	
5-11	Standard system (1d4*+5 major bodies)	
12 or more	Large system (1d4*+10 major bodies)	

†Stellar evolution and Class can modify d12 Planet System Type result.

Paleodwarf	-10	Superdwarf	+5
Subdwarf	-5	Hyperdwarf	+10
Blue star	-<solar mass>		

*If d4 roll is 4, reroll d4 and add results together.

NOTE: If system star is Non-main sequence, assume system is Circumstellar disk.

Sometimes more than two stars can be gravitationally bound together, forming trinary or larger groups. Within these multiple star groups, individual stars typically pair up in various combinations: Binary pair orbited by a third star; central primary star orbited by binary pair; binary primary orbited by a second binary pair; and so forth. Generally, if an odd-numbered star orbits less than x5 the previous star's orbit, then the odd-numbered star and the previous star will orbit as a pair around their primary, centered at that orbital distance and orbiting each other at [Orbital distance/1d10*+1]; for every 10 rolled, reroll d10 and add the results together (cumulative).

Multi-star systems where two or more stars orbit the same primary in planet-like, non-binary orbits (multiplex stars) are possible when the primary star's mass is overwhelmingly greater than other stars in a low eccentricity system.

2.6 STAR PECULIARITIES

Age differences are not uncommon in stellar neighborhoods, since stars born in other regions intermingle as they orbit throughout the galaxy. Roll d10: 1 Much older, 2-5 Older, 6-9 Younger, 10 Much younger.

Carbon rich stars' protoplanetary disks had a higher carbon/oxygen ratio during formation, producing carbon systems and planets.

Cataclysms are unusual, destructive events that drastically affect a star system: Stellar instability, post-main sequence phase, rogue star or giant planet disrupting orbits, or a recent nearby supernova are just a few of the possibilities. To determine severity, roll d10: 1-2 Minor, 3-7 Major, 8-9 Extreme, 10 Ultimate.

2.5 MULTI-STAR SYSTEM

ROLL d4† FOR MULTI-STAR SYSTEM.

0	1d4 stellar companions (First companion orbit: 1d10**x20 AU) and roll d4 again for another stellar companion.
1-3	One stellar companion (Orbit: 1d10**x20 AU)
4	One stellar companion (Orbit: 1d10**x20 AU) and roll d4 again for another stellar companion.

†Blue stars modify first d4 Multi-Star System roll by -1.
**For every 1 rolled, reroll d10 and divide result by another 10 (cumulative). For every 10 rolled, reroll and multiply result by another 10 (cumulative).
NOTE: For odd-numbered companions, multiply orbit result by [previous pair orbit x 10].

ROLL d12 FOR COMPANION TYPE.

1	Same Star Type and Size
2-4	-1 Star Size
5-9	-2 Star Size
10-11	One lesser Star Type (Roll d8 for Star Class.)
12	Random Star Type (Roll d20 above for Star Type. Any result above primary is same type and size.)

ROLL d10† FOR ECCENTRICITY.

1	Slight (e = 1/[2d10*+20])
2-4	Minor (e = 1/[d10+10])
5-7	Moderate (e = 2/[d10+10])
8-9	Major (e = 5/[d10+10])
10 or more	Extreme (e = 10/[d10+10])

†Modify d10 Companion Eccentricity roll By +1 per companion above binary.

ROLL d10† FOR MULTI-STAR MAJOR BODIES

Circumbinary bodies: [1d10*/Total stars]/[Total forbidden orbits x Total forbidden orbits]
Circumstellar bodies: [1d10*/(Total stars x 2)]/[Total forbidden orbits x Total forbidden orbits]
†Star type and stellar evolution can modify d10 Multi-Star Major Bodies result.

Paleodwarf	-10	Red star	-2	White star	+1	Hyperdwarf	+5
Subdwarf	-5	Orange star	-1	Superdwarf	+2	Blue star	-<solar mass>

*For every 10 rolled, reroll d10 and add the results together (cumulative).
NOTE: If Multi-Star Major Body total is less than 1 or for bodies around any Non-main sequence star, consider the result a Debris disk (or empty if stellar orbits are too close, chaotic, etc.).

2.6 STAR PECULIARITIES

ROLL D100 FOR STAR PECULIARITIES.

Subdwarf	New	Red	Main	Blue	Giant	Multi	Remnant	Peculiarity
01-02	01	01-03	01-02	01	01	01	01	None
03-07	02-04	04-14	03-07	02-02	02-04	02-06	01-09	Age difference
08-29	05-09	15-19	08-09	03-04	05-14	07-10	10-19	Carbon rich
30-34	10-12	20-24	10-14	05-19	15-29	11-15	20-34	Cataclysm
35-39	13-24	25-34	15-19	20-24	30-39	16-39	35-44	Chaotic orbits
40-44	25-34	35-39	20-29	25-29	40-44	40-49	45-49	Debris density
45-49	35-44	40-43	30-34	30-39	45-49	50-59	50-59	Excessive radiation
50-52	45-54	44-47	35-39	40-59	50-59	60-64	60-69	Nebula
53-69	55-64	48-49	40-44	60-69	60-64	65-69	70	Powerful stellar wind
70-86	65-71	50-54	45-64	70-74	65-69	70-74	71-79	Rotation anomaly
87-89	72-76	55-64	65-74	75-79	70-74	75-84	80-92	Strong magnetic field
90-95	77-79	65-69	75-89	80-84	75-79	85-89	93	Unusual metallicity
95-97	80-96	70-98	90-97	85-96	80-96	90-97	94-96	Variable star
98-99	97-98	99	98-99	97-98	97	97-99	97	Roll twice
00	99-00	00	00	99-00	98-00	00	98-00	Special

Chaotic orbits of stars and planets are variably aligned to the ecliptic plane. Assume all chaotic systems are also eccentric, plus divide major body totals in half (minimum 1 unless total was already none). For each orbiting object, roll d10: 1 (1d10*+50 degrees), 2-3 (1d10*+20 degrees), 4-8 (1d10* degrees), 9-10 (1d10*+10 degrees); for every 10 rolled, reroll d10 and add the results together (cumulative).

Debris density is an unusual mass level of dust, ice, and planetesimals scattered throughout a star system. Roll d10: 1 Much lower, 2-5 Lower, 6-9 Higher, 10 Much higher.

Excessive radiation strongly affects planetary habitability, atmospheres, and volatile compositions. Assume all close planets and any solid inner planets without strong magnetic fields lack volatiles and none roll for secondary volatiles during planet generation.

Nebulae are regions of gas and dust visible from the star system. Roll d10 for apparent size: 1-4 Tiny, 5-7 Small, 8-9 Large, 10 Dominant.

Powerful stellar winds shorten the lifespan of main sequence stars. Roll d10: 1 Much slower, 2-5 Slower, 6-9 Faster, 10 Much faster.

Rotation anomalies often result from unusual magnetic field strength and stellar age. Roll d10: 1 Much slower, 2-5 Slower, 6-9 Faster, 10 Much faster.

Strong magnetic field charges the interplanetary space around a star, providing stronger defense against cosmic radiation but also increasing the likelihood of powerful solar flares. Stars with this characteristic tend to be brighter and rotate faster.

Unusual metallicity can affect the evolutionary type of a star. Roll d10: 1 Much lower, 2-5 Lower, 6-9 Higher, 10 Much higher.

Variable stars significantly change luminosity. For small stars this typically occurs because of major sunspots or extreme solar flares, whereas large and giant star instabilities can cause them to periodically swell and shrink. Temperature zones around these stars are unstable.

MAIN SEQUENCE LUMINOSITY (solar) AND LIFETIME (years) OF DWARF STARS

STAR TYPE (mass)	LUMINOSITY	MAIN SEQUENCE	POST-MAIN SEQUENCE	REMNANT
Red dwarf (1/16)	1/10000	50 trillion	Blue dwarf	White dwarf
Red dwarf (1/12)	1/5000	20 trillion	Blue dwarf	White dwarf
Red dwarf (1/10)	1/2000	15 trillion	Blue dwarf	White dwarf
Red dwarf (1/8)	1/1000	10 trillion	Blue dwarf	White dwarf
Red dwarf (1/7)	1/750	7 trillion	Red subgiant	White dwarf
Red dwarf (1/6)	1/500	5 trillion	Red subgiant	White dwarf
Red dwarf (1/5)	1/200	3 trillion	Red subgiant	White dwarf
Red dwarf (1/4)	1/100	2 trillion	Red subgiant	White dwarf
Orange dwarf (dim)	1/50	100 billion	Red giant	White dwarf
Orange dwarf (standard)	1/10	50 billion	Red giant	White dwarf
Orange dwarf (bright)	1/5	20 billion	Red giant	White dwarf
Yellow dwarf (dim)	1/2	15 billion	Red giant	White dwarf
Yellow dwarf (standard)	1	10 billion	Red giant	White dwarf
Yellow dwarf (bright)	2	5 billion	Red giant	White dwarf
White star (dim)	5	4 billion	Red giant	White dwarf
White star (standard)	10	3 billion	Red giant	White dwarf
White star (bright)	50	2 billion	Red giant	White dwarf
Blue star (4)	100	1 billion	Bright red giant	White dwarf
Blue star (5)	200	700 million	Bright red giant	White dwarf
Blue star (6)	500	500 million	Bright red giant	White dwarf
Blue star (7)	750	200 million	Bright red giant	White dwarf
Blue star (8)	1000	100 million	Bright blue giant	Neutron star
Blue star (12)	5000	50 million	Bright blue giant	Neutron star
Blue star (16)	10,000	20 million	Red supergiant	Neutron star
Blue star (20)	20,000	15 million	Red supergiant	Neutron star
Blue star (24)	50,000	10 million	Red supergiant	Neutron star
Blue star (32)	100,000	5 million	Red supergiant	Neutron star
Blue star (48)	200,000	2 million	Red supergiant	Neutron star
Blue star (64)	500,000	1 million	Blue supergiant	Neutron star
Blue star (128)	1,000,000	???	Red hypergiant	Neutron star
Blue star (256+)	5,000,000	???	Blue hypergiant	Black hole

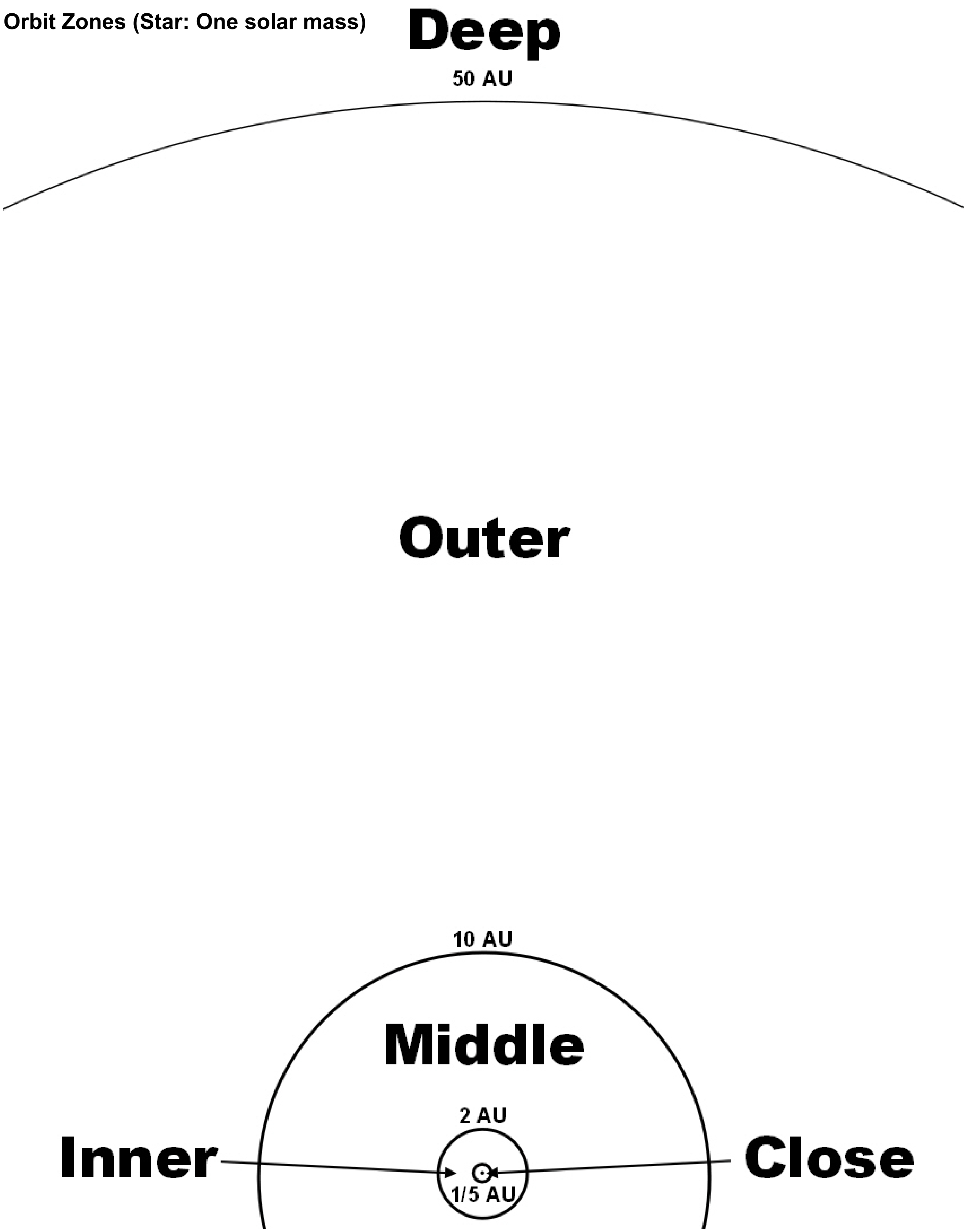
NOTE: Metallicity affects main sequence lifespan.

Paleodwarf (Population III)	-50%	Superdwarf (Late Population I)	+20%
Subdwarf (Population II)	-20%	Hyperdwarf (Population 0)	-20%

POST MAIN SEQUENCE LUMINOSITY

Star/Remnant	Luminosity	Note
Neutron star	1/10000 to 1/1000000	1-3 solar masses at about 1/1000 earth radius.
White dwarf	1/100 to 1/1000	0.2 to 1.33 solar mass and about 1 earth radius.
Blue dwarf	1/5 to 1	0.2 to 0.5 solar radii.
Red subgiant	100 to 10,000	5-50 solar radii.
Red giant	1000 to 10,000	20-100 solar radii.
Bright red giant	10,000 to 100,000	50-500 solar radii.
Bright blue giant	100,000 to 1,000,000	5-50 solar radii.
Red supergiant	200,000 to 2,000,000	500-1000 solar radii.
Blue supergiant	10,000 to 1,000,000	10-100 solar radii.
Red hypergiant	100,000 to 2,000,000	Over 1000 solar radii, highly unstable star.
Blue hypergiant	1,000,000 or more	100-500 solar radii, highly unstable star.

Orbit Zones (Star: One solar mass)



3.1 SYSTEM CARBON/OXYGEN RATIO

In systems with more oxygen relative to carbon, rocky planets tend to be made up of silicates and ice planets primarily form from water. Dwarf main sequence stars most often have oxygen-rich systems.

Where carbon predominates, carbides and graphite replace rock to form carbon planets. Water is scarce, so ice planets tend to be less common and are made of ammonia, methane, and carbon monoxide instead. Both metal-poor and metal-rich stars, as well as post main sequence stars and stellar remnants tend to form carbon systems.

3.2 SYSTEM ARCHITECTURE

Compact and **standard** systems are the most common planetary arrangements found in the universe. Their belts are denser and the outer regions (Kuiper belt and scattered disk) are more heavily populated.

Scattered systems most often occur when a massive body orbits either very close or very far away from the primary star, limiting the natural inward migration of planets. Any belts and fields are much less dense and outer orbits have low populations of objects.

Eccentric systems most often form in multi-star systems or when early planetary migration was chaotic. Although orbits can initially intersect, these interactions smooth out as planetary systems age either through natural lessening of eccentricity or ejection of one of the bodies.

For circumstellar planets in multi-star systems, assume result is Eccentric and reroll System Architecture depending on the orbit location of the secondary star:

Deep:	1d10-1
Outer:	1d10-3
Middle:	1d10-5
Inner/Close:	Compact System

For circumbinary planets, assume Scattered System Architecture and multiply the First body orbit result by [Apoapsis x 5].

3.1 SYSTEM CARBON/OXYGEN RATIO

ROLL d10† FOR CARBON/OXYGEN RATIO.

-5 or less	Carbon-rich
-4 to 9	Oxygen-rich
10 or more	Carbon-rich

†Stellar evolution can modify Carbon/Oxygen ratio.

