Linked from "Appendix C" in *Why the Universe Is the Way It Is*

Part 3. Probability Estimates for the Features Required by Various Life Forms

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Notes: Estimate of dependency and longevity factors are accounted for at the end of the list. References to relevant science research papers and books also follow the list. The definition used here for a planet is broad enough to include a large satellite orbiting another planet. For an explanation of why satellites in general and starless planets are not suitable candidates for life-support see *Lights in the Sky and Little Green Men* by Hugh Ross, Kenneth Samples, and Mark Clark (Colorado Springs, CO: NavPress, 2002), pp. 39-41.

A. Requirements to sustain bacteria for 90 days or less

Parameter	Probability that feature will fall in the required range
relative abundances of different exotic mass particles	.01
decay rates of different exotic mass particles	.05
density of quasars in the local volume of the universe during early cosmic history	.1
density of giant galaxies in the local volume of the universe during early cosmic history	.03
galaxy size	.01
galaxy type	.1
galaxy mass distribution	.02
size of galactic central bulge	.05
galaxy location	.01
variability of local dwarf galaxy absorption rate	.2
quantity of galactic dust	.2
giant star density in galaxy	.2
star location relative to galactic center	.2
star distance from corotation circle of galaxy	.05
ratio of inner dark halo mass to stellar mass for galaxy	.1
z-axis extremes of star's orbit	.2
proximity of solar nebula to a normal type I supernova eruption	.01
timing of solar nebula formation relative to a normal type I supernova eruption	.01

proximity of solar nebula to a type II supernova eruption	.01
timing of solar nebula formation relative to type II supernova eruption	.01
timing of hypernovae eruptions	.5
number of hypernovae eruptions	.3
masses of stars that become hypernovae	.2
flux of cosmic ray protons	.2
gas dispersal rate by companion stars, shock waves, and molecular cloud expansion in the Sun's birthing star cluster	.1
number of stars in birthing cluster	.1
star formation rate in parent star vicinity during history of that star	.1
birth date of the star-planetary system	.4
number of stars in planetary system	.7
density of brown dwarfs in neighborhood of life support planet	.5
absorption rate of planets and planetismals by parent star	.1
star age	.4
star metallicity	.05
star mass	.001
star color	.4
star rotation rate	.3
star magnetic field	.1
stellar wind strength	.2
star's carbon to oxygen ratio	.01
galactic tidal forces on planetary system	.2
white dwarf binary types, rates, & locations	.01
structure of comet cloud surrounding planetary system	.5
planetary distance from star	.01
inclination of planetary orbit	.5
axis tilt of planet	.5
planetary rotation period	.5
planetary revolution period	.3
planetary orbital eccentricity	.3
polycyclic aromatic hydrocarbon abundance in solar nebula	.1
number of moons	.5
surface gravity (escape velocity)	.001
magnetic field of planet	.01
albedo (planet reflectivity)	.2
density of planet	.1
density of interstellar and interplanetary dust particles in vicinity of life-support planet	.4
reducing strength of planet's primordial mantle	.3
thickness of crust	.1
silicate dust annealing by nebular shocks	.02
asteroidal & cometary collision rate	.3
mass of planet colliding with primordial Earth	.002
location of planet's collision with primordial Earth	.05
atmospheric transparency	.2
atmospheric pressure	.1

atmospheric viscosity	.3
atmospheric temperature gradient	.02
carbon dioxide quantity in atmosphere	.001
total quantity of water vapor in the atmosphere	.001
percentage of the atmosphere comprised of water vapor	.01
methane quantity in the atmosphere	.01
oxygen quantity in atmosphere	.1
nitrogen quantity in atmosphere	.001
carbon monoxide quantity in atmosphere	.1
chlorine quantity in atmosphere	.1
cobalt quantity in crust and/or soil	.1
arsenic quantity in crust and/or soil	.1
copper quantity in crust and/or soil	.1
boron quantity in crust and/or soil	.1
cadmium quantity in crust and/or soil	.1
calcium quantity in crust and/or soil	.6
fluorine quantity in crust and/or soil	.1
iodine quantity in crust and/or soil	.2
magnesium in crust and/or soil	.4
manganese quantity in crust and/or soil	.1
nickel quantity in crust and/or soil	.1
phosphorus quantity in crust and/or soil	.02
potassium quantity in crust and/or soil	.4
tin quantity in crust and/or soil	.1
zinc quantity in crust and/or soil	.1
molybdenum quantity in crust and/or soil	.05
vanadium quantity in crust and/or soil	.1
chromium quantity in crust and/or soil	.1
selenium quantity in crust and/or soil	.1
iron quantity in oceans	.01
tropospheric ozone quantity	.2
stratospheric ozone quantity	.2
mesospheric ozone quantity	.2
quantity of greenhouse gases in atmosphere	.01
quantity of sea salt aerosols in troposphere	.2
ratio of electrically conducting inner core radius to radius of the adjacent turbulent fluid shell	.2
ratio of core to shell (see above) magnetic diffusivity	.2
magnetic Reynold's number of the shell (see above)	.2
elasticity of iron in the inner core	.2
electromagnetic Maxwell shear stresses in the inner core	.2
core precession frequency for planet	.1
rate of interior heat loss for planet	.1
quantity of sulfur in the planet's core	.1
quantity of silicon in the planet's core	.1
viscosity at Earth core boundaries	.01
viscosity of lithosphere	.2
thickness of mid-mantle boundary	.1
intensity of primordial cosmic superwinds	.05
number of smoking quasars	.05

formation of large terrestrial planet in the presence of two or more gas giant planets	.01
total mass of Oort Cloud objects	.3
mass distribution of Oort Cloud objects	.3
hydrothermal alteration of ancient oceanic basalts	.1
location of dislocation creep relative to diffusion creep in and near the crust-mantle boundary (determines mantle convection dynamics)	.1
number & mass of planets in system suffering significant drift	.01
mass of the galaxy's central black hole	.1
date for the formation of the galaxy's central black hole	.2
timing of the growth of the galaxy's central black hole	.4
rate of in-spiraling gas into galaxy's central black hole during life epoch	.05
distance from nearest giant galaxy	.5
distance from nearest Seyfert galaxy	.9
quantity of magnetars (proto-neutron stars with very strong magnetic fields) produced during galaxy's history	.3
ratio of galaxy's dark halo mass to its baryonic mass	.2
ratio of galaxy's dark halo mass to its dark halo core mass	.2
galaxy cluster formation rate	.1
tidal heating from neighboring galaxies	.5
tidal heating from dark galactic and galaxy cluster halos	.5
intensity and duration of galactic winds	.3
density of dwarf galaxies in vicinity of home galaxy	.1
amount of photoevaporation during planetary formation from parent star and other nearby stars	.1
in-spiral rate of stars into black holes within parent galaxy	.7
strength of magnetocentrifugally launched wind of parent star during its protostar era	.2
degree to which the atmospheric composition of the planet departs from thermodynamic equilibrium	.1
delivery rate of volatiles to planet from asteroid-comet belts during epoch of planet formation	.05
Q-value (rigidity) of planet during its early history	.2
injection efficiency of shock wave material from nearby supernovae into collapsing molecular cloud that forms star and planetary system	.01
number of giant galaxies in galaxy cluster	.1
number of large galaxies in galaxy cluster	.1
number of dwarf galaxies in galaxy cluster	.1
number and sizes of planets and planetesimals consumed by star	.3
distance of galaxy's corotation circle from center of galaxy	.1
rate of diffusion of heavy elements from galactic center out to the galaxy's corotation circle	.2
outward migration of star relative to galactic center	.3
viscosity gradient in protoplanetary disk	.1
average quantity of gas infused into the universe's first star clusters that reside in the vicinity of the potential life	