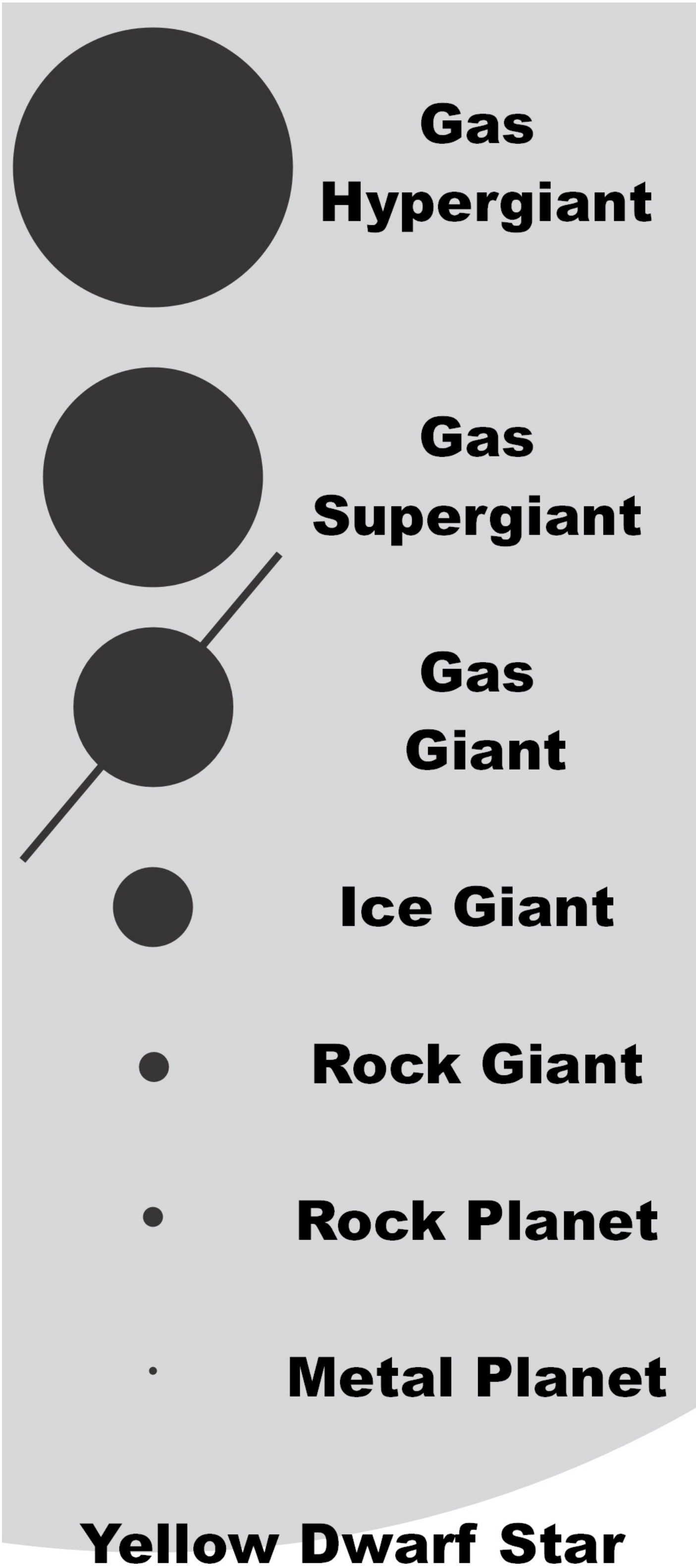
Paleodwarf	-10	Superdwarf	+2
Subdwarf	-5	Hyperdwarf	+5
White dwarf	+5	Neutron star	+10

3.2 SYSTEM ARCHITECTURE

ROLL d10 FOR PLANET SYSTEM ARCHITECTURE.

1-4	Compact system: First body = [1/(d10 x d10)] x [Star Mass] AU	
5-7	Standard system: First body = [1d10/20] x [Star Mass] AU	
8-9	Scattered system: First body = [1d10/5] x [Star Mass] AU	
10	Eccentric system (Roll d10-1 System Architecture, then roll d10 for eccenticity of each body.)	
	1-4	Minor (e = 1/[d10+10])
	5-7	Moderate (e = 2/[d10+10])
	8-9	Major (e = 5/[d10+10])
	10	Extreme (e = 10/[d10+10])

NOTE: For multi-star systems, assume for circumstellar planets it is an Eccentric System and reroll System Architecture as d10-1 (Deep), d10-3 (Outer), d10-5 (Middle), or assume Compact System Architecture if stars are closer than Middle Zone. For circumbinary, assume Scattered System Architecture and multiply the First body result by [Apoapsis x 5].



3.3 PLANETARY BODIES

For each massive gas or ice planet that orbits closer than Middle Zone, roll the following die once for Inner Zone or twice for Close Zone, round result down, then subtract any whole number result from system major bodies total. This new total cannot be less than the number of bodies that already exist in the system.

10-99 Me =	1d10/10
100-999 Me =	1d10/5
1000+ Me =	1d10/2.

DISKS, BELTS & CLOUDS

Circumstellar/debris disk is dust and debris extending [1d10*x10 x Star Mass] AU radius around a star. Any planet orbiting within it will clear a path, dividing the debris disk into prominent rings.

Dust belts consist of small particles pervading the space between planets [width = 1d10*/(Orbital radius) AU]. This dust scatters stellar light (called zodiacal light, which is confined to the ecliptic plane) and produces thermal emission. An **ash belt** is a belt of very fine particles. A **frost belt** is a belt of ice particles.

Asteroid belts are regions of a solar system between two major bodies occupied by numerous asteroids and minor planets. They usually form from the primordial solar nebula as a group of planetesimals with too much orbital energy for them to accrete into a planet. Most individual asteroids fall into four basic groups: carbonaceous (carbon-rich), silicate (rocky), icy, and metallic. If not between two major bodies' orbits, assume belt fills the rest of orbital zone. **Meteoroid belts** have more metal-rich asteroids than average. **Ore belts** mostly consist of tiny, metal-rich asteroids.

Comet belts are mostly ice-rich asteroids, with **comet clouds** orbiting in a sphere around the star. Rare **gas belts** are dense, violent, gas-rich comet belts and **gas clouds** similarly populated comet clouds.

3.3 PLANETARY BODIES

ROLL d12 FOR MAJOR BODY TYPE.

INNER	MIDDLE	OUTER	TYPE (Roll d20† for major body subtype and roll d8 for mass)		
1-3	1	1	Metal body		
			1-6	Dust belt	
			7-8	Meteoroid belt	
			9-16	Metal dwarf: Me = [1d8*]/200	
			17-18	Metal planet: Me = [1d8]/20	
			19	Solid metal dwarf: Me = [1d8]/200	
			20	Rare metal body (Roll d20 for rare body type.)	
				1-10	Ore belt
				11-17	Metal giant: Me = [1d8*]/2
				18-19	Solid metal planet: Me = [1d8]/20
				20	Special
4-9	2-3	2-3	Rock body		
			1-2	Debris disk	
			3-6	Asteroid belt	
			7-10	Rock dwarf: Me = [1d8*]/100	
			11-15	Rock planet: Me = [1d8*]/10	
			16-19	Rock giant: Me = 1d8+1	
			20	Rare rock body (Roll d20 for rare body type.)	
				1-10	Ash belt
				11-17	Coreless rock planet: Me = [1d8]/10
				18-19	Rock supergiant: Me = $[1d8+2]^2$
				20	Special
10-11	4-6	4-10	Ice body		
			1	Frost belt	
			2-3	Comet belt	
			4-5	Coreless ice dwarf: Me = [1d8]/200	
			6-8	Ice dwarf: Me = [1d8*]/200	
			9-13	Ice planet: Me = 1d8*/10	
			14-19	Ice giant: Me = 2d8*	
			20	Rare ice body (Roll d20 for rare body type.)	
				1-4	Comet cloud
				5-14	Coreless ice planet: Me = 1d8/10
				15-19	Ice supergiant: Me = $[1d8^*+2]^2$
				20	Special
12†	7-12	11-12	Gas body		
			1-7	Gas planet: Me = 2d8	
			8-17	Gas giant: Me = 2 x $[(1d8+1)^2]$	
			18-19	Gas supergiant: Me = 2 x $[(1d8+2)^3]$	
			20	Rare gas body (Roll d20 for rare body type.)	
				1	Gas cloud
				2-5	Gas belt
				6-15	Gas hypergiant: Me = 1d8*x500
				16-19	Substar: Me = 1d8*x2000
				20	Special

†Star Class can affect Major Body Type d20 roll.
Orange star -1 White star +1 Blue star -<mass>
Red star -2 (supergiant = giant; hypergiant = supergiant)
Brown star -5 (supergiant/hypergiant/substar = giant)

NOTE: For carbon-rich systems, all bodies that are not beyond Middle orbit use the Inner Major Body Type table; the Middle Major Body Type table is not used.

3.3 PLANETARY BODIES (continued)

WORLDS

Metal bodies consist primarily of an iron-rich core with little or no mantle (**solid metal dwarf/ planet**). Iron-rich planets are smaller and more dense than other types of planets of comparable mass. Such planets usually have weak magnetic fields (if any) and no geologic activity, especially at higher planetary masses. Since water and iron are unstable over geological timescales, wet iron planets in the habitable zone may be covered by lakes of iron carbonyl and other exotic volatiles rather than water.

Very hot metal bodies have a molten crust (lava metal planet), at super hot even iron melts (molten metal planet), and by ultra hot iron boils (boiling metal planet).

A **rock body** has a solid surface composed primarily of silicate rocks or metals. Except for **coreless rock planets**, they have a mostly iron core with a surrounding silicate mantle and outer crust.

Rock bodies below one earth mass (Me) have thin atmospheres and, unless affected by strong tidal interactions, tend to have little to no geological activity or magnetic fields. Between 1 and 5 Me, active geology and a strong magnetic field help retain a moderate atmosphere. Geological activity and terrain variability become less between 5-10 Me due to thicker crust; some cores may be too viscous to generate strong magnetic fields to protect the planet's otherwise thick atmosphere. Beyond 10 Me, a rock planet without hydrogen/helium volatiles will have a dense atmosphere above a featureless terrain, with a weak or strong magnetic field; otherwise, a crushing atmospheric envelope of gas and clouds will dominate the planet (gas dwarf).

Very hot rock bodies have a molten crust (lava planet), by super hot even iron melts (slag planet), and at ultra hot iron boils (furnace planet).

In very metal-rich and very metal-poor star systems, rock bodies often form as **carbon planets** (with carbide rocks and graphite instead of silicates). Water and carbon dioxide are extremely rare in such systems, replaced by carbon monoxide, hydrogen, methane and other hydrocarbons, with hydrospheres of oil and tar.

Ice bodies have an icy mantle (mostly water, possibly with ammonia, methane, and/or other volatiles) overlying a rocky core (excepting **coreless ice dwarfs/planets**). Sufficiently massive or tidally-affected ice planets may have subsurface liquid oceans. Atmospheres tend to be thicker than rock worlds when temperatures are high enough for volatiles to be gases; otherwise, volatiles form a frozen crust (with hydrosphere in certain temperature ranges).

Within the moderate zone, the ices melt to form a global ocean and thicker atmosphere (ocean dwarf/planet/giant). Orbiting closer than that, the ocean becomes supercritical, without any clear boundary between hydrosphere or atmosphere (steam dwarf/planet/giant).

Ice giants often have dense envelopes of hydrogen and helium that crush the ice below into supercritical liquid phases. This ionized ocean generates a strong, often off-axis magnetic field.

A **gas body** is a planet composed mainly of hydrogen and helium. The outermost portion of the dense hydrogen envelope includes many layers of mostly water and ammonia clouds. This massive atmosphere surrounds a layer of liquid metallic hydrogen, with a molten rocky core at its center. Their magnetic fields can be exceptionally strong, especially for more massive **gas supergiants**.

Substellar objects (**substars**, also known as brown dwarfs) are occupy the mass range between the heaviest gas giants and the lightest stars. Substars above 5000 Me may fuse deuterium and those above 20,000 Me might fuse lithium as well.

3.4 ORBITS

System architecture, eccentricity, and the mass of the previous planet influence the orbit of the next body outward. This result is multiplied by the current orbital radius to determine the next orbit.

3.4 ORBITS

ROLL d4 AND d6 FOR NEXT PLANET ORBIT.
Previous planet orbit distance x [1 + ({1d6+1d4}/10)]
NOTE: Add all applicable modifiers to the total numerator result.

Compact system	-1
Scattered system	+1
Minor eccentricity	+1
Moderate eccentricity	+2
Major eccentricity	+3
Extreme eccentricity	+4
Body is 100 Me	+1
Body is 1000 Me	+2
Body is 10000 Me	+3

3.5 PLANET PECULIARITIES

SPECIAL FEATURES

Volatile poor bodies have one lower density level than what is rolled. **Volatile rich** bodies have one density level higher than rolled.

Slow rotation bodies roll one level lower than rolled, whereas bodies with **fast rotation** roll one level higher.

Minimal axial tilt bodies rotate at 1d10-1 degrees relative to the orbital plane.

Extreme axial tilt bodies rotate at 40 + (1d100/2) degrees relative to the orbital plane.

Smaller core bodies are less dense and have lower gravity. **Larger core** bodies are denser and possess greater gravity.

Geologically dead bodies never had any native volcanism or tectonic activity after they were formed. Aside from atmospheric effects and outside events, impact craters form the vast majority of all landform variation. For gas bodies, consider this “weak magnetic field”.

Geologically extinct bodies had volcanism and possibly tectonic activity in the past, but have little if any at present. Mountains, volcanoes, valleys, and other landforms exist along with impact craters not erased by atmospheric weathering. For gas bodies, consider this “mild weather”.

Geologically active bodies currently experience volcanism and tectonics, although the mechanism driving it varies depending on type of body (molten interior of a rocky planet, the liquid beneath the icy crust of an ice world, tidal heating from orbital effects, etc). Rocky and metal planets with geological activity often also possess magnetic fields. For gas bodies, consider this “violent weather”.

Magnetic fields deflect stellar wind from the orbital body, preventing erosion of volatiles and allowing a long-lasting atmosphere to remain. For rocky planets between 1-5 Me, ice giants or greater, and all gas planets, a magnetic field is intrinsic, so this result implies an unusual field strength. Roll d10: 1-2 Much weaker, 3-5 Weaker, 6-8 Stronger, 9-10 Much Stronger.

Less dense bodies have less gravity than usual for their size. **More dense** bodies have greater gravity for their size.

Generally flat terrain on a solid body implies a surface with less variation in elevation than typical for its mass and geological activity. For planets with dense gas envelopes, consider this result "calm weather" instead.

Highly varied terrain means the surface of a solid body has much greater differences in elevation and landform than typical for its type. Gas planets and others with dense gas envelopes have "very violent weather".

3.5 PLANET PECULIARITIES

ROLL d100 FOR PLANET FEATURES.

DWARF	PLANET	GIANT	SUPER+	FEATURE
01-09	01-04	01-02	01	Volatile poor
10-14	05-14	03-29	02-17	Volatile rich
15-24	15-19	30-32	18-19	Slow rotation
25-29	20-24	33-37	20-29	Fast rotation
30-39	25-29	38-40	30-34	Minimal axial tilt
40-44	30-34	41-49	35-39	Extreme axial tilt
45-49	35-39	50-53	40-44	Smaller core
50-54	40-42	54-55	45-46	Larger core
55-59	43-44	56-59	47-54	Geologically dead
60-67	45-49	60-69	55-59	Geologically extinct
68-69	50-64	70-74	60	Geologically active
70-74	65-76	75-79	61-79	Magnetic field
75-79	77-81	80-84	80-84	Less dense
80-84	82-86	85-87	85-86	More dense
85-89	87-89	88-96	87-97	Generally flat terrain
90-98	90-98	97-98	98	Highly varied terrain
99	99	99	99	Roll twice
00	00	00	00	Special feature

ROLL d100 FOR NATURAL SATELLITES.

01-24	None
25-39	Irregular moon (1d10* tiny moons)
40-69	Minor moon (1d10*/2 dwarf moons)
70-84	Major moon (1d10*/5 moons)
85-89	Giant moon OR two major moons
90+	Ring system (with 1d10*x1d10 moonlets) OR two major moons OR one giant moon
99	Roll twice
00	Special satellite

NOTE: Modify each roll according to orbit zone. Close = -50 (d100)/-5 (d10); Inner -20 (d100)/-2 (d10); Middle +50 (d100)/+5 (d10); Outer +20 (d100)/+2 (d10); Deep +0 (d100)/+0 (d10).

ROLL d100 FOR ROTATION PERIOD.

01-04	Tidal locked (day = orbital period)
05-19	Resonant (orbital period x 1d10*/3)
20-29	Very long (10000/1d6* hours)
30-39	Long (1d10*+5 x 1d10*+5 hours)
40-69	Medium (1d10*+20 hours)
70-99	Short (1d10+10 hours)
99	Very short (1d10+2 hours)
00	Special rotation period

NOTE: Orbit zone and planet mass affects d100 Rotation roll.

Close orbit	-100	Inner orbit	-50	Above 50 Me	+50
Below ½ Me	+10	10-49 Me	+20		

ROLL d100 FOR AXIAL TILT.

Close orbit: 1d100*/5 degrees
Middle orbit: 1d100*/3
Inner orbit: 1d100*/4
Outer/Deep orbit: 1d100*/2

*On a roll of 100, roll again and add the results together before dividing.

3.5 PLANET PECULIARITIES (continued)

NATURAL SATELLITES

Roll once for dwarfs, twice for planets, three times for giants, four times for supergiants, five times for hypergiants, and six times for substars.

Every extra time a ring system is rolled, consider that body's rings to be that much more extensive or unusual.

If greater detail is desired, moon systems can utilize the same tables as planets with a few changes. Roll d12 Major Body Type table just like a planet, but do not use d20 subtables. Gas body results are ice bodies with significant volatiles (possible atmospheres and hydrospheres); consider 12 a Special moon type. Skip the d100 Natural Satellite roll.

Moon system AU = planet radius (Rp)
NOTE: If orbit is less than 50 Rp, moon rotation is tidally locked.
Irregular moon: d100*/[d100xd100 thousand] Me
Moonlet: 1/d10* billion Me
Minor moon: d10*/d10 million Me
Major moon: d10*/d10 thousand Me
Giant moon: d10*/d10 tenths Me

ROTATION PERIOD

Bodies with faster rotation tend to have greater temperature and (if an atmosphere is present) weather variation. Planets with slower rotation rates (especially tidal locking when the orbital period is greater than a few weeks) usually have weaker magnetic fields as well.

AXIAL TILT

Much like rotation period, a body's axial tilt affects temperature, weather, and seasonal variations, although it does not usually reflect any difference in magnetic field strength.

ROUGH CALCULATIONS FOR PLANETS

PLANET MASS/RADIUS CHART

Body Mass (Me) (earth masses)	**Body Radius (earth radii/Re) Gas**	**Ice**	**Rock**	**Metal**
SUBPLANETARY				
0.0000000001	—	0.003	0.002	0.0015
0.0000000002	—	0.004	0.003	0.002
0.0000000005	—	0.006	0.004	0.003
0.000000001	—	0.008	0.006	0.004
0.000000002	—	0.01	0.008	0.006
0.000000005	—	0.011	0.01	0.008
0.00000001	—	0.012	0.011	0.01
0.00000002	—	0.013	0.012	0.011
0.00000005	—	0.015	0.013	0.012
0.0000001	—	0.016	0.015	0.013
0.0000002	—	0.018	0.016	0.015
0.0000005	—	0.02	0.018	0.016
0.000001	—	0.025	0.02	0.018
0.000002	—	0.03	0.025	0.02
0.000005	—	0.035	0.03	0.025
0.00001	—	0.04	0.035	0.03
0.00002	—	0.05	0.04	0.035
0.00005	—	0.06	0.05	0.04
PLANETARY				
0.0001	—	0.08	0.06	0.05
0.0002	—	0.1	0.08	0.06
0.0005	—	0.12	0.1	0.08
0.001	—	0.15	0.12	0.1
0.002	—	0.2	0.15	0.12
0.005	—	0.25	0.2	0.15
0.01	—	0.3	0.25	0.2
0.02	—	0.4	0.3	0.25
0.05	—	0.5	0.4	0.3
0.1	1.5	0.6	0.5	0.4
0.2	2	0.8	0.6	0.5
0.5	3	1	0.8	0.6
1	3.5	1.2	1	0.8
2	4	1.5	1.2	1
5	5	2	1.5	1.2
10	7	3	2	1.5
20	8	4	2.2	2
50	9	4	2.5	2.2
SUPERPLANETARY				
100	10	4	2.8	2.3
200	11	4	3	2.5
500	11	4	3	2.6
1000+	11	4	3	2.8

GRAVITY CALCULATION

Mass / [Radius]^2 = Gravity (g)

PLANET ORBIT PERIOD CALCULATION

Square Root of [(Orbit Radius AU)^3] = Years

3.6 VOLATILES

DENSITY

Depending on the state of matter of the constituent molecules, volatiles present on an orbital body comprise its cryosphere (frozen surface), hydrosphere (liquid surface), and atmosphere (gaseous envelope). If all are frozen or gaseous, then the Volatile Density reflects the relative cryosphere or atmosphere thickness, respectively. When each is in a different state, use the following rule of thumb to determine density level:

Dominant: Same density
Main (main with major): One level lower
Major (main with major): Two levels lower
Minor (in parenthesis): Three levels lower

Many volatiles can be liquid at certain temperature ranges, but only when an atmosphere of sufficient pressure exists; otherwise it is a gas.

COMPOSITION

Negligible: Only trace amounts of elements and molecules beyond those that make up the orbital body exist.

Carbon dioxide with oxygen (sulfur dioxide): Although carbon dioxide is a white ice from cold zone orbits outward, a very thin atmosphere of oxygen will still exist except on ultra cold or frozen bodies. From moderate/cold zone inward, the greenhouse effect of gaseous carbon dioxide will increase the body's temperature at least one level (one for thin atmosphere, two for moderate, three for thick, etc). If sulfur dioxide is also present, it forms a white frost when at least cold, but evaporates into highly reflective yellow-white clouds on warmer bodies, slightly reducing any greenhouse effect; it also scatters sunlight, reducing the illumination that reaches the surface and minimizing global temperature variations. In all circumstances with gaseous oxygen, solar radiation will produce an ozone layer.

Carbon dioxide dominant (sulfur dioxide): A cold or colder body will have a tenuous atmosphere of carbon dioxide created from sublimation by stellar ultraviolet light, dominated by sulfur dioxide if present. When carbon dioxide becomes gaseous, bodies are much like the above entry, except with a negligible ozone layer.

Carbon dioxide with nitrogen (methane): Since the freezing point of nitrogen is only slightly higher than oxygen, bodies with this volatile composition are very similar to carbon dioxide with oxygen worlds, just with a minimal ozone layer. When methane is present, it is ice very cold zone orbits. Otherwise, it remains a greenhouse gas that stellar radiation breaks down into a hazy, hydrocarbon smog.

Carbon dioxide with water & nitrogen (methane, ammonia, or both): Water is liquid at moderate temperatures and pressures, steam when hotter, and ice when colder. Although gaseous nitrogen helps to keep water from rising out of the lower atmosphere, moderate or warmer bodies less than 1 Me will still slowly lose it and dry out; when water reaches the upper atmosphere, ultraviolet radiation breaks it down into hydrogen and oxygen, the latter of which increases over time. Because of greenhouse effects, such bodies can have liquid water at farther than usual orbits, especially if there is methane (which is an even stronger greenhouse gas). Any ammonia present is frozen on cold bodies, but light enough to form cloud cover on warmer ones and will readily dissolve in liquid water and form ammonium hydroxide.

Water with oxygen (nitrogen): In moderate or warmer zones, water will escape through the atmosphere and become dissociated by ultraviolet radiation into hydrogen and oxygen until the planet becomes dry. Nitrogen in the atmosphere will slow this process, especially if the planet's temperature and escape velocity is at least Earth-equivalent. Of course, from the moderate/cold zone and beyond, water is frozen and the oxygen atmosphere is thinner with increasing distance from its star.

3.6 VOLATILES

ROLL d10 FOR VOLATILE DENSITY (relative atmospheric pressure).

2 or less	Trace (tenuous)
3-5	Very Poor (very thin)
6-7	Poor (thin)
8-9	Moderate (moderate)
10-12	Rich (thick)
13-14	Very Rich (very thick)
15 or more	Abundant (crushing)

NOTE: Modify d10 roll with all applicable modifiers.

No magnetic field	-5	Metal rich system	+1
Moon	-2	Metal poor system	-1
Close orbit	-2	Young system	+1
Inner orbit	-1	Old system	-1
Dwarf planet	-1	Ancient system	-2
1-2 Me	+1	Blue star	-<star mass>
3-5 Me	+2	Giant star	-3
6-9 Me	+3	Supergiant star	-4
10-19 Me	+4	Hypergiant star	-5
20+ Me	+5	Ice body	+2

ROLL d100 FOR VOLATILE COMPOSITION.

METAL	ROCK	ICE	CARBON	VOLATILES (Roll d10 for significant additional volatiles.)
01-04	01-09	01	01-10	Negligible
05-14	10-14	02-05	11	Carbon dioxide with oxygen (1-2 Sulfur Dioxide, 3-9 None, 10 Other)
15-39	15-44	06-09	12	Carbon dioxide dominant (1-4 Sulfur dioxide, 5-9 None, 10 Other)
40-59	45-54	10-14	13-15	Carbon dioxide with nitrogen (1-7 None, 8-9 Methane, 10 Other)
60-62	55-59	15-19	16	Carbon dioxide with water & nitrogen (1-5 None, 6-7 Methane, 8-9 Ammonia, 10 Methane and ammonia)
63	60-64	20-29	17	Water with oxygen (1-6 None, 7-9 Nitrogen, 10 Other)
64	65-69	30-39	18	Water with carbon dioxide & nitrogen (1-7 None, 8-9 Methane, 10 Other)
65-69	70-74	40-49	19	Nitrogen with water (1-6 None, 7-9 Ammonia, 10 Other)
70-89	75-84	50-64	20-39	Nitrogen dominant (1-4 None, 5-8 Water, 9-10 Water & ammonia)
90-92	85-87	65-72	40-59	Nitrogen with carbon monoxide (1-6 None, 7-9 Methane, 10 Other)
93-94	88-89	73-80	60-79	Carbon monoxide dominant (1-7 None, 8-9 Methane, 10 Other)
95	90	81-85	80-84	Neon dominant (1 None, 2-9 Hydrogen/Helium, 10 Other)
96-99	91-94	86-89	85-94	Helium dominant (1 None, 2-9 Hydrogen, 10 Other)
99+	95+	90+	95+	Hydrogen/helium dominant (1-9 None, 10 Other)
00	00	00	00	Special atmosphere (natural 00 only)

NOTE: If mass is above 1 Me, add [mass x 5] to d100 roll. If below 1 Me, subtract [inverse of mass].

Water with carbon dioxide & nitrogen (methane): Except when it is an ice on super cold or frozen worlds, nitrogen forms a very thin atmosphere over the frozen carbon dioxide and water of the body, with carbon dioxide overtaking its dominance at moderate/cold zones and contributing to global warming at those points as well. When liquid water or steam becomes dominant at moderate or greater temperatures, it begins to dissolve the carbon dioxide, which can also become trapped in rocks (markedly so in geologically active planets). Nitrogen also mitigates the escape of unfrozen water from the atmosphere, especially on Earth-mass or greater planets, creating a water weather cycle. Any gaseous methane component will form a hydrocarbon haze that also increases the greenhouse effect another level.

3.6 VOLATILES

COMPOSITION (continued)

Nitrogen with water (ammonia): Nitrogen is a gas except in very cold or frozen zones and will form an atmosphere around even dwarf-sized bodies. Where water is liquid, nitrogen slows its escape from lighter bodies and prevents it for 1 Me or greater mass planets. Ammonia freezes at cold temperatures and below, is liquid at moderate/cold temperatures, and dissolves to become ammonium hydroxide in liquid water.

Nitrogen dominant (water or water and ammonia): This volatile composition is similar to the one above, except that if water and/or ammonia are present, the fractions are much lower.

Nitrogen with carbon monoxide (methane): In very cold or colder zones, nitrogen and carbon monoxide form ices at nearly the same temperature, with carbon monoxide freezing just before and boiling just after nitrogen; in very narrow temperature ranges carbon monoxide may be liquid under a nitrogen atmosphere. From cold zones inward both are gases. Where present, methane forms a cryosphere in very cold temperatures and produces hydrocarbon smog when moderate/cold or warmer. In cold environments, a hydrocarbon weather cycle may exist, with rivers, lakes, and seas of oils and tar.

Carbon monoxide dominant (methane): Carbon monoxide freezes in super cold zones and is gaseous when warmer. Any methane present will be ice when at least very cold, liquid at cold temperatures, and a gaseous smog when warmer.

Neon dominant (hydrogen/helium): Except in the frozen outer reaches of a solar system, neon will form an atmosphere, quite often mixed with hydrogen and helium. If the hydrogen/helium component is sufficiently thick and within a very narrow temperature range, neon can liquify. In the farthest zones, hydrogen can liquefy and even freeze, but helium will always remain gaseous. Atmospheric escape of these gases is inevitable for bodies less than 2 Me with higher than cold temperatures.

Helium dominant (hydrogen): Helium remains gaseous in all orbital zones, since all other volatiles freeze long before it can reach temperatures low enough to liquefy and it only becomes solid at near absolute zero under extreme pressure. Any hydrogen present will be a gas except at the edge of frozen zones, where it can liquefy, or a solid when super frozen.

Hydrogen/helium dominant: All planets and even large moons begin with an atmosphere of hydrogen and helium, but any bodies less than 2-3 Me with higher than cold temperatures will rapidly lose these gases through atmospheric escape. Hydrogen ice can form at super frozen temperatures, but most bodies massive enough to retain these gases also generate enough internal heat to prevent this. Under all circumstances helium remains gaseous. Significant traces of water, ammonia, methane, and other volatiles and gases exist in these atmospheres, often forming high altitude clouds.

EQUILIBRIUM TEMPERATURE ZONES

TEMPERATURE ZONE	MAXIMUM ORBITAL RADIUS FROM STAR (AU) Red-	Red	Red+	Orange	Yellow	White	White+	Blue (4)	Blue (8)	Blue (16)
CLOSE ORBITS	**0.01**	**0.02**	**0.05**	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**
Ultra Hot	0.0005	0.001	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5
Super Hot	0.001	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5	1
Very Hot	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5	2	5
Hot	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10
INNER ORBITS	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**	**20**	**50**	**100**
Moderate/Hot	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20
Moderate	0.05	0.1	0.2	0.5	1	2	5	10	20	50
Moderate/Cold	0.1	0.2	0.5	1	2	5	10	20	50	100
MIDDLE ORBIT	**0.5**	**1**	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**
Cold	0.5	1	2	5	10	20	50	100	200	500
OUTER ORBITS	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**	**2000**
Very Cold	1	2	5	10	20	50	100	200	500	1000
Super Cold	1.5	3	7.5	15	30	75	150	300	750	1500
DEEP ORBITS	**2+**	**5+**	**10+**	**20+**	**50+**	**100+**	**200+**	**500+**	**1000+**	**2000+**
Ultra Cold	5	10	20	50	100	200	500	1000	2000	5000
Frozen	20	50	100	200	500	1000	2000	5000	10,000	20,000
Super Frozen	200	500	1000	2000	5000	10,000	20,000	50,000	100,000	200,000
Cryogenic	200+	500+	1000+	2000+	5000+	10,000+	20,000+	50,000+	100,000+	200,000+

NOTE: Red- stars are below 1/8 Ms; red+ stars are 1/5 or ¼ Ms; white+ stars are bright white stars.

MATTER STATES IN TEMPERATURE ZONES

Ultra Hot: Metal vaporizes.
Super Hot: Rock vaporizes, metal melts.
Very Hot: Rock melts, metal solidifies (except lead).
Hot: Lead melts, rock solidifies.
Moderate/Hot: Water vaporizes.
Moderate: Water liquefies.
Moderate/Cold: Water freezes.
Cold: CO_2, sulfur dioxide & ammonia freeze.
Very Cold: Methane freezes.
Super Cold: Nitrogen and carbon monoxide freeze.
Ultra Cold: Oxygen freezes.
Frozen: Neon freezes.
Super Frozen: Hydrogen freezes.
Cryogenic: Helium liquefies.

LIQUID RANGE (Kelvin)

Atmospheric pressure = Moderate

Carbon:	3900*
Metal:	1600-2500+
Rock:	1300+
Lead:	600-2000
Water:	273-373
Sulfur dioxide:	201-263
Ammonia:	195-240
Carbon dioxide	215*
Methane:	90-112
Oxygen:	54-90
Carbon monoxide:	68-82
Nitrogen:	63-77
Neon:	24-27
Hydrogen:	14-20
Helium:	1-4**

*Only liquid under very thick or crushing pressures.

**Almost never liquid in nature since no other gas remains unfrozen at such low temperatures.

Almost all life in the universe owes its existence to the unique properties of liquid water and the easy reactivity of carbon molecules.

4.1 NATIVE LIFE

Certain factors improve the chance for native life to emerge on a world: A stable star, liquid water, and protection from hard radiation are but a few. No matter what form, though, life starts simple, potentially increasing in complexity over billions of years, and under rare circumstances producing a species capable of intelligent self-direction.

Start with the Basic Life table and roll all applicable dice. Should all of them come up 1's, roll on the Complex Life table to determine if such creatures developed on that world. Only if all those dice also roll 1's can you check to see if Intelligent Life arose.