support galaxy	.1
level of supersonic turbulence in the vicinity of the potential life support galaxy during the infancy of the universe	.05
number and sizes of intergalactic hydrogen gas clouds in galaxy's vicinity	.4
average longevity of intergalactic hydrogen gas clouds in galaxy's vicinity	.4
avoidance of apsidal phase locking in the orbits of planets in the planetary system	.03
number density of the first metal-free stars to form in the vicinity of the future potential life support galaxy	.02
epoch at which the first metal-free stars form in the vicinity of the future potential life support galaxy	.1
level of spot production on star's surface	.5
average circumstellar medium density for white dwarf red giant pairs in the vicinity of the potential life support planet's protoplanetary disk	.2
number densities of metal-poor and extremely metal-poor galaxies in vicinity of potential life support galaxy	.1
amount of gas infalling into the central core of the galaxy	.1
level of cooling of gas infalling into the central core of the galaxy	.2
heavy element abundance in the intracluster medium for the early universe in the vicinity of the potential life support galaxy	.1
quantity of volatiles on and in Earth-sized planet in the habitable zone	.001
rate of infall of intergalactic gas into emerging and growing galaxies during first five billion years of cosmic history in the vicinity of the potential life support galaxy	.1
pressure of the intra-galaxy-cluster medium in the vicinity of the potential life support galaxy	.1
proximity of solar nebula to a type I supernova whose core underwent significant gravitational collapse before carbon deflagration	.01
timing of solar nebula formation relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion	.01
proximity of emerging solar nebula relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion	.01
sizes of largest cosmic structures in the local region of the universe	.01
Kozai oscillation level in planetary system	.7
efficiency of flows of silicate melt, hypersaline hydrothermal fluids, and hydrothermal vapors in the upper crust	.4
supernova eruption rate when galaxy is young	.2
range of rotation rates for stars in the galaxy that are on the verge of becoming supernovae	.2
quantity of dust formed in the ejecta of Population III supernovae in vicinity of future life support galaxy	.1

chemical composition of dust ejected by Population III stars in vicinity of future life support galaxy	.3
epoch when the merging of galaxies peaks in the vicinity of potential life support galaxy	.05
sulfur and sulfate content of oceans	.3
density of dust-exporting stars in solar neighborhood	.4
average rate of increase in galaxy sizes in the local region of the universe	.05
proximity of solar nebula to asymptotic giant branch stars	.05
timing of solar nebula formation relative to its close approach to asymptotic giant branch stars	.05
quantity and proximity of gamma-ray burst events relative to emerging solar nebula	.01
infall of buckminsterfullerenes from interplanetary and interstellar space upon surface of planet	.3
quantity of silicic acid in the oceans	.1
timing of star formation peak for the local part of the universe	.2
timing of star formation peak for the galaxy	.2
density and thickness of atmosphere	.01
flux of extrasolar dust into atmosphere	.8
nitrogen quantity in oceans	.03
oxygen quantity in inner core	.01
oxygen quantity in outer core	.01
dwarf galaxy merger rate with home galaxy	.03
density of black holes, neutron stars, and plerionic supernova remnants in the galaxy	.4
inclination of the planes of the planetary system's asteroid belts	.4
epoch at which metal-free (pop III) stars cease forming in vicinity of potential life support galaxy	.1
average mass of metal-free (pop III) stars in vicinity of potential life support galaxy	.1
epoch in cosmic history at which number density of gamma ray burst events peak in the local volume of the universe	.3
rate at which protoplanetary disk photoevaporates	.05
density of molecular hydrogen in the galaxy	.1
angle of planet's collision with primordial Earth	.05
velocity of planet's collision with primordial Earth	.01
depth of terrestrial water at point of planet's collision with primordial Earth	.02
size of the planet's core relative to planet size	.01
number of gas giant planets in planetary system	.1
position & mass of Jupiter relative to Earth	.002
position & mass of Saturn relative to Earth	.01
position & mass of Uranus relative to Earth	.01
position & mass of Neptune relative to Earth	.01
ratio Saturn to Jupiter mass	.01
ratio of Uranus to Jupiter mass	.05
ratio of Neptune to Jupiter mass	.05
eccentricity and inclination of Jupiter's orbit	.05

eccentricity and inclination of Saturn's orbit	.05
eccentricity and inclination of Uranus's orbit	.1
eccentricity and inclination of Neptune's orbit	.1
inward drift and rate of inward drift in major planet orbital distances during planetary system's formation history	.01
distance of gas giant planets from zones of mean motion resonances	.01
amount of outward migration by Jupiter during early solar system history	.01
amount of outward migration by Saturn during early solar system history	.01
amount of outward migration by Uranus during early solar system history	.1
amount of outward migration by Neptune during early solar system history	.1
initial mass of Kuiper Belt asteroids and comets	.1
initial mass distribution of Kuiper Belt asteroids and comets	.2
initial average orbital distance of Kuiper Belt asteroids and comets	.1
reduction of Kuiper Belt mass during planetary system's early history	.05
outward displacement of average orbital distance of Kuiper Belt asteroids and comets	.1
number of terrestrial planets in planetary system	.1
position and mass of other terrestrial planets in planetary system relative to Earth	.01
inclination and eccentricity of other terrestrial planets in planetary system	.01
distance of other terrestrial planets from zones of mean motion resonances	.01
planetary formation site within the circumstellar disk	.01
type, degree, and duration of interaction between the protoplanet and the circumstellar disk	.01
amount of migration from initial formation site for potential life support planet	.01
solar nebula exposure to stellar winds from expanding asymptotic giant branch stars	.05
number density of clumpuscules (dense cold clouds of molecular hydrogen gas) in the vicinity of the galaxy	.3
average mass of clumpuscules in the vicinity of the galaxy	.3
location of clumpuscules in the vicinity of the galaxy	.1
level of dislocation creep of the lower mantle's silicate perovskite	.1
pressure at planet's core-mantle boundary	.03
temperature at planet's core-mantle boundary	.1
quantity of iron in planet's core	.001
diameter of ordinary dark matter halo surrounding the galaxy	.1
mass of ordinary dark matter halo surrounding the galaxy	.1

diameter of exotic dark matter halo surrounding the galaxy	.1
mass of exotic dark matter halo surrounding the galaxy	.1
upper mantle viscosity	.05
lower mantle viscosity	.1
mantle temperature	.1
relative abundance of perovskite in lower mantle	.1
relative abundance of mangesiowüstite in lower mantle	.1
radiative conductivity of lower mantle	.05
average inclination of inner asteroid belt objects after the accretion era	.1
average inclination Kuiper Belt objects after the accreation era	.1
average magnetic field strength in star's atmosphere	.2
anisotropy level of radiation field in star's atmosphere	.2
density of ultra-dwarf galaxies (or supermassive globular clusters) in vicinity of the galaxy	.1
galaxy cluster size	.01
galaxy cluster density	.03
galaxy cluster location	.02
pebble density in solar nebula's protoplanetary disk	.005
rate at which solar nebula ran away from its birth cluster	.03
formation rate of molecular hydrogen on dust grain surfaces when the galaxy is young	.1
number of medium- or large-sized galaxies merging with the galaxy since the formation and stabilization of its thick galactic disk	.2
intensity of far ultraviolet radiation from nearby stars when the circumsolar disk was condensing into planets	.001
phosphorus abundance in solar nebula	.03
magnitude of chemical exchange occurring at the liquid core-deep mantle boundary of planet	.1
amount of methane generated in upper mantle of planet	.03
amount of buildup of heavy elements in the galaxy	.03
timescale for the buildup of heavy elements in the galaxy	.02
planet's silicate abundance	.1
timing of the 1:2 resonance event for Jupiter and Saturn	.1
intensity of superwinds generated by primordial supermassive black holes	.03
number of superwind events generated by primordial supermassive black holes	.03
mass of moon orbiting life support planet	.2
galaxy mass	.02
density of galaxies in the local volume around life-support galaxy	.1
average galaxy mass in the local volume around life-support galaxy	.1
rate at which the triple-alpha process (combining of three helium nuclei to make one carbon nucleus) runs inside	

the nuclear furnaces of stars	.002
average mass of cold dark gas-dust clouds in the galaxy	.3
number density of cold dark gas-dust clouds in the galaxy	.3
proximity of cold dark gas-dust clouds to life-support planet	.1
masses of nearest cold dark gas-dust clouds to life support planet	.1
time in galactic history when cold dark gas-dust clouds form	.3
intensity of the late heavy bombardment	.02
chemical composition of the late heavy bombarders	.1
depth of Earth's primordial ocean	.01
upper mantle seismic anisotropy	.1
lower mantle seismic anisotropy	.1
ratio of baryons in galaxy clusters to baryons in between galaxy clusters within the Local Volume of the universe	.1
ratio of baryons in galaxies to baryons in between galaxies in the Local Volume of the universe	.1
degree of central concentration of light-emitting ordinary matter for the life-support galaxy	.05
degree of flatness for the light-emitting ordinary matter for the life-support galaxy	.05
degree of sphericity for the distribution of ordinary dark matter for the life-support galaxy	.1
degree of sphericity for the distribution of exotic dark matter for the life-support galaxy	.1
average albedo of Earth's surface life	.01
level of carbon abundance in the galaxy	.05
gradient of carbon abundance with respect to distance from galactic center	.05
level of oxygen abundance in the galaxy	.05
gradient of oxygen abundance with respect to distance from galactic center	.05
level of nitrogen abundance in the galaxy	.1
gradient of nitrogen abundance with respect to distance from galactic center	.1
infall velocity of galaxy toward center of nearest grouping of galaxies	.05
infall velocity of galaxy toward center of nearest supercluster of galaxies	.1
distance that primordial supernovae dispersed elements heavier than helium	.03
velocity of planet colliding with primordial Earth relative to Earth	.002
collision angle relative to Earth of planet colliding with primordial Earth	.05
photo erosion by nearby giant stars during planetary formation phase	.005
dust extinction of that region of the spiral disk where the potential life support planet forms	.1
surface density of the protoplanetary disk	.01
ratio of mass in the form of debris relative to mass in the	

form of planetesimals for the protoplanetary disk	.1
width of the primordial Kuiper Belt	.1
average mass of the primordial Kuiper Belt objects	.1
mass of the Sun's primordial gas-dust disk	.03
longevity of the Sun's primordial gas-dust disk	.05
initial orbital distance of Jupiter	.01
initial orbital distance of Saturn	.02
initial orbital distance of Uranus	.04
initial orbital distance of Neptune	.05
quantity of terrestrial lightning	.1
type of terrestrial lightning	.2
percentage of galaxies containing stars with planets in stable orbits	.1
percentage of stars in galaxy with planets in stable orbits	.02
amount of iron-60 injected into Earth's primordial core from a nearby type II supernova eruption	.03
thickness of iron-rich silicate layer between the lower mantle and outer liquid core	.1
diffusivity of iron-rich silicate layer between the lower mantle and outer liquid core	.1
magnetism of iron-rich silicate layer between the lower mantle and outer liquid core	.1
elastic anisotropy of iron-rich silicate layer between the lower mantle and outer liquid core	.1
Ekman number (relative importance of viscosity to rotation rate) for Earth's interior	.03
quantity of molecular hydrogen formed by the supernova eruptions of population III stars (the first born stars) in the vicinity of the potential life-support galaxy	.01
quantity of uranium in the inner core	.01
quantity of uranium in the outer core	.01
quantity of uranium in the bottom mantle	.01
quantity of uranium in middle and upper mantle layers	.01
quantity of uranium in the crust	.01
quantity of thorium in the inner core	.01
quantity of thorium in the outer core	.01
quantity of thorium in the bottom mantle	.01
quantity of thorium in the middle and upper mantle layers	.01
quantity of thorium in the crust	.01
quantity of potassium-40 in the bottom mantle	.01
quantity of potassium-40 in the middle and upper mantle layers	.01
ratio of asteroids to comets for the late heavy bombardment of Earth	.03
rate of destruction and dispersal of dust as a result of supernova eruptions in the potential life-support galaxy	.1
percent of baryons processed by the first stars (population III stars) in the vicinity of and inside the primordial Milky Way Galaxy	.04
solar system's orbital radius about the center of the Milky	

Way Galaxy	.01
quantity of soluble zinc in the oceans	.05
quantity of soluble silicon and silica in the oceans	.05
quantity of phosphorous and phosphates in the oceans	.01
availability of light to upper layers of the oceans	.1
proximity of emerging solar system nebula to red giant stars	.05
number of red giant stars in close proximity to emerging solar system nebula	.1
masses of red giant stars in close proximity to emerging solar system nebula	.1
proximity of emerging solar system nebula to fluorine-ejecting planetary nebulae	.05
number of fluorine-ejecting planetary nebulae in close proximity to emerging solar system nebula	.1
number of large galaxy collisions with the Milky Way Galaxy during the past ten billion years	.03
number of large galaxy collisions in the near vicinity of the Milky Way Galaxy during the past ten billion years	.05
frequency of core collapse supernovae	.1
shape of the Milky Way Galaxy's ordinary dark matter halo	.1
mass of the potential life support planet	.002
timing of potential life-support planet's birth relative to spiral substructure formation	.2
luminosity variability of the primordial sun	.1
level of turbulence in the sun's primordial planetary disk	.1
level of warping in the Milky Way Galaxy's spiral disk	.1
density of the galaxy	.01
impact energy of moon-forming collidor event	.0001
Earth formation date relative to the formation date for the solar system nebula	.02
flux of interplanetary dust into atmosphere	.7
density of particulates in the atmosphere	.1
degree of suppression of dwarf galaxy formation by cosmic reionization in the local volume of the universe	.02
silicon abundance in planetary system's primordial nebula	.01
rate of decrease of the thickness of the gas disk in the life-support galaxy	.1
hydrogen escape from the atmosphere to outer space	.01
oxygen abundance in the galactic bulge	.1
production of H_3^+ by the galaxy's population III (first generation) stars	.05
production of H_3^+ by the galaxy's population II (second generation) stars	.05
intensity of ultraviolet radiation arriving from the sun at the time and shortly after life's origin on Earth (before photosynthesis can establish a significant ozone shield)	.002
wavelength response pattern of ultraviolet radiation arriving from the sun at the time or shortly after life's origin on Earth	.02
gas density of the local interstellar medium	.05

degree of oxidation of the phosphorus compounds in the protoplanetary disk of the solar nebula	.05
mass of the disk of dust, asteroids, and comets for the primordial planetary system	.01
degree to which the solar wind penetrates Earth's magnetosphere	.3
ratio of viscous to rotational forces in the planet's liquid core	.01
inward migration of pebble-sized and smaller icy rubble from the outer primordial planetary disk	.01
ratio of iron to chondritic meteorites at the time and place of Earth's birth	.01
number of ultracompact dwarf galaxies in the vicinity of the potential life support galaxy during that galaxy's youth	.1
number of starless hydrogen gas clouds in the near vicinity of the potential life support galaxy	.3
average mass of starless hydrogen gas clouds in the near vicinity of the potential life support galaxy	.3
dust to gas ratio in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
gas temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust to gas ratio in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
dust temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
gas temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
quantity of carbon monoxide in the potential life support galaxy early in its history	.1
number density of dark matter minihalos in the primordial Local Group	.01
intensity or speed of high-velocity galactic outflows during the youth of the potential life support galaxy	.01
thickness of the thick disk for the potential life support galaxy	.03
epoch of peak production of type I supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type I supernovae in the potential life support galaxy	.1
epoch of peak production of type II supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type II supernovae in the potential life support galaxy	.1
virial radius of the exotic matter halo surrounding the potential life support galaxy	.02
mass of the corona surrounding the potential life support galaxy	.1
diameter of the corona surrounding the potential life support galaxy	.1
average strength of local gravitational instabilities in the potential life support galaxy	.03
level of magnetic turbulence in the galactic interstellar medium	.1