Alien creatures indicated by this test could take myriad shapes. Often the similarities between lifeforms can be as surprising as the differences.

4.1 NATIVE LIFE

BASIC LIFE (Roll all applicable dice. If all results are 1, then basic life is native to the world.)

d4	Baseline chance
d6	Not moderate zone
d8	Not main sequence star
d10	Planet less than 500 million years old
d12	No oxygen/carbon dioxide/methane in atmosphere
d20	No liquid water
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	No magnetosphere
d100	Insignificant atmosphere
d100	Carbon system
d100	Gas planet
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star)

COMPLEX LIFE (If basic life is native to a world, roll all applicable dice. If all results are 1, then complex life is also native.)

d10	Baseline chance
d6	No magnetic field
d8	Not yellow/orange/red main sequence star
d12	No oxygen/carbon dioxide/methane in atmosphere
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	Insignificant atmosphere
d100	Variable/flare star
d100	Carbon system
d100	Gas planet
d100	Planet less than 2 billion years old
d100	Planet less than 500 million years old (Roll in addition to all previous age factors)
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star)
d100	Adjacent to belt
d100	High debris density
d4	Not moderate zone
d20	No liquid water

INTELLIGENT LIFE ((If complex life is native to a world, roll all applicable dice. If all results are 1, then intelligent life also arose.)

d100	Baseline chance
d100	No magnetic field
d100	Not yellow main sequence star
d100	No oxygen/carbon dioxide/methane in atmosphere
d100	Adjacent to belt
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	Insignificant atmosphere
d100	Variable/flare star
d100	Planet less than 4 billion years old
d100	Planet less than 2 billion years old (Roll in addition to all previous age factors)
d100	Planet less than 500 million years old ((Roll in addition to all previous age factors)
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star.)
d100	Not moderate zone
d100	No liquid water
d100	Carbon system
d100	High debris density
d100	Gas planet

4.2 COLONIZATION

INTERPLANETARY

In time, a native intelligent species may master science well enough to become a spacefaring civilization. Objects and passengers are first sent into orbit around the homeworld, then launched out to the other worlds of the star system. With the vast resources and territories of the star system available, increasing numbers of settlements, space stations, and habitats are constructed to meet the demands of an ever-growing, interplanetary population. Rings of artificial satellites and megastructures eventually orbit the star, growing into a circumstellar, spheroidal swarm in the oldest, richest, and most heavily developed systems.

Add +1 to total Development roll per century of interplanetary capability.

Using the Interplanetary table can also determine the level of development for each orbital body and zone in a system. Roll one die higher if the civilization is Stellar or two dice higher if Galactic. Assume description applies to the zone or planet, any of its moons, and the nearby space around it.

PRE-STELLAR

Starting from the home system, every star surrounding it will steadily be colonized, with successive waves of colonization reaching outward from these younger settlements. Though travel between star systems often takes decades with sublightspeed technology, a determined species can still completely populate a major galaxy within a few million years. Isolated by the impracticality of interstellar travel, each population will largely develop on its own, adapting to its surroundings and eventually evolving into new species.

Moderate Expansion: 1-2 parsecs/century (Maximum = 25 parsecs/century).

DEVELOPMENT INDEX

None: No orbiters or landers, but possible flybys of places of interest.

Minimal: Minor robotic presence throughout system, orbiters and landers at places of interest, inhabited stations at very important nearby areas, and flybys of most other areas.

Light: Major robotic presence throughout system and all areas visited. Permanent settlement of very important nearby areas, inhabited stations at very important distant areas.

Moderate: Fully settled, industrialized, and some megaengineering of nearby valuable areas. Stations established at most other valuable areas and there is an ubiquitous robotic presence throughout system.

Heavy: All valuable nearby areas fully settled, industrialized, and optimized through megaengineering as needed. Most other areas colonized and/or exploited. Minor exhaustion of asteroids, comets, moons, and other resources.

Extreme: Most of the system is settled with best areas heavily megaengineered and exploited. Major exhaustion of asteroids, comets, moons, and other system resources.

Ultimate: Entire system is megaengineered for habitation and/or industrialization. System resources exhausted, including non-ideal worlds. Possible solar engineering.

STELLAR

Should a spacefaring society discover a physics loophole that allows faster than light transport, travel between star systems becomes practical. With the resources of multiple star systems and nebulae within practical reach, monolithic artificial worlds and gargantuan interstellar starships become home for the majority of life. Colonies could spread across an entire galaxy within millenia, with sectors and regions maintaining social, economic, and political ties and rivalries.

4.2 COLONIZATION

SYSTEM DEVELOPMENT INDEX (Roll all dice equal to and less than highest indicated and add together.)

DICE*	INTERPLANETARY	PRE-STELLAR	STELLAR	GALACTIC
(1d4-3)	Interstellar	Unknown	--	--
d4	Deep Orbit	Wild	Unknown	Intergalactic
d6	Other Worlds	Frontier	Wild	Unknown
d8	Distant resources	Middle	Frontier	Wild
d10	Close resources	Inner	Middle	Frontier
d12	Main World	Core	Inner	Middle
d20	--	--	Core	Inner
d100	--	--	--	Core

*For each die that rolls its highest number, reroll it and add the results together.

NOTE: Add one higher die for each of the following factors. If highest die rolled is already d100, roll another d100 (or more) and add to total.

- Home system
- Large system
- Circumstellar disk
- Frontier covers galaxy quadrant
- Superdwarf
- Hyperdwarf (two dice higher)
- Frontier covers entire galaxy (two dice higher)

NOTE: Roll one die lower for each of the following factors.

- Empty system
- Subdwarf
- First century of colonization
- Intergalactic
- Paleodwarf (two dice lower).
- Dawn of spaceflight (two dice lower)

NOTE: Use 1d4-3 only if the lowest die indicated is below d4.

DEVELOPMENT INDEX RESULTS

TOTALS	DEVELOPMENT
0-9	None
10-19	Minimal
20-49	Light
50-99	Moderate
100-199	Heavy
200-499	Extreme
500+	Ultimate

SPHERES OF COLONIZATION

(Multiply by total expansion distance for outer radius.)

Core	x1/10
Inner	x1/5
Middle	x1/2
Frontier	x1
Wild	x2
Unknown	x5

Moderate Expansion: 20-50 parsecs/century (Maximum = 200+ parsecs/century)

GALACTIC

Any civilization with true galactic reach likely discovered a method of instantaneous travel between points. Massive quantities of material and energy can be transferred to and from any region in short order, so much so that the resources of whole sectors could be rapidly exhausted; aggressive cultures often burn out the galaxy and themselves if they reach this point. Some civilizations may form into a galactic collective, eternally managed by godlike superintelligences, while others fracture into countless domains, enclaves, clans, and individuals scattered throughout the galaxy and beyond.

Moderate Expansion: 100-1000 parsecs/ century (Maximum: ???).

> *"The wilderness should be left as it is, when it is so easy to build paradise in space from so little."*
> *—Iain M. Banks*

HABITATS

Although the vast majority of star systems lack orbital bodies suitable for naturally-evolved, carbon-based lifeforms to inhabit–without genetic engineering, environmental modification through terraforming, or both–almost all possess enough asteroid and comet material to construct dozens (if not hundreds or even thousands) of megascale habitats.

Most common of all such space habitats are ringworlds, where centripetal force on the inside of the rotating band produces artificial gravity. Along with high walls on either side, this force is sufficient to retain an atmosphere while also leaving the sky open to space. Whatever environments and landscapes desired can be installed.

Material strength is the limiting factor on ringworld size. If constructed of carbon nanotubes, a radius of up to 1000 kilometers (620 miles) and width of 500 km (310 mi) is possible, providing living area equivalent to a small moon for a fraction of the material. To simulate a standard planetary day/night cycle, they often rotate with the axis perpendicular to the plane of orbit and use mirrors (for inner orbits) or artificial lighting (for middle orbits and beyond) for illumination. Such structures are within the realm of even Interplanetary-level technology.

Exotic matter with tensile strength stronger than molecular bonds could allow far larger ringworlds to be built. An ideal size can be calculated to provide comfortable gravity while also rotating once per day, which combined with an axial tilt creates a natural day/night cycle without need for mirrors or artificial illumination. For Earth-standard parameters, this is a radius of about 1.9 million km (1.15 million mi), which gives a circumference of 12 million km (7.2 million miles) and around 12-120 times Earth's surface area depending on width. These usually orbit around a star at a distance optimized for temperature, with seasons dependent on orbital eccentricity. Without demolishing planets, the standard orbital debris of most dwarf star systems can provide enough materials for one or two of these space habitats. However, even if such impossibly strong matter is possible, these megastructures are very rarely built by Interplanetary or Pre-Stellar societies due to economic impracticality.

POWER

With effectively limitless supply, solar energy is an obvious and easy source of power. To more effectively harvest this resource, satellites are placed in orbit around a star to collect the energy and beam it throughout the system. Statites–satellites using solar sails to remain suspended in place by the star's radiation pressure–allow an ever-increasing swarm of these collectors to surround the star and capture a greater fraction of its output without complex orbital mechanics, even to the point of dimming its light as seen from interplanetary and interstellar distances.

Aside from power collection, these swarms can be designed as a stellar-scale information processor of immense capacity. This type of computing superobject is only practical to Stellar or Galactic civilizations that can circumvent the limitations of light speed. Swarms arranged in an asymmetric bubble can even be used as a stellar engine to produce a very slight thrust to propel a star system over millions of years in a given direction.

STARGATES

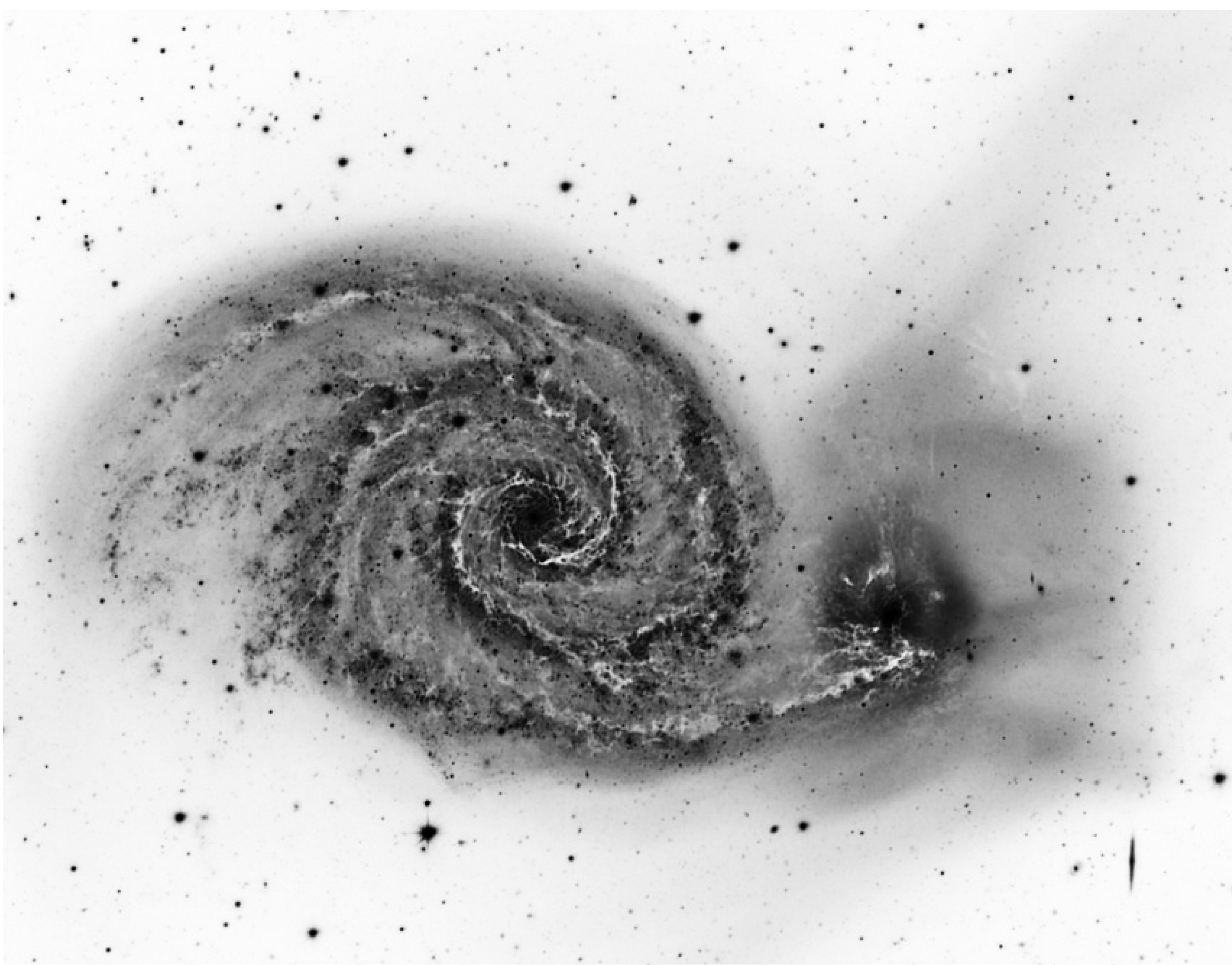
Jumping instantaneously from one point to another is the ultimate form of travel imaginable. If jump-capable starships are the method employed by a starfaring civilization, the entire galaxy (and beyond) can be within reach.

If space-based stargates are utilized, consider what kind of placement the requirements and limitations of the technology imply. When jump range is limited or normal space travel is required to build two linkage points before activation, then stargates will be in any conveniently close star system. Should they need to be located far away from strong gravity fields, deep orbits or even empty interstellar space might be necessary.

If it proves possible to locate teleportation portals so that one can simply step through it from one world into another, the nature of interstellar travel drastically changes. Such portals will be located in places that the builders (or species they built the portals for) find naturally tolerable, but also defensible, such as a waystation located at the center of a ringworld or on its outer rim.

STELLAR ENGINEERING

By lifting substantial portions of a star's matter, useful materials could be harvested. Adjusting mass, rotation, and metallicity can alter the characteristics of the star, which through careful stellar husbandry can moderate its activity and extend main sequence lifespan.



6.1 TABLES

6.1.1 GALAXY TABLES

ROLL d4 FOR GALACTIC NEIGHBORHOOD.
ROLL d20 FOR EACH GALAXY TYPE.
ROLL d12 FOR EACH GALAXY SUBTYPE (d8: Galaxy Region).

1-3 Group (1d6-1 galaxies; if result is 0, neighborhood is a 1d10x10 Mpc Void with 1d4-1 galaxies.)
- 1 Intergalactic (Roll d8: 1-2 Stream, 3-7 Remnant, 8 Aura)
- 2-5 Irregular Galaxy
  - 1-4 Dwarf Amorphous (Roll d8: 1 Cluster, 2-3 Association, 4-7 Group, 8 Field)
  - 5-9 Dwarf Spiral (Roll d8: 1-2 Nucleus, 3-7 Arm, 8 Halo)
  - 10-12 Dwarf Elliptical (Roll d8: 1-3 Core, 4-7 Ellipse, 8 Halo)
- 6-14 Spiral Galaxy
  - 1-2 Flat (Roll d8: 1 Nucleus, 2-7 Disk, 8 Halo)
  - 3-9 Barred (Roll d8: 1 Nucleus, 2 Bar, 3 Arm, 4-6 Disk, 7 Halo, 8 Satellite)
  - 10-12 Classic (Roll d8: 1-3 Bulge, 4 Arm, 5-6 Disk, 7 Halo, 8 Satellite)
- 15-18 Lenticular Galaxy
  - 1-2 Dwarf (Roll d8: 1 Nucleus, 2-7 Disk, 8 Halo)
  - 3-9 Common (Roll d8: 1-2 Bulge, 3-5 Disk, 6-7 Halo, 8 Satellite)
  - 10-12 Giant (Roll d8: 1-3 Bulge, 4-5 Disk, 6-7 Halo, 8 Satellite)
- 19-20 Elliptical Galaxy
  - 1-4 Dwarf (Roll d8: 1-4 Core, 5-7 Ellipse, 8 Halo)
  - 5-9 Common (Roll d8: 1-3 Core, 4-6 Ellipse, 7 Halo, 8 Satellite)
  - 10-12 Giant (Roll d8: 1-2 Core, 3-5 Ellipse, 6-7 Halo, 8 Satellite)

4 Cluster (2d10* galaxies; for each 1 rolled on d10, a galaxy is Dominant type.)
- 1-2 Intracluster (Roll d8: 1-3 Stream, 4-7 Exile, 8 Aura)
- 3-5 Irregular (Roll d8 Irregular table above for subtype.)
- 6-7 Spiral (Roll d8 Spiral table above for subtype.)
- 8-17 Lenticular (Roll d8 Lenticular table above for subtype.)
- 18-20 Elliptical (Roll d8 Elliptical table above for subtype.)
- ** Dominant Elliptical Galaxy
  - 1-6 Common (Roll d10: 1-2 Core, 3-4 Ellipse, 5-6 Halo, 7-8 Satellite)
  - 7-8 Giant (Roll d10: 1 Core, 2-3 Ellipse, 4-6 Halo, 7-8 Satellite)

*If d10 roll is 10, reroll and add results together.