thermal pressure of the planet's ionosphere	.01
quantity of phosphorus mononitride and carbon monophosphide in the gas-dust cloud from which the solar system formed	.03
shape of the galaxy cluster	.5
shape of the galaxy supercluster	.5
outer radius of the "dead zone," the low-viscosity, very-low-ionization zone for the primordial planetary disk	.01
cooling efficiency of the protoplanetary disk	.1
outer protoplanetary disk lifetime	.005
solid to gas ratio in the outer protoplanetary disk	.01
level of large scale turbulence in the protoplanetary disk	.02
timing for the formation of the first stars in the vicinity of the Local Group of galaxies	.05
timing for the complete reionization of the local intergalactic medium	.05
average magnetic energy density in the quiet solar photosphere	.02
proximity of the primordial solar system nebula to the remnants of eruptions of novae	.05
number density of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
average mass of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
number density of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
average mass of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
supernova rate in the life support galaxy	.1
timing of outward migration of Jupiter	.03
timing of outward migration of Saturn	.05
timing of outward migration of Uranus	.1
timing of outward migration of Neptune	.1
number of extrasolar planets and planetesimals captured from the outer planetary disks of near-passing stars	.1
timing of the initiation of enrichment of the interstellar medium with s-process elements for the potential life-support galaxy	.1
proximity of the emerging solar system nebula to either a white dwarf or a neutron star that is accreting hydrogen gas or to the stellar winds blowing out from a neutron star or a collapsar disk	.002
density of matter in and about the environs of the Local Group of galaxies	.1
density of baryons in the Local Volume of the universe	.05
density of baryons in the Local Group of galaxies	.05
ratio of baryons in galaxies to baryons in between galaxies in the Local Group of galaxies	.1
epoch of peak star formation in the potential life support galaxy	.01
ratio of type I to type II supernovae in the potential life support galaxy	.02
ratio of polycyclic aromatic hydrocarbons to stars in the galaxy	.05
closest proximity of the solar system to a black hole during the	

history of life	.5
quantity of warm dust in the interplanetary medium	.5
level of coronal mass ejections from the solar surface	.4
birthrate of massive stars in the solar neighborhood	.1
number density of intracluster clouds in and around the Local Group of galaxies	.1
average mass of intracluster clouds in and around the Local Group of galaxies	.1
metallicity of the galaxy's halo	.02
shape of the galactic dark matter halo	.1
temperature of the hot intracluster medium for the Local Group of galaxies	.05
inward migration of icy meter-sized rubble from the outer part of the protoplanetary disk	.001
density of stars in the sun's birthing star cluster	.01
carbon abundance in the protoplanetary disk of the potential life support planetary system	.001
number density of dark matter subhalos surrounding the galaxy	.1
average mass of the dark matter subhalos surrounding the galaxy	.1
formation times for the dark matter halo and subhales surrounding the galaxy	.01
planet formation time scale in the protoplanetary disk	.03
rate of growth of the galactic bulge in the spiral galaxy	.03
strength of the ultraviolet background for the protogalaxy	.1
extent of the warp of the galactic disk	.2
proximity of the emerging solar system nebula to very low mass red giant and asymptotic giant branch stars	.01
richness or density of galaxies in the supercluster of galaxies	.1
misalignment angle between the magnetic and rotational axes of the star during the planet formation era	.1
infall velocity of matter into the dark matter halo of the potential life support galaxy	.05
migration speed of Jupiter early in its history	.01
migration speed of Saturn early in its history	.02
migration speed of Uranus early in its history	.05
migration speed of Neptune early in its history	.05
level of magnetization of the spiral disk for the potential life support galaxy	.05
percentage of the Milky Way Galaxy's halo that is comprised of MACHOs	.2
metallicity of the galaxy's halo	.1
strength of the wind emanating from the galaxy's nuclear core	.05
mass of the initial or primordial galaxy	.005
magnetization of the protoplanetary disk	.1
level of mixing of the elements and chemicals in the protoplanetary disk	.02
strength of the vertical magnetic field emanating from the galactic center	.1
level of radial differential rotation during the sun's youth	.1
level of enhanced mixing in the interiors of low-mass red giant s	

tars that were in the vicinity of the solar system's protoplanetary disk	.1
date when half the stars in the galaxy would have already been formed	.2
density of dwarf dark matter halos in the vicinity of the Milky Way Galaxy	.01
metallicity enrichment by dwarf galaxies of the intergalactic medium in the vicinity of the potential life support galaxy	.1
average star formation rate throughout cosmic history for dwarf galaxies that are in the vicinity of the potential life support galaxy	.02
quantity of heavy elements infused into the intergalactic medium by dwarf galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
quantity of heavy elements infused into the intergalactic medium by the superwinds of large galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
average size of cosmic voids in the vicinity of the potential life support galaxy	.5
number of cosmic voids per unit of cosmic space in the vicinity of the potential life support galaxy	.5
number of galaxies per unit of dark matter halo virial mass in the vicinity of the potential life support galaxy	.1
ratio of the number density of dark matter subhalos to the number density of dark matter halos in the vicinity of the potential life support galaxy	.1
quantity of diffuse, large-grained intergalactic dust in the vicinity of the potential life support galaxy	.1
ratio of baryonic matter to exotic matter in dwarf galaxies in the vicinity of the potential life support galaxy	.1
ratio of baryons in the intergalactic medium relative to baryons in the circumgalactic medium for the potential life support galaxy	.1
intergalactic photon density in the vicinity of the potential life support galaxy	.4
quantity of baryons in the warm-hot intergalactic medium in the vicinity of the potential life support galaxy	.2
radiative thermal conductivity level of the lower mantle	.01
abundance of olivine in the upper mantle	.1
level of chemical heterogeneities throughout the lower mantle	.1
rate at which the planet's inner core rotates faster than the mantle and the crust	.1
radiative thermal conductivity of the lower mantle	.01
quantity of Trichodesmium bacteria in the oceans	.0001
level of mixing in the early protoplanetary disk of the solar nebula	.05
distance of the Magellanic Clouds from the Milky Way Galaxy	.5
timing of the movement of the main asteroid belt from its place of birth (much closer to the sun) to its present location (between Mars and Jupiter)	.1

Probability for occurrence of all 501 parameters $\approx 10^{-614}$
dependency factors estimate $\approx 10^{303}$
longevity requirements estimate $\approx 10^{-22}$

Probability for occurrence of all 501 parameters $\approx 10^{-333}$
Maximum possible number of life support bodies in observable universe $\approx 10^{22}$

Thus, less than 1 chance in 10^{311} exists that even one such life-support body would occur anywhere in the universe without invoking divine miracles.

B. Requirements to sustain unicellar life for three billion years

Parameter	Probability that feature will fall in the required range
relative abundances of different exotic mass particles	.01
decay rates of different exotic mass particles	.05
density of quasars in the local volume of the universe during early cosmic history	.1
density of giant galaxies in the local volume of the universe during early cosmic history	.03
galaxy size	.01
galaxy type	.1
galaxy mass distribution	.02
size of galactic central bulge	.05
galaxy location	.01
variability of local dwarf galaxy absorption rate	.1
quantity of galactic dust	.1
giant star density in galaxy	.1
star location relative to galactic center	.2
star distance from corotation circle of galaxy	.05
ratio of inner dark halo mass to stellar mass for galaxy	.1
star distance from closest spiral arm	.1
z-axis extremes of star's orbit	.1
proximity of solar nebula to a normal type I supernova eruption	.01
timing of solar nebula formation relative to a normal type I supernova eruption	.01
proximity of solar nebula to a type II supernova eruption	.01
timing of solar nebula formation relative to type II supernova eruption	.01
timing of hypernovae eruptions	.2
number of hypernovae eruptions	.1
masses of stars that become hypernovae	.1
flux of cosmic ray protons	.2
variability of cosmic ray proton flux	.2
gas dispersal rate by companion stars, shock waves, and molecular cloud expansion in the Sun's birthing star cluster	.1
number of stars in birthing cluster	.02
star formation rate in parent star vicinity during history of that star	.1
variation in star formation rate in parent star vicinity during history of that star	.2
birth date of the star-planetary system	.02
number of stars in planetary system	.7
number and timing of close encounters by nearby stars	.05

proximity of close stellar encounters	.1
masses of close stellar encounters	.1
density of brown dwarfs in neighborhood of life support planet	.2
absorption rate of planets and planetismals by parent star	.1
star age	.4
star metallicity	.05
ratio of ^{40}K, $^{235,238}U$, ^{232}Th to iron in star-planetary system	.1
star orbital eccentricity	.1
star mass	.001
star luminosity change relative to speciation types & rates & dates	.1
star color	.4
star rotation rate	.3
rate of change in star rotation rate	.3
star magnetic field	.1
star magnetic field variability	.1
stellar wind strength	.2
stellar wind variability	.3
short period variation in parent star diameter	.4
star's carbon to oxygen ratio	.01
star's space velocity relative to Local Standard of Rest	.1
star's short term luminosity variability	.2
star's long term luminosity variability	.3
amplitude and duration of star spot cycle	.5
number & timing of solar system encounters with interstellar gas clouds and cloudlets	.2
galactic tidal forces on planetary system	.2
white dwarf binary types, rates, & locations	.01
structure of comet cloud surrounding planetary system	.5
planetary distance from star	.01
inclination of planetary orbit	.5
axis tilt of planet	.3
rate of change of axial tilt	.1
period and size of axis tilt variation	.2
planetary rotation period	.5
rate of change in planetary rotation period	.2
planetary revolution period	.3
planetary orbital eccentricity	.3
rate of change of planetary orbital eccentricity	.2
rate of change of planetary inclination	.5
period and size of planetary eccentricity variation	.4
period and size of planetary inclination variation	.7
precession in planet's rotation	.5
rate of change in planet's precession	.5
polycyclic aromatic hydrocarbon abundance in solar nebula	.1
number of moons	.2
surface gravity (escape velocity)	.001
tidal force from sun and moon	.5
magnetic field of planet	.01
rate of change & character of change in magnetic field	.2
albedo (planet reflectivity)	.2

density of planet	.1
density of interstellar and interplanetary dust particles in vicinity of life-support planet	.4
reducing strength of planet's primordial mantle	.3
thickness of crust	.01
timing of birth of continent formation	.9
oceans-to-continents ratio	.9
rate of change in oceans to continents ratio	.9
global distribution of continents	.3
frequency, timing, & extent of ice ages	.9
frequency, timing, & extent of global snowball events	.7
silicate dust annealing by nebular shocks	.02
asteroidal & cometary collision rate	.3
change in asteroidal & cometary collision rates	.3
rate of change in asteroidal & cometary collision rates	.3
mass of planet colliding with primordial Earth	.002
timing of planet colliding with primordial Earth	.05
location of planet's collision with primordial Earth	.05
average rainfall precipitation	.01
variation and timing of average rainfall precipitation	.1
atmospheric transparency	.1
atmospheric pressure	.1
atmospheric viscosity	.3
atmospheric temperature gradient	.02
carbon dioxide quantity in atmosphere	.001
total quantity of water vapor in the atmosphere	.001
percentage of the atmosphere comprised of water vapor	.01
methane quantity in the atmosphere	.01
rates of change in carbon dioxide levels in atmosphere throughout the planet's history	.001
rates of change in water vapor levels in atmosphere throughout the planet's history	.001
rates of change in methane level in atmosphere throughout the planet's history	.01
oxygen quantity in atmosphere	.1
rate of change in oxygen level in atmosphere throughout the planet's history	.1
nitrogen quantity in atmosphere	.001
carbon monoxide quantity in atmosphere	.1
chlorine quantity in atmosphere	.1
aerosol particle density emitted from forests	.1
cobalt quantity in crust and/or soil	.1
arsenic quantity in crust and/or soil	.1
copper quantity in crust and/or soil	.1
boron quantity in crust and/or soil	.1
cadmium quantity in crust and/or soil	.1
calcium quantity in crust and/or soil	.6
fluorine quantity in crust and/or soil	.1
iodine quantity in crust and/or soil	.2
magnesium in crust and/or soil	.4

manganese quantity in crust and/or soil	.1
nickel quantity in crust and/or soil	.1
phosphorus quantity in crust and/or soil	.02
potassium quantity in crust and/or soil	.4
tin quantity in crust and/or soil	.1
zinc quantity in crust and/or soil	.1
molybdenum quantity in crust and/or soil	.05
vanadium quantity in crust and/or soil	.1
chromium quantity in crust and/or soil	.1
selenium quantity in crust and/or soil	.1
iron quantity in oceans	.01
tropospheric ozone quantity	.02
stratospheric ozone quantity	.02
mesospheric ozone quantity	.02
oxygen to nitrogen ratio in atmosphere	.2
quantity of greenhouse gases in atmosphere	.01
rate of change in greenhouse gases in atmosphere	.01
poleward heat transport in atmosphere by mid-latitude storms	.5
quantity and extent of forest fires	.3
quantity and extent of grass fires	.3
quantity of sea salt aerosols in troposphere	.2
soil mineralization	.1
quantity of anaerobic nitrogen-fixing bacteria in the early oceans	.0001
quantity of decomposer bacteria in soil	.01
quantity of nitrifying microbes in soil	.01
quantity, timing, & placement of methanogens	.00001
ratio of electrically conducting inner core radius to radius of the adjacent turbulent fluid shell	.2
ratio of core to shell (see above) magnetic diffusivity	.2
magnetic Reynold's number of the shell (see above)	.2
elasticity of iron in the inner core	.2
electromagnetic Maxwell shear stresses in the inner core	.2
core precession frequency for planet	.1
rate of interior heat loss for planet	.1
quantity of sulfur in the planet's core	.1
quantity of silicon in the planet's core	.1
quantity of water at subduction zones in the crust	.02
quantity of high pressure ice in subducting crustal slabs	.1
hydration rate of subducted minerals	.1
water absorption capacity of planet's lower mantle	.1
tectonic activity	.01
rate of decline in tectonic activity	.1
volcanic activity	.2
rate of decline in volcanic activity	.2
location of volcanic eruptions	.4
continental relief	.8
viscosity at Earth core boundaries	.01
viscosity of lithosphere	.2
thickness of mid-mantle boundary	.1

rate of sedimentary loading at crustal subduction zones	.2
biomass to comet infall ratio	.1
regularity of cometary infall	.3
intensity of primordial cosmic superwinds	.05
number of smoking quasars	.05
formation of large terrestrial planet in the presence of two or more gas giant planets	.01
total mass of Oort Cloud objects	.3
mass distribution of Oort Cloud objects	.3
air turbulence in troposphere	.5
quantity of sulfate aerosols in troposphere	.4
quantity of phytoplankton	.001
hydrothermal alteration of ancient oceanic basalts	.1
location of dislocation creep relative to diffusion creep in and near the crust-mantle boundary (determines mantle convection dynamics)	.1
size of oxygen sinks in the planet's crust	.2
size of oxygen sinks in the planet's mantle	.2
mantle plume production	.2
number & mass of planets in system suffering significant drift	.01
mass of the galaxy's central black hole	.1
date for the formation of the galaxy's central black hole	.2
timing of the growth of the galaxy's central black hole	.4
rate of in-spiraling gas into galaxy's central black hole during life epoch	.05
distance from nearest giant galaxy	.5
distance from nearest Seyfert galaxy	.9
amount of mass loss by star in its youth	.1
rate of mass loss of star in its youth	.3
rate of mass loss by star during its middle age	.3
quantity of magnetars (proto-neutron stars with very strong magnetic fields) produced during galaxy's history	.1
variation in coverage of star's surface by faculae	.7
ratio of galaxy's dark halo mass to its baryonic mass	.2
ratio of galaxy's dark halo mass to its dark halo core mass	.2
galaxy cluster formation rate	.1
proximity of supernovae and hypernovae throughout history of planet and planetary system	.1
tidal heating from neighboring galaxies	.5
tidal heating from dark galactic and galaxy cluster halos	.5
intensity and duration of galactic winds	.3
density of dwarf galaxies in vicinity of home galaxy	.1
amount of photoevaporation during planetary formation from parent star and other nearby stars	.1
in-spiral rate of stars into black holes within parent galaxy	.7
strength of magnetocentrifugally launched wind of parent star during its protostar era	.2
degree to which the atmospheric composition of the planet departs from thermodynamic equilibrium	.05
delivery rate of volatiles to planet from asteroid-comet belts	