ROLL d100 FOR GALAXY PECULIARITIES.

Elliptical	Lenticular	Spiral	Irregular	Dwarf	Giant	Dominant	Cluster	Peculiarity
01-05	01-05	01-05	01-05	01-05	01-05	01-02	01-05	None
06-15	06-10	06-10	—	—	01-10	03-12	06-10	Active nucleus
16-20	11-15	11-15	06-10	06-20	11-15	13-15	11-15	Compact
21-25	16-35	16-25	11-15	21-22	16-20	16-20	16-20	Dusty
26-30	36-40	26-30	16-20	23-24	21-25	21-27	21-25	Expansive
31-35	41-50	31-40	—	—	26-30	28-30	26-35	Extended halo
36-55	51-60	41-45	—	25-30	31-35	31-33	36-40	Gas poor
—	—	46-50	21-40	31-40	36-40	34-35	41-45	Gas rich
56-60	61-65	51-55	41-50	41-50	41-50	36-42	46-70	Interacting
61-65	—	56-60	—	51-70	51-55	43-45	71-75	Metal poor
66-75	66-75	61-65	51-55	71-74	56-65	46-55	76-80	Older
76-83	76-80	66-75	56-60	—	66-88	56-65	81-82	Satellites
84-85	81-82	76-80	61-80	75-80	89-90	66-70	83-88	Starburst
86-90	83-88	81-85	81-85	81-90	—	—	89-90	Sub-size
91-95	89-94	86-90	86-90	91-92	91-95	71-95	91-94	Super-size
96-97	95-97	91-95	91-95	93-97	96-97	96-97	95-97	Younger
98-99	98-99	96-99	98-98	98-99	98-99	98-99	98-99	Roll twice
00	00	00	00	00	00	00	00	Special

6.1.2 STAR TABLES

ROLL d8 FOR STELLAR NEIGHBORHOOD.

1 or less	Young (Neighborhood Age: 1d10**x100 million years)
2-7	Mature (Star Age: 1d10 billion years†)
8-11	Old (Star Age: Stelliferous Year/d10*)
12 or more	Ancient (Star Age: Stelliferous Year - [1d10-1] billion years)

*For every 10 rolled, reroll d10 and add the results together (cumulative)

**For every 1 rolled, reroll d10 and divide result by another 10 (cumulative).
For every 10 rolled, reroll and add the results together (cumulative).

†If age of the Stelliferous Era is less than Middle, use Ancient age fomula instead.

NOTE: Galaxy Region modifies the d8 result.

Halo/Aura	+5	Core	+2	Disk	+1	Arm	-2
Satellite	+3	Bulge	+2	Nucleus	-1	Association	-3
Stream	+3	Ellipse	+1	Bar	-2	Cluster	-5

ROLL d10 FOR STELLAR EVOLUTION.

Less than -10	Paleodwarf
-10 to 2	Subdwarf
3-9	Dwarf
10-20	Superdwarf
21 or more	Hyperdwarf

NOTE: Period of the Stelliferous Era determines stellar evolution.

Ancient	-10	Middle	+0	End	+5
Early	-5	Late	+2		

NOTE: Apply all relevant factors to modify stellar evolution.

Dominant galaxy	+2	Dusty galaxy	+1	Disk	-1	Void	-5
Starburst galaxy	+2	Bar	+1	Ellipse	-2	Halo	-5
Nucleus	+2	Core	+1	Satellite galaxy	-5	Aura	-10
Giant galaxy	+1	Sub-size galaxy	-1	Metal-poor galaxy	-5	Stream	-5
Super-size galaxy	+1	Younger galaxy	-2	Diffuse galaxy	-1		
Arm	+1	Dwarf galaxy	-2	Intergalactic region	-10		

ROLL d20 FOR STAR TYPE (Roll d8: solar mass).		**ROLL d6 FOR SYSTEM TYPE.**
1 or less	White star (If neighborhood under 2 billion years, roll d20 again for subtype.)	
	1 Blue star (1d8*+3)	1 Planet, 2-6 Multi-star
	2-20 White star (2 solar mass)	1-2 Planet, 3-6 Multi-star
2-3	Yellow star (1 solar mass)	1-3 Planet, 4-6 Multi-star
4-8	Orange star (½ solar mass)	1-4 Planet, 5-6 Multi-star
9-19	Red star (1/[1d8*+3])	1-5 Planet, 6 Multi-star
20 or more	Non-main sequence (Roll progenitor star type with the following table and die.)	

Under 2 billion years old: Blue star only.
2-4.9 billion years old: Roll White star subtype with d4.
5-9.9 billion years old: Roll White star subtype with d8.
10-199 billion years old: Roll Star Type with d8.
Over 200 billion years old: Roll Star Type with d20.

*If d8 roll is 8, reroll d8 and add results together (open-ended).

NOTE: Stellar Neighborhood age can modify the d20 roll result.

Under 10 million years old	-2	50-99 billion years old	+6	20-49 trillion years old	+18
10-999 million years old	-1	100-199 billion years old	+8	50-100 trillion years old	+19
1 billion years old	+0	200-499 billion years old	+10	Over 100 trillion years old	+20
2-4 billion years old	+1	500-999 billion years old	+12		
5-9 billion years old	+2	1 trillion years old	+14		
10-14 billion years	+3	2-4 trillion years old	+15		
15-19 billion years old	+4	5-9 trillion years old	+16		
20-49 billion years old	+5	10-19 trillion years old	+17		

6.1.2 STAR TABLES (continued)

ROLL d8 FOR STAR SIZE (except Blue and Red Stars)

1	Bright (+20% mass)
2-4	Standard
5-8	Dim (-20% mass)

ROLL d12† FOR PLANET SYSTEM TYPE.

Less than -2	Empty system (no major bodies)
1 to -2	Circumstellar disk (1d4* major bodies; if roll is 1, reroll d4.) 1 No major bodies 2-4 One major body
2-4	Small system (1d4+2 major bodies)
5-11	Standard system (1d4*+5 major bodies)
12 or more	Large system ([1d4*+1] x [1d4*+1] major bodies)

†Stellar evolution and Type can modify d12 Planet System Type result.

Paleodwarf	-10	Superdwarf	+5	Blue star	-<solar mass>
Subdwarf	-5	Hyperdwarf	+10		

*If d4 roll is 4, reroll d4 and add results together (open-ended).

NOTE: If system star is Non-main sequence, assume system type is Circumstellar disk.

ROLL d4† FOR MULTI-STAR SYSTEM.

0	1d4 stellar companions (First companion orbit: 1d10**x20 AU) and roll d4 again for another stellar companion.
1-3	One stellar companion (Orbit: 1d10**x20 AU)
4	One stellar companion (Orbit: 1d10**x20 AU) and roll d4 again for another stellar companion.

†Blue stars modify first d4 Multi-Star System roll by -1.

**For every 1 rolled, reroll d10 and divide result by another 10 (cumulative).
For every 10 rolled, reroll and multiply result by another 10 (cumulative).

NOTE: For odd-numbered companions, multiply orbit result by [previous pair orbit x 10].

ROLL d12 FOR COMPANION TYPE.

1	Same Star Type and Size
2-4	-1 Star Size
5-9	-2 Star Size
10-11	One lesser Star Type (Roll d8 for Star Type.)
12	Random Star Type (Roll d20 above for Star Type. Any result above primary is same type and size.)

ROLL d10† FOR EACH COMPANION ECCENTRICITY.

1	Slight (e = 1/[2d10*+20])
2-4	Minor (e = 1/[d10+10])
5-7	Moderate (e = 2/[d10+10])
8-9	Major (e = 5/[d10+10])
10 or more	Extreme (e = 10/[d10+10])

†Modify d10 Companion Eccentricity roll by +1 per companion above binary (cumulative).

ROLL d10† FOR MULTI-STAR MAJOR BODIES

Circumbinary bodies: [1d10*/Total stars]/[Total forbidden orbits x Total forbidden orbits]
Circumstellar bodies: [1d10*/(Total stars x 2)]/[Total forbidden orbits x Total forbidden orbits]

†Star type and stellar evolution can modify d10 Multi-Star Major Bodies result.

Paleodwarf	-10	Red star	-2	White star	+1	Hyperdwarf	+5
Subdwarf	-5	Orange star	-1	Superdwarf	+2	Blue star	-<solar mass>

*For every 10 rolled, reroll d10 and add the results together (cumulative).

NOTE: If Multi-Star Major Body total is less than 1 or for bodies around any Non-main sequence star, consider the result a Debris disk (or empty if stellar orbits are too close, chaotic, etc.).

6.1.2 STAR TABLES (continued)

ROLL D100 FOR STAR PECULIARITIES.

Subdwarf	New	Red	Main	Blue	Giant	Multi	Remnant	Peculiarity
01-02	01	01-03	01-02	01	01	01	01	None
03-07	02-04	04-14	03-07	02-02	02-04	02-06	01-09	Age difference
08-29	05-09	15-19	08-09	03-04	05-14	07-10	10-19	Carbon rich
30-34	10-12	20-24	10-14	05-19	15-29	11-15	20-34	Cataclysm
35-39	13-24	25-34	15-19	20-24	30-39	16-39	35-44	Chaotic orbits
40-44	25-34	35-39	20-29	25-29	40-44	40-49	45-49	Debris density
45-49	35-44	40-43	30-34	30-39	45-49	50-59	50-59	Excessive radiation
50-52	45-54	44-47	35-39	40-59	50-59	60-64	60-69	Nebula
53-69	55-64	48-49	40-44	60-69	60-64	65-69	70	Powerful stellar wind
70-86	65-71	50-54	45-64	70-74	65-69	70-74	71-79	Rotation anomaly
87-89	72-76	55-64	65-74	75-79	70-74	75-84	80-92	Strong magnetic field
90-95	77-79	65-69	75-89	80-84	75-79	85-89	93	Unusual metallicity
95-97	80-96	70-98	90-97	85-96	80-96	90-97	94-96	Variable star
98-99	97-98	99	98-99	97-98	97	97-99	97	Roll twice
00	99-00	00	00	99-00	98-00	00	98-00	Special

MAIN SEQUENCE LUMINOSITY (solar) AND LIFETIME (years) OF DWARF STARS

STAR TYPE (mass)	LUMINOSITY	MAIN SEQUENCE	POST-MAIN SEQUENCE	REMNANT
Red dwarf- (1/16)	1/10000	50 trillion	Blue dwarf	White dwarf
Red dwarf- (1/12)	1/5000	20 trillion	Blue dwarf	White dwarf
Red dwarf- (1/10)	1/2000	15 trillion	Blue dwarf	White dwarf
Red dwarf (1/8)	1/1000	10 trillion	Blue dwarf	White dwarf
Red dwarf (1/7)	1/750	7 trillion	Red subgiant	White dwarf
Red dwarf (1/6)	1/500	5 trillion	Red subgiant	White dwarf
Red dwarf+ (1/5)	1/200	3 trillion	Red subgiant	White dwarf
Red dwarf+ (1/4)	1/100	2 trillion	Red subgiant	White dwarf
Orange dwarf (dim)	1/50	100 billion	Red giant	White dwarf
Orange dwarf (standard)	1/10	50 billion	Red giant	White dwarf
Orange dwarf (bright)	1/5	20 billion	Red giant	White dwarf
Yellow dwarf (dim)	1/2	15 billion	Red giant	White dwarf
Yellow dwarf (standard)	1	10 billion	Red giant	White dwarf
Yellow dwarf (bright)	2	5 billion	Red giant	White dwarf
White star (dim)	5	4 billion	Red giant	White dwarf
White star (standard)	10	3 billion	Red giant	White dwarf
White star (bright)	50	2 billion	Red giant	White dwarf
Blue star (4)	100	1 billion	Bright red giant	White dwarf
Blue star (5)	200	700 million	Bright red giant	White dwarf
Blue star (6)	500	500 million	Bright red giant	White dwarf
Blue star (7)	750	200 million	Bright red giant	White dwarf
Blue star (8)	1000	100 million	Bright blue giant	Neutron star
Blue star (12)	5000	50 million	Bright blue giant	Neutron star
Blue star (16)	10,000	20 million	Red supergiant	Neutron star
Blue star (20)	20,000	15 million	Red supergiant	Neutron star
Blue star (24)	50,000	10 million	Red supergiant	Neutron star
Blue star (32)	100,000	5 million	Red supergiant	Neutron star
Blue star (48)	200,000	2 million	Red supergiant	Neutron star
Blue star (64)	500,000	1 million	Blue supergiant	Neutron star
Blue star (128)	1,000,000	???	Blue supergiant	Neutron star
Blue star (256)	5,000,000	???	Red hypergiant	Black hole

NOTE: Metallicity affects main sequence lifespan.

Paleodwarf (Population III)	-50%	Superdwarf (Late Population I)	+20%
Subdwarf (Population II)	-20%	Hyperdwarf (Population 0)	-20%

6.1.3 PLANET TABLES

ROLL d10 FOR SYSTEM ARCHITECTURE (roll once per star).

1-4	Compact system: First body = [1/(d10 x d10)] x [Star Mass] AU
5-7	Standard system: First body = [1d10/20] x [Star Mass] AU
8-9	Scattered system: First body = [1d10/5] x [Star Mass] AU
10	Eccentric system (Roll d10-1 System Architecture, then roll d10 for eccenticity of each body.)

1-4	Minor (e = 1/[d10+10])
5-7	Moderate (e = 2/[d10+10])
8-9	Major (e = 5/[d10+10])
10	Extreme (e = 10/[d10+10])

NOTE: For multi-star systems, assume for circumstellar planets it is an Eccentric System and reroll System Architecture as d10-1 (Deep), d10-3 (Outer), d10-5 (Middle), or assume Compact System Architecture if stars are closer than Middle Zone. For circumbinary, assume Scattered System Architecture and multiply the First body result by [Apoapsis x 5].

ROLL d10† FOR SYSTEM CARBON/OXYGEN RATIO (roll once per star).

-5 or less	Carbon-rich
-4 to 9	Oxygen-rich
10 or more	Carbon-rich

†Stellar evolution can modify Carbon/Oxygen ratio.

Paleodwarf	-10	Superdwarf	+2	White dwarf	+5
Subdwarf	-5	Hyperdwarf	+5	Neutron star	+10

ROLL d4 AND d6 FOR NEXT PLANET ORBIT.

Next planet = Previous planet orbit distance x [1 + ({1d6+1d4}/10)]

NOTE: Add all applicable modifiers to the numerator result.

Body is 100 Me	+1	Moderate eccentricity	+2	Compact system	-1
Body is 1000 Me	+2	Major eccentricity	+3		
Body is 10000 Me	+3	Extreme eccentricity	+4		
Minor eccentricity	+1	Scattered system	+1		

ROLL d10 FOR VOLATILE DENSITY.

2 or less	Trace (tenuous)
3-5	Very Poor (very thin)
6-7	Poor (thin)
8-9	Moderate (moderate)
10-12	Rich (thick)
13-14	Very Rich (very thick)
15 or more	Abundant (crushing)

NOTE: Modify d10 roll with all applicable modifiers.

No magnetic field	-5	Metal rich system	+1
Moon	-2	Metal poor system	-1
Close orbit	-2	Young system	+1
Inner orbit	-1	Old system	-1
Dwarf planet	-1	Ancient system	-2
1-2 Me	+1	Blue star	-<star mass>
3-5 Me	+2	Giant star	-3
6-9 Me	+3	Supergiant star	-4
10-19 Me	+4	Hypergiant star	-5
20+ Me	+5	Ice body	+2

6.1.3 PLANET TABLES

ROLL d12 FOR MAJOR BODY TYPE.