during epoch of planet formation	.05
Q-value (rigidity) of planet during its early history	.2
variation in Q-value of planet during its early history	.3
injection efficiency of shock wave material from nearby supernovae into collapsing molecular cloud that forms star and planetary system	.01
number of giant galaxies in galaxy cluster	.1
number of large galaxies in galaxy cluster	.1
number of dwarf galaxies in galaxy cluster	.1
number and sizes of planets and planetesimals consumed by star	.3
distance of galaxy's corotation circle from center of galaxy	.1
rate of diffusion of heavy elements from galactic center out to the galaxy's corotation circle	.2
outward migration of star relative to galactic center	.3
viscosity gradient in protoplanetary disk	.1
long and medium period variations in star's diameter	.5
average quantity of gas infused into the universe's first star clusters that reside in the vicinity of the potential life support galaxy	.1
frequency of late impacts by large asteroids and comets	.2
level of supersonic turbulence in the vicinity of the potential life support galaxy during the infancy of the universe	.05
number and sizes of intergalactic hydrogen gas clouds in galaxy's vicinity	.4
average longevity of intergalactic hydrogen gas clouds in galaxy's vicinity	.4
avoidance of apsidal phase locking in the orbits of planets in the planetary system	.03
number density of the first metal-free stars to form in the vicinity of the future potential life support galaxy	.02
epoch at which the first metal-free stars form in the vicinity of the future potential life support galaxy	.1
level of spot production on star's surface	.5
variability of spot production on star's surface	.5
size of the carbon sink in the deep mantle of the planet	.1
average circumstellar medium density for white dwarf red giant pairs in the vicinity of the potential life support planet's protoplanetary disk	.2
number densities of metal-poor and extremely metal-poor galaxies in vicinity of potential life support galaxy	.1
rate of growth of central spheroid for the galaxy	.05
amount of gas infalling into the central core of the galaxy	.1
level of cooling of gas infalling into the central core of the galaxy	.2
heavy element abundance in the intracluster medium for the early universe in the vicinity of the potential life support galaxy	.1
quantity of volatiles on and in Earth-sized planet in the habitable zone	.001

rate of infall of intergalactic gas into emerging and growing galaxies during first five billion years of cosmic history in the vicinity of the potential life support galaxy .1
pressure of the intra-galaxy-cluster medium in the vicinity of the potential life support galaxy .1
proximity of solar nebula to a type I supernova whose core underwent significant gravitational collapse before carbon deflagration .01
timing of solar nebula formation relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion .01
proximity of emerging solar nebula relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion .01
sizes of largest cosmic structures in the local region of the universe .01
level of spiral substructure in spiral galaxy .2
Kozai oscillation level in planetary system .7
efficiency of stellar mass loss during final stages of stellar burning for old stars in vicinity of potential life support planet .3
efficiency of flows of silicate melt, hypersaline hydrothermal fluids, and hydrothermal vapors in the upper crust .4
supernova eruption rate when galaxy is young .2
range of rotation rates for stars in the galaxy that are on the verge of becoming supernovae .2
quantity of dust formed in the ejecta of Population III supernovae in vicinity of future life support galaxy .1
chemical composition of dust ejected by Population III stars in vicinity of future life support galaxy .3
epoch when the merging of galaxies peaks in the vicinity of potential life support galaxy .05
efficiency of ocean pumps that return nutrients to ocean surfaces .1
sulfur and sulfate content of oceans .3
density of extragalactic intruder stars in solar neighborhood .4
density of dust-exporting stars in solar neighborhood .4
average rate of increase in galaxy sizes in the local region of the universe .05
change in average rate of increase in galaxy sizes throughout cosmic history in the local region of the universe .2
proximity of solar nebula to asymptotic giant branch stars .05
timing of solar nebula formation relative to its close approach to asymptotic giant branch stars .05
quantity and proximity of gamma-ray burst events relative to emerging solar nebula .01
proximity of superbubbles to planetary system during life epoch of life-support planet .1
proximity of strong ultraviolet emitting stars to planetary system during life epoch of life-support planet .02
infall of buckminsterfullerenes from interplanetary and

interstellar space upon surface of planet	.3
quantity of silicic acid in the oceans	.1
water absorption by planet's mantle	.01
timing of star formation peak for the local part of the universe	.2
timing of star formation peak for the galaxy	.2
density and thickness of atmosphere	.01
flux of extrasolar dust into atmosphere	.8
oxygen quantity in oceans	.01
nitrogen quantity in oceans	.03
oxygen quantity in inner core	.01
oxygen quantity in outer core	.01
dwarf galaxy merger rate with home galaxy	.03
lifetimes of methane in different atmospheric layers	.01
density of black holes, neutron stars, and plerionic supernova remnants in the galaxy	.4
inclination of the planes of the planetary system's asteroid belts	.4
variations in the inclinations of the planes of the planetary system's asteroid belts	.5
epoch at which metal-free (pop III) stars cease forming in vicinity of potential life support galaxy	.1
average mass of metal-free (pop III) stars in vicinity of potential life support galaxy	.1
epoch in cosmic history at which number density of gamma ray burst events peak in the local volume of the universe	.3
rate at which protoplanetary disk photoevaporates	.05
density of molecular hydrogen in the galaxy	.1
angle of planet's collision with primordial Earth	.05
velocity of planet's collision with primordial Earth	.01
depth of terrestrial water at point of planet's collision with primordial Earth	.02
size of the planet's core relative to planet size	.01
number of gas giant planets in planetary system	.1
position & mass of Jupiter relative to Earth	.002
position & mass of Saturn relative to Earth	.01
position & mass of Uranus relative to Earth	.01
position & mass of Neptune relative to Earth	.01
ratio Saturn to Jupiter mass	.01
ratio of Uranus to Jupiter mass	.05
ratio of Neptune to Jupiter mass	.05
eccentricity and inclination of Jupiter's orbit	.05
eccentricity and inclination of Saturn's orbit	.05
eccentricity and inclination of Uranus's orbit	.1
eccentricity and inclination of Neptune's orbit	.1
major planet orbital variations and instabilities	.01
inward drift and rate of inward drift in major planet orbital distances during planetary system's formation history	.01
distance of gas giant planets from zones of mean motion resonances	.01

amount of outward migration by Jupiter during early solar system history	.01
amount of outward migration by Saturn during early solar system history	.01
amount of outward migration by Uranus during early solar system history	.1
amount of outward migration by Neptune during early solar system history	.1
initial mass of Kuiper Belt asteroids and comets	.1
initial mass distribution of Kuiper Belt asteroids and comets	.2
initial average orbital distance of Kuiper Belt asteroids and comets	.1
reduction of Kuiper Belt mass during planetary system's early history	.05
outward displacement of average orbital distance of Kuiper Belt asteroids and comets	.1
number of terrestrial planets in planetary system	.1
position and mass of other terrestrial planets in planetary system relative to Earth	.01
inclination and eccentricity of other terrestrial planets in planetary system	.01
distance of other terrestrial planets from zones of mean motion resonances	.01
planetary formation site within the circumstellar disk	.01
type, degree, and duration of interaction between the protoplanet and the circumstellar disk	.01
amount of migration from initial formation site for potential life support planet	.01
solar nebula exposure to stellar winds from expanding asymptotic giant branch stars	.05
number density of clumpuscules (dense cold clouds of molecular hydrogen gas) in the vicinity of the galaxy	.3
average mass of clumpuscules in the vicinity of the galaxy	.3
location of clumpuscules in the vicinity of the galaxy	.1
level of dislocation creep of the lower mantle's silicate perovskite	.1
pressure at planet's core-mantle boundary	.03
temperature at planet's core-mantle boundary	.1
quantity of iron in planet's core	.001
long term water loss from planet due to photodissociation	.01
diameter of ordinary dark matter halo surrounding the galaxy	.1
mass of ordinary dark matter halo surrounding the galaxy	.1
diameter of exotic dark matter halo surrounding the galaxy	.1
mass of exotic dark matter halo surrounding the galaxy	.1
upper mantle viscosity	.05
lower mantle viscosity	.1
mantle temperature	.1