INNER	MIDDLE	OUTER	TYPE (Roll d20† for major body subtype and roll d8 for mass)			
1-3	1	1	Metal body			
			1-6	Dust belt		
			7-8	Meteoroid belt		
			9-16	Metal dwarf: Me = [1d8*]/200		
			17-18	Metal planet: Me = [1d8]/20		
			19	Solid metal dwarf: Me = [1d8]/200		
			20	Rare metal body (Roll d20 for rare body type.)		
					1-10	Ore belt
					11-17	Metal giant: Me = [1d8*]/2
					18-19	Solid metal planet: Me = [1d8]/20
					20	Special
4-9	2-3	2-3	Rock body			
			1-2	Debris disk		
			3-6	Asteroid belt		
			7-10	Rock dwarf: Me = [1d8*]/100		
			11-15	Rock planet: Me = [1d8*]/10		
			16-19	Rock giant: Me = 1d8+1		
			20	Rare rock body (Roll d20 for rare body type.)		
					1-10	Ash belt
					11-17	Coreless rock planet: Me = [1d8]/10
					18-19	Rock supergiant: Me = $[1d8+2]^2$
					20	Special
10-11	4-6	4-10	Ice body			
			1	Frost belt		
			2-3	Comet belt		
			4-5	Coreless ice dwarf: Me = [1d8]/200		
			6-8	Ice dwarf: Me = [1d8*]/200		
			9-13	Ice planet: Me = 1d8*/10		
			14-19	Ice giant: Me = 2d8*		
			20	Rare ice body (Roll d20 for rare body type.)		
					1-4	Comet cloud
					5-14	Coreless ice planet: Me =1d8/10
					15-19	Ice supergiant: Me = $[1d8^*+2]^2$
					20	Special
12†	7-12	11-12	Gas body			
			1-7	Gas planet: Me = 2d8		
			8-17	Gas giant: Me = 2 x $[(1d8+1)^2]$		
			18-19	Gas supergiant: Me = 2 x $[(1d8+2)^3]$		
			20	Rare gas body (Roll d20 for rare body type.)		
					1	Gas cloud
					2-5	Gas belt
					6-15	Gas hypergiant: Me = 1d8*x500
					16-19	Substar: Me = 1d8*x2000
					20	Special

†Star Class can affect Major Body Type d20 roll. If natural 20 is rolled, ignore these modifiers.

Orange star -1 White star +1 Blue star -<mass>

Red star -2 (supergiant = giant; hypergiant = supergiant)

Brown star -5 (supergiant/hypergiant/substar = giant)

NOTE: For carbon-rich systems, all bodies that are not beyond Middle orbit use the Inner Major Body Type table; the Middle Major Body Type table is not used.

6.1.3 PLANET TABLES (continued)

ROLL d100 FOR VOLATILE COMPOSITION.

METAL	ROCK	ICE	CARBON	VOLATILES (Roll d10 for significant additional volatiles.)
01-04	01-09	01	01-10	Negligible
05-14	10-14	02-05	11	Carbon dioxide with oxygen (1-2 Sulfur Dioxide, 3-9 None, 10 Other)
15-39	15-44	06-09	12	Carbon dioxide dominant (1-4 Sulfur dioxide, 5-9 None, 10 Other)
40-59	45-54	10-14	13-15	Carbon dioxide with nitrogen (1-7 None, 8-9 Methane, 10 Other)
60-62	55-59	15-19	16	Carbon dioxide with water & nitrogen (1-5 None, 6-7 Methane, 8-9 Ammonia, 10 Methane and ammonia)
63	60-64	20-29	17	Water with oxygen (1-6 None, 7-9 Nitrogen, 10 Other)
64	65-69	30-39	18	Water with carbon dioxide & nitrogen (1-7 None, 8-9 Methane, 10 Other)
65-69	70-74	40-49	19	Nitrogen with water (1-6 None, 7-9 Ammonia, 10 Other)
70-89	75-84	50-64	20-39	Nitrogen dominant (1-4 None, 5-8 Water, 9-10 Water & ammonia)
90-92	85-87	65-72	40-59	Nitrogen with carbon monoxide (1-6 None, 7-9 Methane, 10 Other)
93-94	88-89	73-80	60-79	Carbon monoxide dominant (1-7 None, 8-9 Methane, 10 Other)
95	90	81-85	80-84	Neon dominant (1 None, 2-9 Hydrogen/Helium, 10 Other)
96-99	91-94	86-89	85-94	Helium dominant (1 None, 2-9 Hydrogen, 10 Other)
99+	95+	90+	95+	Hydrogen/helium dominant (1-9 None, 10 Other)
00	00	00	00	Special atmosphere (natural 00 only)

NOTE: If mass is above 1 Me, add [mass x 5] to d100 roll. If mass is below 1 Me, subtract [inverse mass].

ROLL d100 FOR PLANET FEATURES.

DWARF	PLANET	GIANT	SUPER+	FEATURE
01-09	01-04	01-02	01	Volatile poor
10-14	05-14	03-29	02-17	Volatile rich
15-24	15-19	30-32	18-19	Slow rotation
25-29	20-24	33-37	20-29	Fast rotation
30-39	25-29	38-40	30-34	Minimal axial tilt
40-44	30-34	41-49	35-39	Extreme axial tilt
45-49	35-39	50-53	40-44	Smaller core
50-54	40-42	54-55	45-46	Larger core
55-59	43-44	56-59	47-54	Geologically dead
60-67	45-49	60-69	55-59	Geologically extinct
68-69	50-64	70-74	60	Geologically active
70-74	65-76	75-79	61-79	Magnetic field
75-79	77-81	80-84	80-84	Less dense
80-84	82-86	85-87	85-86	More dense
85-89	87-89	88-96	87-97	Generally flat terrain
90-98	90-98	97-98	98	Highly varied terrain
99	99	99	99	Roll twice
00	00	00	00	Special feature

ROLL d100 FOR NATURAL SATELLITES.

01-24	None
25-39	Irregular moon (1d10* tiny moons)
40-69	Minor moon (1d10*/2 dwarf moons)
70-84	Major moon (1d10*/5 moons)
85-89	Giant moon
90+	Ring system (with 1d10*x1d10 moonlets)
99	Roll twice
00	Special satellite

NOTE: Dwarfs roll once, planets roll twice, giants roll three times, supergiants roll four times, hypergiants roll five times, and substars roll six times.

NOTE: Modify each roll according to orbit zone. Close = -50 (d100)/-5 (d10); Inner -20 (d100)/-2 (d10); Middle +50 (d100)/+5 (d10); Outer +20 (d100)/+2 (d10); Deep +0 (d100)/+0 (d10).

6.1.3 PLANET TABLES (continued)

ROLL d100 FOR ROTATION PERIOD.

01-04	Tidal locked (day = orbital period)
05-19	Resonant (orbital period x 1d10*/3)
20-29	Very long (10000/1d6* hours)
30-39	Long (1d10*+5 x 1d10*+5 hours)
40-69	Medium (1d10*+20 hours)
70-99	Short (1d10+10 hours)
99	Very short (1d10+2 hours)
00	Special rotation period

NOTE: Orbit zone and planet mass affects d100 Rotation roll.

Close orbit	-100	Inner orbit	-50	Above 50 Me	+50
Below ½ Me	+10	10-49 Me	+20		

ROLL d100 FOR AXIAL TILT.

Close orbit: 1d100*/4 degrees
Inner/Middle orbit: 1d100*/3
Outer/Deep orbit: 1d100*/2

*On a roll of 100, roll again and add the results together before dividing.

ROUGH PLANET MEAN RADIUS CALCULATION (Earth radii)

Metal body: $[\text{Planet mass}]^{0.35}$
Rock body: $[\text{Planet mass}]^{0.3}$
Ice planet: Square root of planet mass
Gas planet: $22.6 \times [(\text{mass})^{-0.0886}]$ Re

GRAVITY CALCULATION

$\text{Mass} / [\text{Radius}]^2 = \text{Gravity (g)}$

PLANET ORBIT PERIOD CALCULATION

Square Root of $[(\text{Orbit Radius AU})^3]$ = Years

TEMPERATURE	**MAXIMUM ORBITAL RADIUS FROM STAR (AU)**									
ZONE	**Red-**	**Red**	**Red+**	**Orange**	**Yellow**	**White**	**White+**	**Blue (4)**	**Blue (8)**	**Blue (16)**
CLOSE ORBITS	**0.01**	**0.02**	**0.05**	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**
Ultra Hot	0.0005	0.001	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5
Super Hot	0.001	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5	1
Very Hot	0.002	0.005	0.01	0.02	0.05	0.1	0.2	0.5	2	5
Hot	0.01	0.02	0.05	0.1	0.2	0.5	1	2	5	10
INNER ORBITS	**0.1**	**0.2**	**0.5**	**1**	**2**	**5**	**10**	**20**	**50**	**100**
Moderate/Hot	0.02	0.05	0.1	0.2	0.5	1	2	5	10	20
Moderate	0.05	0.1	0.2	0.5	1	2	5	10	20	50
Moderate/Cold	0.1	0.2	0.5	1	2	5	10	20	50	100
MIDDLE ORBIT	**0.5**	**1**	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**
Cold	0.5	1	2	5	10	20	50	100	200	500
OUTER ORBITS	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**	**2000**
Very Cold	1	2	5	10	20	50	100	200	500	1000
Super Cold	1.5	3	7.5	15	30	75	150	300	750	1500
DEEP ORBITS	**2+**	**5+**	**10+**	**20+**	**50+**	**100+**	**200+**	**500+**	**1000+**	**2000+**
Ultra Cold	5	10	20	50	100	200	500	1000	2000	5000
Frozen	20	50	100	200	500	1000	2000	5000	10,000	20,000
Super Frozen	200	500	1000	2000	5000	10,000	20,000	50,000	100,000	200,000
Cryogenic	200+	500+	1000+	2000+	5000+	10,000+	20,000+	50,000+	100,000+	200,000+

NOTE: Red- stars are below 1/8 Ms; red+ stars are 1/5 or ¼ Ms; white+ stars are bright white stars.

6.1.4 LIFE TABLES

BASIC LIFE (Roll all applicable dice. If all results are 1, then basic life is native to the world.)

d4	Baseline chance
d6	Not moderate zone
d8	Not main sequence star
d10	Planet less than 500 million years old
d12	No oxygen/carbon dioxide/methane in atmosphere
d20	No liquid water
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	No magnetosphere
d100	Insignificant atmosphere
d100	Carbon system
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Gas planet
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star)

COMPLEX LIFE (If basic life is native to a world, roll all applicable dice. If all results are 1, then complex life is native.)

d10	Baseline chance
d4	Not moderate zone
d6	No magnetic field
d8	Not yellow/orange/red main sequence star
d12	No oxygen/carbon dioxide/methane in atmosphere
d20	No liquid water
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	Insignificant atmosphere
d100	Variable/flare star
d100	Carbon system
d100	Gas planet
d100	Planet less than 2 billion years old
d100	Planet less than 500 million years old (Roll in addition to all previous age factors)
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star)
d100	Adjacent to belt
d100	High debris density

INTELLIGENT LIFE ((If complex life is native to a world, roll all applicable dice. If all results are 1, then intelligent life is native.)

d100	Baseline chance
d100	No magnetic field
d100	Not yellow main sequence star
d100	No oxygen/carbon dioxide/methane in atmosphere
d100	Insignificant amounts of water (Roll in addition to no liquid water)
d100	Insignificant atmosphere
d100	Variable/flare star
d100	Planet less than 4 billion years old
d100	Planet less than 2 billion years old (Roll in addition to all previous age factors)
d100	Planet less than 500 million years old (Roll in addition to all previous age factors)
d100	Planet less than 100 million years old (Roll in addition to all previous age factors)
d100	Subdwarf star
d100	Paleodwarf star (Roll in addition to subdwarf star.)
d100	Adjacent to belt
d100	High debris density
d100	Not moderate zone
d100	No liquid water
d100	Carbon system
d100	Gas planet

6.1.5 CIVILIZATION TABLES

COLONIZATION RATES (per century)

RATE	PRE-STELLAR	STELLAR	GALACTIC
Slow	1 parsecs	10 parsecs	100 parsecs
Moderate	2 parsecs	20 parsecs	200 parsecs
Fast	5 parsecs	50 parsecs	500 parsecs

SPHERES OF COLONIZATION (Multiply by total expansion distance.)

Core	x1/10
Inner	x1/5
Middle	x1/2
Frontier	x1
Wild	x2
Unknown	x5

SYSTEM DEVELOPMENT INDEX (Roll all dice equal to and less than highest indicated and add together.)

DICE*	INTERPLANETARY	PRE-STELLAR	STELLAR	GALACTIC
(1d4-3)	Interstellar	Unknown	--	--
d4	Deep Orbit	Wild	Unknown	Intergalactic
d6	Other Worlds	Frontier	Wild	Unknown
d8	Distant resources	Middle	Frontier	Wild
d10	Close resources	Inner	Middle	Frontier
d12	Homeworld	Core	Inner	Middle
d20	--	--	Core	Inner
d100	--	--	--	Core

*For each die that rolls its highest number, reroll it and add the results together.

NOTE: Add one higher die for each of the following factors. If highest die rolled is already d100, roll another d100 (or more) and add to total.

Home system	Superdwarf
Large system	Hyperdwarf (two dice higher)
Circumstellar disk	Frontier covers entire galaxy (two dice higher)
Frontier covers galaxy quadrant	

NOTE: Roll one die lower for each of the following factors.

Empty system	Intergalactic
Subdwarf	Paleodwarf (two dice lower).
First century of colonization	Dawn of spaceflight (two dice lower)

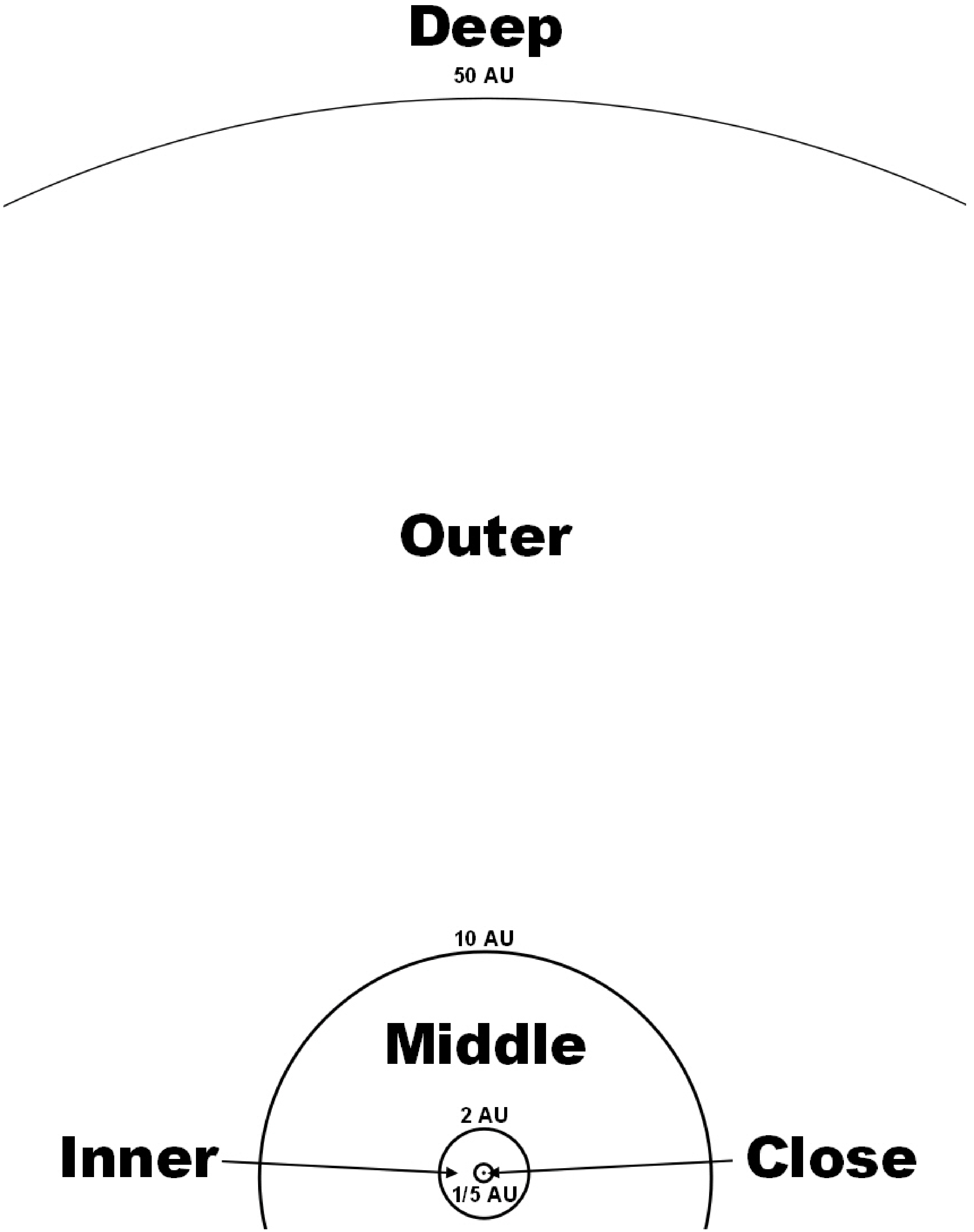
NOTE: Use 1d4-3 only if the lowest die indicated is below d4.

DEVELOPMENT INDEX RESULTS

TOTALS	DEVELOPMENT
0-9	None
10-19	Minimal
20-49	Light
50-99	Moderate
100-199	Heavy
200-499	Extreme
500+	Ultimate

ORBITAL BODIES

STAR SYSTEM


Deep
50 AU
Outer
10 AU
Middle
2 AU
Inner
Close
1/5 AU

8.1 PLANET SYSTEM SAMPLE

Daniel decides to generate a Middle Stelliferous Era star system going from galaxy level down to planets and life.

GALAXY

He makes a HaVoQ roll, rolling the d4, d6, d8, d12, d20, and d100 together.

d4 = 2	d12 = 4
d6 = 5	d20 = 13
d8 = 6	d100 = 72

Using Table 1.1, d4 determines Galactic Neighborhood, d20 Galaxy Type, d12 Galaxy Subtype, and d8 the Galaxy Region in which the star system is found; d6 is used only to determine how many major galaxies are in a group. In this case, the rolls give the following results:

d4 = 2 (Group)	d12 = 4 (Barred)
d6 = 5 (4 galaxies)	d20 = 13 (Spiral)
d8 = 6 (Disk)	d100 = 72 (Satellites)

"This is a barred spiral galaxy (part of a group of four major galaxies) and the star system is located in its disk region."

If Daniel wants, he can roll the d20 and d12 to determine the other galaxies in the group.

The last roll remaining is d100, which is used for Table 1.2 Galaxy Peculiarities. His roll of 72 for a spiral galaxy indicates it has an unusual number or type of satellites.

STAR

Table 2.1 requires d8 Stellar Neighborhood, d10 Star Age, and d10 Stellar Evolution. Because the star system exists in the Middle Stelliferous and is located in a spiral disk, each roll is modified.

d8 = [5 + 1 disk] 6 (Mature)
d10 = 4 (4 billion years old)
d10 = [9 -1 disk] 8 (Dwarf)

Therefore, this system is a 4 billion year old dwarf star in a neighborhood of mature stars. He also notes from the Main Sequence Luminosity chart that standard yellow dwarfs at this age are considered main sequence.

For the next tables, Daniel makes another HaVoQ roll will all polyhedral dice.

d4 = 2	d12 = 12
d6 = 2	d20 = 2
d8 = 3	d100 = 83

Daniel refers to Table 2.2 Star Systems first, which uses d20 and d6, since these results will determine which other tables to use next.

d6 = 2 (Planet system)
d20 = 2 (Yellow star)

In this case, Tables 2.3 Star Size (d8), 2.4 Planet System (d12 and d4), and 2.6 Star Peculiarities (d100) are used next.

d8 = 3 (Standard size)
d12 = 12 (Large system)
d4 = 1 (11 major bodies)
d100 = 83 (Unusual metallicity)

Daniel's star system is a 4 billion year old standard yellow dwarf star with unusually high metallicity (Daniel rolled d10 based on the peculiarity description and got a 7) and a eleven body planetary system.

PLANETS

Initially, Daniel makes d10 rolls for Tables 3.1 and 3.2, which influence the major body results he will roll next.

d10 = 8 (Oxygen-rich)
d10 = 6 (Standard system)

Table 3.2 requires an additional d10 roll to determine First Body distance, which is modified by star mass.

d10 = [7/20 x 1 solar mass] (0.35 AU)

A HaVoQ roll is made and cross-referenced to Tables 3.3 Planetary Bodies (d12, d20, d8), 3.4 Orbits (d4, d6), and 3.5 Planet Peculiarities (d100); the latter table has several d100 lists, but Daniel will mainly use the Planet Features list for the initial rolls to get a broad sketch of the system. He may drill down deeper for various bodies he feels warrant further detail.

First Body (Inner Orbit: 0.35 AU)

d12 = 3 (Metal body)
d20 = 17 (Metal planet)
d8 = 1 (1/20 earth mass)
d100 = 43 (Geologically dead)
d4 & d6 = [4 + 6] 10 (2.0 x 0.35 AU)

"Metal planet: 0.05 earth mass, 0.35 AU orbit, geologically dead."

To determine the next body's orbital radius, the previous planet's orbit radius is multiplied by [1 + ({1d6+1d4}/10]. In this case: 0.35 AU x [1 + ({4+6}/10)] = 0.35 AU x [1 + 10/10] = 0.35 AU x [1+1] = 0.35 AU x 2 = 0.7 AU

Second Body (Inner Orbit: 0.7 AU)

d12 = 5 (Rock body)
d20 = 14 (Rock planet)
d8 = 8 (8/10 earth mass)
d100 = 09 (Volatile rich)
d4 & d6 = [1 + 3] (1.4 x 0.7 AU)

This rock planet of 0.8 earth masses orbits at 0.7 AU and is volatile rich. Daniel decides to get into deeper detail about this potentially interesting planet, so he rolls d100s for the rest of Table 3.5, then uses Table 3.6 Volatiles to determine volatile composition. On Table 3.5 for natural satellites, he rolls twice (since it is a planet), but -20 is subtracted from each roll because of its inner orbit location; the rotation rate roll is modified by -50 for the same reason. Daniel rolls a natural 00 result, though, so no modifier is applied.

d100 (Moon) = [19 - 20 = -1] (None)
d100 (Moon) = [37 - 20 = 17] (None)
d100 (Rotation) = 00 (Special rotation)
d100 (Axis) = 10 (10/4 = 2.5 degrees)

To get some inspiration for the special rotation period result, Daniel rerolls d100, applying the -50 modifier, and gets 44 - 50 = -6 (Tidal locked). To make this a special case, he decides the planet rotation rate is about the same as its year, but it spins retrograde. Curious as to the length of this planet's year, he uses the equation [square root of (orbit radius)^3] = 0.59 years (215.5 earth days).

Table 3.6 requires two d10 and one d100 rolls. For the first d10 roll, the -1 inner orbit modifier is cancelled by the +1 metal rich system modifier for this unusually high metallicity dwarf system; also, because this planet is very volatile rich, the result is two levels higher than rolled. The d100 Volatile Composition roll is modified by -1 [inverse mass = 10/8 = 1.25 = 1] for less than 1 Me mass.

d10 = 6 [Thin + 2 lvls] (Thick)
d100 = [40 - 1] 39 (Carbon dioxide dominant)
d10 = 3 (Minor sulfur dioxide)

When Daniel consults the Equilibrium Temperature Zones chart, he determines this planet is within the moderate zone, where carbon dioxide and sulfur dioxide are gaseous and form a thick atmosphere. An extreme greenhouse effect from the CO_2 (three temperature zones greater than equilibrium) is slightly offset by the reflective properties of sulfur dioxide clouds (one temperature zone less), making the surface of the planet evenly hot, with temperatures high enough to melt lead.

"Hot rock planet: 0.8 earth mass, 0.7 AU orbit (215.5 earth day), tidal-locked retrograde rotation, 2.5 degree axial tilt, thick carbon dioxide dominant atmosphere with sulfur dioxide clouds, no natural satellites."

8.1 PLANET SYSTEM SAMPLE (Continued)

The next orbit is [1 + (4/10) = 1.4] times 0.7 AU = 0.98 AU; Daniel rounds this up to 1 AU.

Third Body (Inner Orbit: 1 AU)

d12 = 8 (Rock body)
d20 = 11 (Rock planet)
d8* = [8 + 2] (10/10)
d100 = 00 (Special feature)
d4 & d6 = [3 + 2] (1.5 x 1 AU)

For this rock planet's mass, Daniel rolled d8 and got an 8 result, so he rolled again and added the two rolls together (8 + 2). With this kind of ideal type and orbit, plus the "special feature" result, he is curious to see what further rolls reveal about the world. He rolls the other d100s on Table 3.5, using the same modifiers used for the previous planets since this is still an inner orbit body.

d100 (Moon) = [26 - 20 = 6] (None)
d100 (Moon) = 00 (Special satellite)
d100 (Rotation) = 96 (Medium: 1d10+20 hrs)
d100 (Axis) = [93/4] (23 degrees)

Wow, another special result? He decides it will be a giant moon (unusual for this orbit zone) and rolls [(1d10*/1d10) x 1/10 Me] to determine its mass: [1/8 x 1/10 = 1/80 Me] = 0.0125 Me. Daniel uses the optional rules for determining moon types (page 23) and rolls d12 on the Inner column of Table 3.3, netting a 7 (Rock body) result

For the fun of it, he rolls d100 Dwarf Planet Features from Table 3.5; the 47 he rolls indicates it has a smaller core than usual. Because of this, he decides to use the Rough Calculations for Planets chart to figure out the giant moon's radius and gravity. A rock body has a radius of [body mass]$^{0.3}$, so [0.0125]$^{0.3}$ = 0.27 earth radii. Gravity is [Mass/(Radius^2)], so [0.0125/0.0729 = 0.171g], but since the moon has a small core Daniel arbitrarily rolls [d100/4] to figure out what percentage to take off this total and, rolling [16/4 = 4%], slightly modifies it down to 0.164g.

After rolling [1d10+20] and getting a [4 + 20 = 24] 24 hour rotation rate, Daniel uses Table 3.6 to determine volatiles. For d10 Volatile Density, he factors a -1 inner orbit, +1 metal rich system, and +1 for a 1-2 Me body, netting a +1 modifier; the d100 Volatile Composition roll is unmodified because mass is neither over nor under 1 Me.

d10 = [9 + 1] 10 (Thick)
d100 = 73 (Nitrogen with water)
d10 = 5 (No minor)

Very interesting. With so many factors to make life possible, Daniel decides to roll on Table 4.1. Using the Special Feature result he rolled earlier, he decides carbon dioxide and methane are also present in the atmosphere, plus water is at moderate level (instead of thin), so for Basic, Complex, and Intelligent life, only the baseline die need be rolled: d4, d10, and d100, respectively.

d4 (Basic) = 1 d10 (Complex) = 1
d100 (Intelligent) = 01

Since each roll is a 1, there is not only native life on this planet, but an intelligent species arose here, too! Daniel decides to change the carbon dioxide and methane to oxygen instead.

"Moderate-temperature rock planet: 1 earth mass (1.0g), 1 AU orbit (365 earth day), 24 hour rotation, 23 degree axial tilt, moderate nitrogen/oxygen atmosphere, moderate water hydrosphere, complex native ecosystem with native intelligent species, one giant rocky moon with small core (0.0125 Me/0.27 Re/ 0.164g)."

Fourth Body (Inner Orbit: 1.5 AU)

d12 = 6 (Rock body)
d20 = 15 (Rock planet)
d8 = 1 (1/10 Me)
d100 = 46 (Geologically extinct)
d4 & d6 = [3 + 5] (1.8 x 1.5 AU)

"Moderate/cold rock planet: 0.1 earth mass, 1.5 AU orbit, geologically extinct."

Fifth Body (Middle Orbit: 2.7 AU)

d12 = 2 (Rock body)
d20 = 5 (Asteroid belt)
d8 & d100 = N/A
d4 & d6 = [4 + 5] (1.9 x 2.7 AU)

"Asteroid belt."

Sixth Body (Middle Orbit: 5 AU)

d12 = 9 (Gas body)
d20 = 18 (Gas supergiant)
d8 = 5 (432 Me)
d100 = 66 (Magnetic field)
d4 & d6 = [2 + 6 + 1] (1.9 x 5 AU)

Daniel rolls d10 to determine the strength of the magnetic field for this planet, getting 9 which means it is much stronger than usual, which since gas supergiants typically have exceptionally strong magnetic fields means this one's is super strong.

To round out the gigantic world, Daniel rolls four times on Table 3.5 Natural Satellites; the d100 rolls are modified by +50 for middle orbit and d10 rolls +5.

d100 = [45 + 95 = 90+] (Ring system)
d100 = [63 + 50 = 90+] (Ring system)
d100 = [37 + 50 = 87] (Giant moon)
d100 = [39 + 50 = 89] (Giant moon)

Instead of rings, Daniel chooses to make the ring system minimal and add two giant moons in addition to the two giant moons previously rolled, for a total of four giant moons. The ring system adds [(1d10+5) x (1d10+5)] moonlets; rolling 2 and 4, [(2 + 5) x (4 + 5) = (7 x 9)] = 63 moonlets. Daniel plans to return to this planet later to flesh out the larger satellites.

"Cold gas supergiant: 432 earth mass, 5 AU orbit, super strong magnetic field, minimal ring system, four giant moons, and 60+ moonlets.'

Seventh Body (Middle Orbit: 9.5 AU)

d12 = 10 (Gas body)
d20 = 13 (Gas giant)
d8 = 6 (98 Me)
d100 = 22 (Greater ring system)
d4 & d6 = [3 + 6 + 1] (2 x 9.5 AU)

Middle orbit planets tend to have more satellites than those of other zones, so Daniel chooses to roll three times on Table 3.5 Natural Satellites.

d100 = [36 + 50 = 86] (Giant moon)
d100 = [53 + 50 = 90+] (Ring system)
d100 = [90 + 50 = 90+] (Ring system)

This gas giant has a major ring system with [(1d10+5) x (1d10+5)] x 2 moonlets; rolling 7 and 5, [(7+5) x (5+5) x 2 = 12 x 10 x 2] = 240 moonlets. Daniel thinks this is somewhat excessive, so he arbitrarily trades the x2 modifier for two major moon rolls [(1d10*+5) + (1d10*+5)/5]; rolls of 10 (plus another d10 roll of 4 = 14 since the roll is open-ended on a 10) and 7 add up to [(14 + 5) + (7 + 5)/5 = (19 + 12)/5 = 31/5] 6 major moons, in addition to the giant moon and 120 moonlets.

Daniel gets into further detail about the lone giant moon of this gas giant. Giant moons are d10*/d10 tenths of an earth mass, so his 2 and 9 rolls make it [2/9 x 1/10 = 2/90] = 0.022 Me, nearly twice as massive as the third body's giant moon. He uses the special rules for determining natural satellite types with d12 on Table 3.3 Middle Planetary Bodies and rolls an 11, indicating an ice body with significant volatiles (and possibly a significant atmosphere). When Daniel rolls on Table 3.6 Volatiles to determine this, he modifies the d10 Volatile Density roll by +1 (-2 moon, +1 metal rich system, +2 ice body = +1, and assumes satellite is protected by its gas giant's magnetic field) and the Volatile Composition roll by -45 [inverse mass = 90/2 = 45].

d10 = [8 + 1] 8 (Thick)
d100 = [89 - 45] 51 (Nitrogen with water)
d10 = 10 (Special minor)

8.1 PLANET SYSTEM SAMPLE

Seventh Body (Continued)

Out of curiosity, Daniel finds an online planetary temperature calculator to see if any volatiles are liquid in this temperature zone. Incidentally, methane can easily be liquid at this orbital distance, so Daniel decides to use that as the special minor component of this moon's volatiles. Since nitrogen is the main component and a gas, water is a major component and frozen, and methane is a minor one and liquid, the moon has a moderate nitrogen atmosphere (main = one level lower than thick volatile density since major is not in the same state), abundant water cryosphere (ice bodies are predominantly water ice), and very thin methane/hydrocarbon hydrosphere (minor = three levels lower than volatile density). Quite an unusual moon!

"Gas giant: 98 earth mass, 9.5 AU orbit, major ring system with 100+ moonlets, six major moons, and one giant ice moon (0.022 Me; moderate nitrogen atmosphere, very thin methane/hydrocarbon hydrosphere)."

Eighth Body (Outer Orbit: 19 AU)

d12 = 4 (Ice body)
d20 = 16 (Ice giant)
d8 = [7 + 7] (14 Me)
d100 = 43 (Extreme axial tilt)
d4 & d6 = 2 [4 + 2] (1.6 x 19 AU)

Extreme axial tilt planets roll [40 + (1d100/2)] to determine its extent; Daniel rolls 84, so [40 + (84/2) = 40 + 42] = 82° tilt. To round out the ice giant, he rolls d100 Table 3.5 Natural Satellites twice, adding +20 for outer orbits (and +2 to d10 for the same reason). He assumes a crushing envelope of hydrogen and helium.

d100 = [71 + 20] 90+ (Ring system)
d100 = [37 + 20] 57 (Minor moons)

Moonlet calculation from [(1d10*+2) x (1d10*+2)] generates [(3+2) x (2+2) = (5 x 4)] about 20 moonlets and minor moon calculation from [(1d10*+2)/2] generates [(8+2)/2 = 10/2] five dwarf moons, with a minor ring system.

"Ice giant: 14 earth mass, 19 AU orbit, crushing hydrogen/helium atmosphere, 82° axial tilt, minor ring system, 20+ moonlets, five dwarf moons."

Ninth Body (Outer Orbit: 30 AU)

d12 = 9 (Ice body)
d20 = 10 (Ice giant)
d8 = [(8* + 4) + 5] (17 Me)
d100 = 72 (Violent weather)
d4 & d6 = 2 [1 + 2] (1.3 x 30 AU)

Natural satellite rolls have the same modifiers as the previous planet.

d100 = [92 + 20] 90+ (Ring system)
d100 = [53 + 20] 73 (Major moons)

There are [(2 +2) x (2 +2) = (4 x 4)] 16 moonlets and [(6+2)/5 = 8/5] one major moon along with a minor ring system.

"Ice giant: 17 earth mass, 30 AU orbit, crushing hydrogen/helium atmosphere, violent weather, minor ring system, 15+ moonlets, one major moon."