relative abundance of perovskite in lower mantle	.1
relative abundance of mangesiowüstite in lower mantle	.1
radiative conductivity of lower mantle	.05
average degree of plate subduction at plate boundaries	.05
average longevity of plate subduction at plate boundaries	.05
average inclination of inner asteroid belt objects after the accretion era	.1
average inclination Kuiper Belt objects after the accreation era	.1
average magnetic field strength in star's atmosphere	.2
anisotropy level of radiation field in star's atmosphere	.2
density of ultra-dwarf galaxies (or supermassive globular clusters) in vicinity of the galaxy	.1
galaxy cluster size	.01
galaxy cluster density	.03
galaxy cluster location	.02
pebble density in solar nebula's protoplanetary disk	.005
rate at which solar nebula ran away from its birth cluster	.03
diffuse x-ray emission from nearest spiral arms	.2
magnitude of air movement at the boundaries of water vapor clouds in planet's atmosphere	.01
formation rate of molecular hydrogen on dust grain surfaces when the galaxy is young	.1
number of medium- or large-sized galaxies merging with the galaxy since the formation and stabilization of its thick galactic disk	.2
quantity of large-celled nitrogen fixing cyanobacteria in the oceans	.001
quantity of small-celled nitrogen fixing cyanobacteria in the oceans	.001
quantity of nitrogen fixing bacterioplankton in the oceans	.001
intensity of far ultraviolet radiation from nearby stars when the circumsolar disk was condensing into planets	.001
phosphorus abundance in solar nebula	.03
magnitude of chemical exchange occurring at the liquid core-deep mantle boundary of planet	.1
amount of methane generated in upper mantle of planet	.03
amount of buildup of heavy elements in the galaxy	.03
timescale for the buildup of heavy elements in the galaxy	.02
average width of the light spectrum utilized by phyto-plankton species throughout life's history on the planet	.1
level of biogenic mixing of seafloor sediments	.001
planet's silicate abundance	.1
salinity of the deep ocean	.1
convection in the deep ocean	.1
ventilation of oxygen and carbon dioxide in the deep ocean	.1
timing of the 1:2 resonance event for Jupiter and Saturn	.1
intensity of superwinds generated by primordial supermassive black holes	.03
number of superwind events generated by primordial	

supermassive black holes	.03
mass of moon orbiting life support planet	.1
galaxy mass	.02
density of galaxies in the local volume around life-support galaxy	.1
average galaxy mass in the local volume around life-support galaxy	.1
rate at which the triple-alpha process (combining of three helium nuclei to make one carbon nucleus) runs inside the nuclear furnaces of stars	.002
average mass of cold dark gas-dust clouds in the galaxy	.3
number density of cold dark gas-dust clouds in the galaxy	.3
proximity of cold dark gas-dust clouds to life-support planet	.1
masses of nearest cold dark gas-dust clouds to life support planet	.1
time in galactic history when cold dark gas-dust clouds form	.3
timing of late heavy bombardment	.1
intensity of the late heavy bombardment	.02
chemical composition of the late heavy bombarders	.1
depth of Earth's primordial ocean	.01
upper mantle seismic anisotropy	.1
lower mantle seismic anisotropy	.1
date of star formation shutdown in the galaxy	.2
ratio of baryons in galaxy clusters to baryons in between galaxy clusters within the Local Volume of the universe	.1
ratio of baryons in galaxies to baryons in between galaxies in the Local Volume of the universe	.1
degree of central concentration of light-emitting ordinary matter for the life-support galaxy	.05
degree of flatness for the light-emitting ordinary matter for the life-support galaxy	.05
degree of sphericity for the distribution of ordinary dark matter for the life-support galaxy	.1
degree of sphericity for the distribution of exotic dark matter for the life-support galaxy	.1
average albedo of Earth's surface life	.01
level of carbon abundance in the galaxy	.05
gradient of carbon abundance with respect to distance from galactic center	.05
level of oxygen abundance in the galaxy	.05
gradient of oxygen abundance with respect to distance from galactic center	.05
level of nitrogen abundance in the galaxy	.1
gradient of nitrogen abundance with respect to distance from galactic center	.1
infall velocity of galaxy toward center of nearest grouping of galaxies	.05
infall velocity of galaxy toward center of nearest supercluster of galaxies	.1
distance that primordial supernovae dispersed elements	

heavier than helium	.03
number of gamma ray burst events in the galaxy during life history on the life support planet	.1
proximity of gamma ray burst events to the life-support planet during the planet's life history	.3
velocity of planet colliding with primordial Earth relative to Earth	.002
collision angle relative to Earth of planet colliding with primordial Earth	.05
photo erosion by nearby giant stars during planetary formation phase	.005
dust extinction of that region of the spiral disk where the potential life support planet forms	.1
surface density of the protoplanetary disk	.01
ratio of mass in the form of debris relative to mass in the form of planetesimals for the protoplanetary disk	.1
width of the primordial Kuiper Belt	.1
average mass of the primordial Kuiper Belt objects	.1
mass of the Sun's primordial gas-dust disk	.03
longevity of the Sun's primordial gas-dust disk	.05
initial orbital distance of Jupiter	.01
initial orbital distance of Saturn	.02
initial orbital distance of Uranus	.04
initial orbital distance of Neptune	.05
quantity of terrestrial lightning	.1
type of terrestrial lightning	.2
variation in quantity and type of terrestrial lightning	.3
percentage of galaxies containing stars with planets in stable orbits	.1
percentage of stars in galaxy with planets in stable orbits	.02
amount of iron-60 injected into Earth's primordial core from a nearby type II supernova eruption	.03
thickness of iron-rich silicate layer between the lower mantle and outer liquid core	.1
diffusivity of iron-rich silicate layer between the lower mantle and outer liquid core	.1
magnetism of iron-rich silicate layer between the lower mantle and outer liquid core	.1
elastic anisotropy of iron-rich silicate layer between the lower mantle and outer liquid core	.1
Ekman number (relative importance of viscosity to rotation rate) for Earth's interior	.03
quantity of molecular hydrogen formed by the supernova eruptions of population III stars (the first born stars) in the vicinity of the potential life-support galaxy	.01
date of onset of efficient subduction tectonic activity	.02
quantity of uranium in the inner core	.01
quantity of uranium in the outer core	.01
quantity of uranium in the bottom mantle	.01
quantity of uranium in middle and upper mantle layers	.01

quantity of uranium in the crust	.01
quantity of thorium in the inner core	.01
quantity of thorium in the outer core	.01
quantity of thorium in the bottom mantle	.01
quantity of thorium in the middle and upper mantle layers	.01
quantity of thorium in the crust	.01
quantity of potassium-40 in the bottom mantle	.01
quantity of potassium-40 in the middle and upper mantle layers	.01
level of nitrogen fixation by marine organisms	.0001
variation in level of nitrogen fixation by marine organisms	.01
ratio of asteroids to comets for the late heavy bombardment of Earth	.03
rate of destruction and dispersal of dust as a result of supernova eruptions in the potential life-support galaxy	.1
quantity of viruses in the oceans	.0001
diversity of viruses in the oceans	.001
variation in the quantity and diversity of viruses in the oceans	.01
percent of baryons processed by the first stars (population III stars) in the vicinity of and inside the primordial Milky Way Galaxy	.04
solar system's orbital radius about the center of the Milky Way Galaxy	.01
quantity amommox bacteria (bacteria exploiting anaerobic ammonium oxidation reactions) in the oceans	.005
variation in the quantity of amommox bacteria	.1
quantity of soluble zinc in the oceans	.05
quantity of soluble silicon and silica in the oceans	.05
quantity of phosphorous and phosphates in the oceans	.01
availability of light to upper layers of the oceans	.1
proximity of emerging solar system nebula to red giant stars	.05
number of red giant stars in close proximity to emerging solar system nebula	.1
masses of red giant stars in close proximity to emerging solar system nebula	.1
proximity of emerging solar system nebula to fluorine-ejecting planetary nebulae	.05
number of fluorine-ejecting planetary nebulae in close proximity to emerging solar system nebula	.1
rate at which the sun loses masses during its first 1.0 to 1.5 billion years	.1
number of large galaxy collisions with the Milky Way Galaxy during the past ten billion years	.03
number of large galaxy collisions in the near vicinity of the Milky Way Galaxy during the past ten billion years	.05
frequency of core collapse supernovae	.1
level of rock melting during tectonic fault movements	.01
shape of the Milky Way Galaxy's ordinary dark matter halo	.1
mass of the potential life support planet	.002