Tenth Body (Outer Orbit: 39 AU)

d12 = 5 (Ice body)
d20 = 3 (Comet belt)
d8 & d100 = N/A
d4 & d6 = 2 [2 + 2] (1.4 x 39 AU)

"Comet belt: 39 AU."

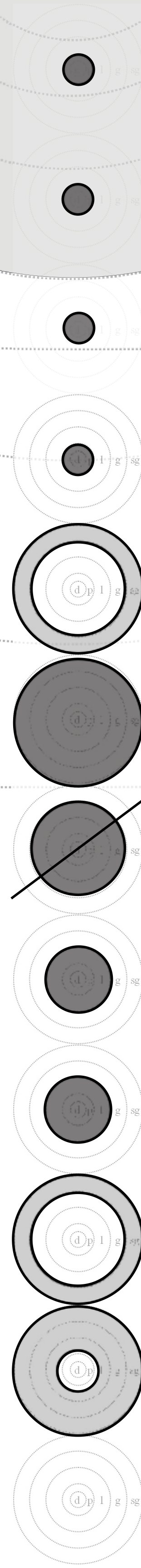
Eleventh Body (Deep Orbit: 55+ AU)

d12 = 8 (Ice body)
d20 = [20: 4] (Rare ice body: Comet cloud)
D4, d6, d8, d100 = N/A

"Comet cloud: 55+ AU."

STAR SYSTEM

Location: Milky Way Galaxy
(Local Group of 4 major galaxies)
Disk region of barred spiral galaxy
Star: Sol (Solar System)
Standard yellow dwarf (1 Ms/Ls)
Main sequence (4 billion yrs old)
Unusually high metallicity
Large, standard planetary system with eleven major bodies.



ORBITAL BODIES

MERCURY: Hot metal planet, 0.05 Me, 0.35 AU orbit, geologically dead, no moons.

VENUS: Hot rock planet, 0.8 Me, 0.7 AU orbit, tidal locked retrograde rotation, 2.5 degree axial tilt, thick carbon dioxide dominant atmosphere with sulfur dioxide clouds, no moons.

EARTH: Moderate rock planet: 1 Me, 1 AU orbit, 24 hr day, 23° axial tilt, moderate nitrogen/oxygen atmosphere, moderate water hydrosphere, complex native ecosystem with native intelligent species, one giant rocky moon (0.0125 Me/0.27 Re/0.165g).

MARS: Moderate/cold rock planet, 0.1 Me, 1.5 AU orbit, geologically extinct, two tiny moons.

MAIN ASTEROID BELT: Asteroid belt (2-4 AU).

JUPITER: Cold gas supergiant, 432 earth mass, 5 AU orbit, super strong magnetic field, minimal ring system, four giant moons, and 60+ moonlets.

SATURN: Gas giant, 98 Me, 9.5 AU orbit, major ring system with 100+ moonlets, six major moons, and one giant ice moon (0.022 Me; moderate nitrogen atmosphere, very thin methane/hydrocarbon hydrosphere).

URANUS: Ice giant, 14 earth mass, 19 AU orbit, crushing hydrogen/helium atmosphere, 82° axial tilt, minor ring system, 20+ moonlets, five dwarf moons.

NEPTUNE: Ice giant, 17 earth mass, 30 AU orbit, crushing hydrogen/helium atmosphere, violent weather, minor ring system, 15+ moonlets, one major moon

KUIPER BELT: Comet belt (39-50 AU).

SCATTERED DISC: Comet cloud (55+ AU).

8.2 MULTI-STAR SAMPLE

Angela decides to randomly roll a star system, assuming it is set in the Middle Stelliferous Era and in an average part of a spiral galaxy. Starting with Table 2.1 Star Associations, she rolls d8 and d10 twice without any modifiers.

d8 = 7 (Mature)
d10 (Evolution) = 8 (Dwarf)
d10 (Age) = 7 (7 billion years)

STARS

The system is 7 billion year old dwarf, one of many in a mature population of stars. Next, Angela makes a HaVoQ roll with d4, d6, d8, d12, d20, and d100. She refers to Table 2.2 first, which uses d20 and d6, since these results will determine which other tables to use next.

d20 = 20 (Stellar remnant)
d6 = 5 (Multi-star)

Now that's not a common result! To determine what the orginal star was and what type of remnant it is now, Angela sees that for systems between 5-9.9 billion years old, she rolls d8 on the White star subtype table: her result was 6, so the progenitor was a White star and its remnant is a White dwarf. Since this is also a multi-star system, the companion also needs to be determined, so she rolls d8 again for Table 2.3 Star Type, then applies the rest of her HaVoC roll to Table 2.5 Multi-Star System and Table 2.6 Star Peculiarities.

d8 = 7 (Dim)
d4 = 2 (One stellar companion)
d12 = 6 (-2 Star size)
d100 = 77 (Rotation anomaly)

The original primary star was a dim white star with a stellar companion two sizes smaller, so the secondary star is a standard yellow dwarf. Checking on the Main Sequence Luminosity chart, the companion is still main sequence and will be for several billion more years. Checking this chart further, Angela notes that white dwarf stars vary from 0.2 up to 1.33 solar masses and, figuring that a white star is approximately middleweight between the smallest red dwarfs and the largest blue stars that die to become such remnants, decides the white dwarf is about 3/4 solar mass. This makes the standard yellow dwarf the current primary star and the white dwarf the companion.

Angela rolls d10s for orbit and eccentricity.

d10 (Eccentricity) = 4 (Minor)
d10 (orbit) = 9 (9 x 20 AU)
d10 (e) = 2 [1/(2+10) = 1/12]

So far, this is a 7 billion year old multi-star system with a standard yellow dwarf primary with a white dwarf companion (3/4 solar mass) orbiting at 180 AU (e = 0.083).

Angela wants to determine how many major bodies orbit the stars of this system. To do this, she needs to determine the forbidden orbits for circumbinary bodies (ones that orbit around both stars) and for circumstellar bodies (ones that orbit around one star). Circumbinary forbidden orbits are all zones from the companions farthest distance from the primary (apoapsis) inward; judging from the diagram on page 16 (and the Equilibrium Temperature Zones chart on page 27), the companion orbits in the deep zone, so all five orbit zones are forbidden. She decides not to roll for any circumbinary bodies.

On the other hand, the distance between the stars means only one orbit zone (deep) is forbidden for circumstellar bodies, so Angela rolls d10s for the yellow dwarf and the white dwarf; she chooses to ignore the +1 white star modifier since it likely destroyed most of its original planets when it left main sequence.

d10 (yellow dwarf) = 7 [{7/(2 stars x 2)}/1 forbidden orbit = (7/4)/1 = 7/4 = 1.75]

d10 (white dwarf) = 4 [{4/(2 stars x 2)}/1 forbidden orbit = (4/4)/1 = 4/4 = 1]

She decides to round up the yellow dwarf result for two bodies; the white dwarf has one. Angela then rolls d100s for the yellow dwarf and multi-star peculiarities.

d100 = 76 (Unusual metallicity)
d100 = 45 (Variable star)

"Standard yellow dwarf variable star (1 Ms) with unusually high metallicity and two major bodies, orbited at 180 AU (e=0.083) by a fast-spinning white dwarf remnant (3/4 Ms) with one major body."

YELLOW DWARF PLANETS

Starting with the yellow dwarf primary, Angela makes the initial d10 rolls for Tables 3.1 and 3.2. Since this is a multi-star system, she assumes the system is Eccentric and rolls d10-1 for system architecture.

d10 (C/O ratio) = 2 (Oxygen rich)
d10 (Architecture) = [10 -1] 9 (Scattered)
d10 (1st body) = 10 [10/5 x 1 solar mass = 2]
d10 (1st body Eccentricity) = 7 (Moderate)
d10 (1st body e) = 2 [2/(2+10) = 2/12]

Yellow Dwarf First Body (Middle Orbit: 2 AU)

d12 = 1 (Metal body)
d20 = 12 (Metal dwarf)
d8 = 3 (3/200 Me)
d100 = 25 (Fast rotation)
d4 & d6 = 10 [4 + 3 + 1 + 2] (2 x 2 AU)

For the d4 and d6 rolls, +1 scattered system and +2 moderate eccentricity modifiers were applied.

There are only a few bodies in the entire system, so Angela decides to get into greater detail and rolls the other d100s on Table 3.5 Planet Peculiarities, applying Middle Orbit modifiers to the moon roll, dwarf planet modifiers to the rotation roll, and increasing the rotation rate by one level because of the previous fast rotation peculiarity.

d100 (Moon) = 60 [60+50= 90+] (Ring system)
d100 (Day) = 50 [50+10=60 Medium + 1 level]
d100 (Axis) = 14 [14/3] (4.67 degrees)

A ring system around a tiny metal world--cool! Rolling 1d10*x1d10, Angela gets (8+5) x (7+5) = (13 x 12) = 156 moonlets. She decides the rings are pedominantly made up of these moonlets and rolls d12 on Table 3.3 Planetary Bodies to determine their composition: 3 means they are primarily rocky. For the rotation rate, Angela rolls 7, which means it has a [7 + 10] 17 hour day.

Table 3.6 Volatiles calls for d10 and d100 rolls. For the density roll, Angela applies the -5 no magnetic field, -1 dwarf planet, -1 old system (considering a stellar remnant), and +1 metal rich system modifiers, netting a total -6 modifier to the d10. The d100 Volatile Composition roll is modified by -67 because of the low mass of the dwarf planet (inverse of 3/200 = 200/3 = 66.67).

d10 (Density): 9 [9 - 6] (Very poor)
d100 (Composition): 76 [76-67] (CO_2 with O_2)
d10 (Minor volatile): 10 (None)

Cross-referencing the orbit with the Equilibrium Temperature Zones chart, Angela determines the basic temperature is Moderate/Cold; although carbon dioxide is gaseous, the very thin density of the atmosphere is insufficient for the greenhouse effect to significantly raise planetary temperature. With the oxygen constituent, this world possesses a weak ozone layer, too.

Curious about the habitability of such a world, Angela researches the effects of such an atmosphere on living beings. She soon learns that elevated carbon dioxide can cause humans and many other creatures to suffer hypoxia, hypercapnia, and even respiratory acidosis. Some kind of filter or genetic engineering might help visitors breath naturally without these problems, but even so the atmosphere of this dwarf planet is so thin supplemental oxygen would be necessary anyway. Just for kicks, though, Angela rolls on Table 4.1 Basic Native Life to see if any arose.

8.2 MULTI-STAR SAMPLE

Yellow Dwarf First Body (Continued)

d4 (Baseline) = 2
d6 (Not Moderate) = 6
d20 (No liquid water) = 18
d100 (Insignificant water) = 46
d100 (No magnetosphere) = 45
d100 (Insignificant atmo) = 50

Not a 1 rolled, so native life never came to be on this planet. It was a 1 in 480 million chance for this body.

"Moderate/cold metal dwarf: 0.015 earth mass (0.229 Re/0.284g), 2 AU orbit, 17 hour rotation, 4.67 degree axial tilt, very thin carbon dioxide/ oxygen atmosphere, moonlet ring (150+)."

Yellow Dwarf Second Body (Middle Orbit: 4 AU)

d10 (Eccentricity) = 5 (Moderate)
d10 (e) = 6 [2/6+10 = 2/16] (e=0.125)
d12 = 3 (Rock body)
d20 = 3 (Asteroid belt)
d8 & d100 = N/A

"Asteroid belt: 4+ AU (e=0.125)."

WHITE DWARF PLANET

Because this planet system is around a stellar remnant, it is assumed to be a debris disk and a +5 modifier is added to the carbon/oxygen ratio d10 roll.

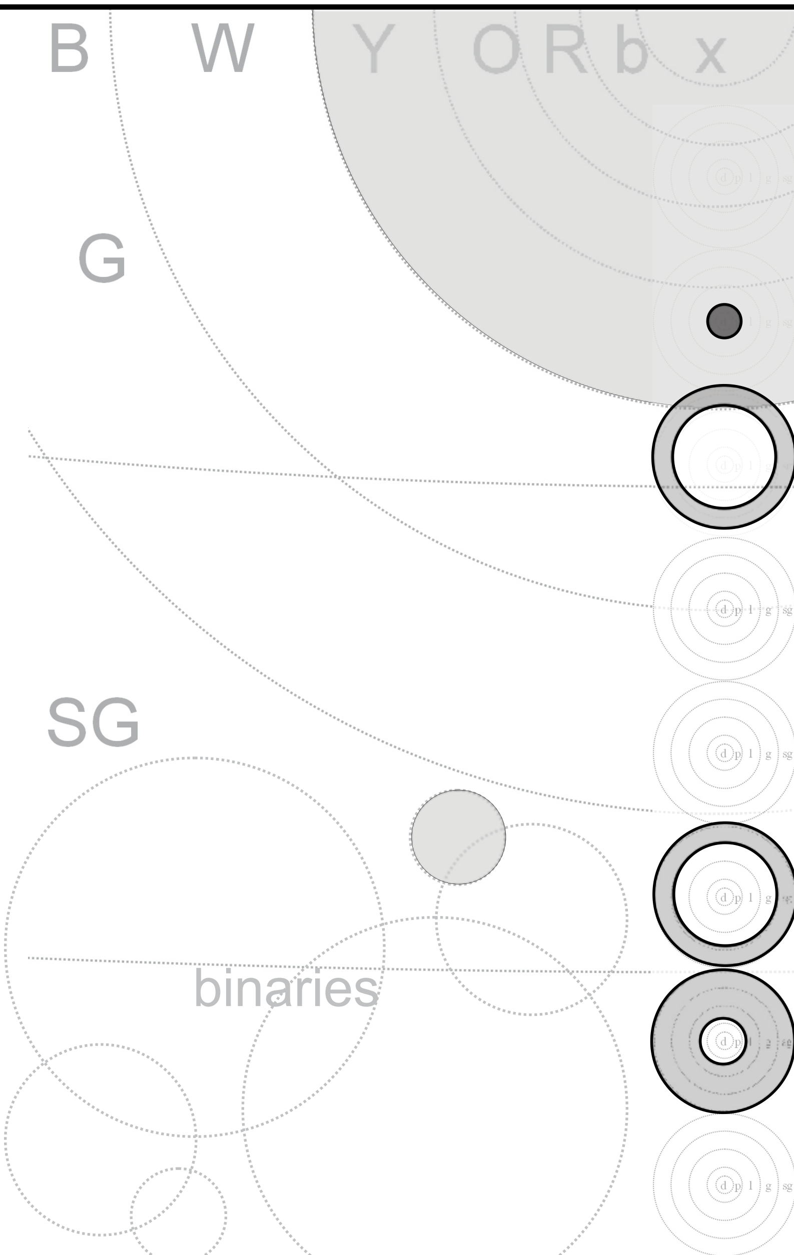
d10 (C/O ratio) = 5 [5 + 5] (Carbon rich)
d10 (Architecture) = 5 [5 - 1] 4 (Compact)
d10 x d10 (1st body) = [1/(10 x 5) x 0.75Ms]
d10 (1st body Eccentricity) = 8 (Major)
d10 (1st body e) = 9 [5/(9+10) = 5/19]

Angela makes the final HaVoQ roll (minus d4 & d6 since no other orbits need to be calculated) to determine this single orbital body. To determine the orbit zone, she assumes since this is a middle sized remnant that its luminosity will similarly be in the middle of the 1/100 to 1/1000 Ls range, so she decides it is 1/500 solar luminosity. This is similar to a red star, so she uses that column for orbital zone radii.

White Dwarf First Body (Close Orbit: 0.015 AU)

d12 = 1 (Metal body)
d20 = 7 (Meteoroid belt)
d8 & d100 = N/A

"Meteoroid belt: 0.015 AU (e=0.263)."



ORBITAL BODIES

CUZA PRIME (yellow dwarf)
PLANET SYSTEM

CUZA MOONBAND: Moderate/cold metal dwarf, 0.015 earth mass (0.229 Re/0.284g), 2 AU orbit (e=0.167), 17 hour rotation, 4.67° axial tilt, very thin carbon dioxide/oxygen atmosphere, moonlet ring

CUZA SUNBAND: Asteroid belt (4+ AU, e= 0.125)

CUZA DWARF (white dwarf remnant)
PLANET SYSTEM

CUZA STEEL BELT: Meteoroid belt (0.015 AU, e=0.263)

CUZA CAIRN BELT: Debris disk (0.02 AU to 50 AU)

STAR SYSTEM

Primary Star: Cuza Prime
Standard yellow dwarf (1 Ms/Ls)
Main sequence (7 billion yrs old)
Unusually high metallicity
Variable Star
Two major bodies
Secondary Star: Cuza Dwarf
White dwarf (¾ Ms, 1/500 Ls)
Unusually fast rotation
Circumstellar disk (1 major body)
No circumbinary major bodies

Instant Universe

Finally!
A star system generator that captures the vastness and variety of space, time, and technology.

by r. pelius cook