eccentricity of sun's orbit about the galactic center	.05
inclination of sun's orbit about the galactic center	.05
timing of potential life-support planet's birth relative to spiral substructure formation	.2
luminosity variability of the primordial sun	.1
level of turbulence in the sun's primordial planetary disk	.1
level of warping in the Milky Way Galaxy's spiral disk	.1
frequency of long-lasting gamma ray bursts	.3
proximity of long-lasting gamma ray bursts	.1
frequency of gamma ray burst events in the galaxy	.2
density of the galaxy	.01
impact energy of moon-forming collidor event	.0001
Earth formation date relative to the formation date for the solar system nebula	.02
flux of interplanetary dust into atmosphere	.7
density of particulates in the atmosphere	.1
frequency of giant volcanic eruptions	.2
degree of suppression of dwarf galaxy formation by cosmic reionization in the local volume of the universe	.02
rate at which abiotic processes deplete nitrogen from the atmosphere by converting that nitrogen into ocean-deposited nitrates	.2
rate at which biological organisms convert nitrates in the ocean into free nitrogen that is subsequently released into the atmosphere	.0001
silicon abundance in planetary system's primordial nebula	.01
rate of decrease of the thickness of the gas disk in the life-support galaxy	.1
level of upward stirring of ocean water by krill	.001
variation in level of upward stirring of ocean water by krill	.05
hydrogen escape from the atmosphere to outer space	.01
variation in the rate of hydrogen escape from the atmosphere to outer space	.1
oxygen abundance in the galactic bulge	.1
production of H_3^+ by the galaxy's population III (first generation) stars	.05
production of H_3^+ by the galaxy's population II (second generation) stars	.05
intensity of ultraviolet radiation arriving from the sun at the time and shortly after life's origin on Earth (before photosynthesis can establish a significant ozone shield)	.002
wavelength response pattern of ultraviolet radiation arriving from the sun at the time or shortly after life's origin on Earth	.02
gas density of the local interstellar medium	.05
degree of oxidation of the phosphorus compounds in the protoplanetary disk of the solar nebula	.05
mass of the disk of dust, asteroids, and comets for the primordial planetary system	.01
degree to which the solar wind penetrates Earth's magnetosphere	.3
amount of methane stored in ocean clathrates	.1

ratio of viscous to rotational forces in the planet's liquid core	.01
inward migration of pebble-sized and smaller icy rubble from the outer primordial planetary disk	.01
timing of the appearance of methanogenic bacteria relative to the timing of the appearance of photosynthetic bacteria	.0001
relative abundance of methanogenic life compared to photosynthetic life	.003
variation in the relative abundance of methanogenic life compared to photosynthetic life	.01
ratio of iron to chondritic meteorites at the time and place of Earth's birth	.01
number of ultracompact dwarf galaxies in the vicinity of the potential life support galaxy during that galaxy's youth	.1
number of starless hydrogen gas clouds in the near vicinity of the potential life support galaxy	.3
average mass of starless hydrogen gas clouds in the near vicinity of the potential life support galaxy	.3
dust to gas ratio in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
gas temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust to gas ratio in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
dust temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
gas temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
quantity of carbon monoxide in the potential life support galaxy early in its history	.1
quantity of carbon monoxide in the potential life support galaxy late in its history	.2
number density of dark matter minihalos in the primordial Local Group	.01
intensity or speed of high-velocity galactic outflows during the youth of the potential life support galaxy	.01
thickness of the thick disk for the potential life support galaxy	.03
rate at which the thick disk for the potential life support galaxy grows thinner	.1
epoch of peak production of type I supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type I supernovae in the potential life support galaxy	.1
epoch of peak production of type II supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type II supernovae in the potential life support galaxy	.1
virial radius of the exotic matter halo surrounding the potential life support galaxy	.02

mass of the corona surrounding the potential life support galaxy	.1
diameter of the corona surrounding the potential life support galaxy	.1
average strength of local gravitational instabilities in the potential life support galaxy	.03
level of magnetic turbulence in the galactic interstellar medium	.1
thermal pressure of the planet's ionosphere	.01
stability of the thermal pressure of the planet's atmosphere	.001
quantity of phosphorus mononitride and carbon monophosphide in the gas-dust cloud from which the solar system formed	.03
shape of the galaxy cluster	.5
shape of the galaxy supercluster	.5
outer radius of the "dead zone," the low-viscosity, very-low-ionization zone for the primordial planetary disk	.01
cooling efficiency of the protoplanetary disk	.1
outer protoplanetary disk lifetime	.005
solid to gas ratio in the outer protoplanetary disk	.01
level of large scale turbulence in the protoplanetary disk	.02
timing for the formation of the first stars in the vicinity of the Local Group of galaxies	.05
timing for the complete reionization of the local intergalactic medium	.05
average magnetic energy density in the quiet solar photosphere	.02
number of tectonic plates making up the surface crust	.1
number density of spicules on the solar surface	.3
proximity of the primordial solar system nebula to the remnants of eruptions of novae	.05
number density of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
average mass of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
number density of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
average mass of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
number of supernova remnants in the vicinity of the life-support planet	.2
variation in the number of supernova remnants in the vicinity of the life support planet	.2
supernova rate in the life support galaxy	.1
timing of outward migration of Jupiter	.03
timing of outward migration of Saturn	.05
timing of outward migration of Uranus	.1
timing of outward migration of Neptune	.1
number of extrasolar planets and planetesimals captured from the outer planetary disks of near-passing stars	.1
timing of the initiation of enrichment of the interstellar medium with s-process elements for the potential life-support galaxy	.1
proximity of the emerging solar system nebula to either a white dwarf or a neutron star that is accreting hydrogen gas or to the stellar winds blowing out from a neutron star or a	

collapsar disk	.002
density of matter in and about the environs of the Local Group of galaxies	.1
density of baryons in the Local Volume of the universe	.05
density of baryons in the Local Group of galaxies	.05
ratio of baryons in galaxies to baryons in between galaxies in the Local Group of galaxies	.1
epoch of peak star formation in the potential life support galaxy	.01
ratio of type I to type II supernovae in the potential life support galaxy	.02
ratio of polycyclic aromatic hydrocarbons to stars in the galaxy	.05
closest proximity of the solar system to a black hole during the history of life	.5
quantity of warm dust in the interplanetary medium	.5
level of coronal mass ejections from the solar surface	.4
birthrate of massive stars in the solar neighborhood	.1
variation in birthrate of massive stars in the solar neighborhood	.2
number density of intracluster clouds in and around the Local Group of galaxies	.1
average mass of intracluster clouds in and around the Local Group of galaxies	.1
peak-to-peak amplitude in the solar magnetic cycle	.2
metallicity of the galaxy's halo	.02
shape of the galactic dark matter halo	.1
temperature of the hot intracluster medium for the Local Group of galaxies	.05
inward migration of icy meter-sized rubble from the outer part of the protoplanetary disk	.001
density of stars in the sun's birthing star cluster	.01
carbon abundance in the protoplanetary disk of the potential life support planetary system	.001
number density of dark matter subhalos surrounding the galaxy	.1
average mass of the dark matter subhalos surrounding the galaxy	.1
formation times for the dark matter halo and subhales surrounding the galaxy	.01
planet formation time scale in the protoplanetary disk	.03
ratio of average surface magnetic field strength to the expansion factor of open magnetic flux tubes on the sun	.1
rate of growth of the galactic bulge in the spiral galaxy	.03
strength of the ultraviolet background for the protogalaxy	.1
extent of the warp of the galactic disk	.2
proximity of the emerging solar system nebula to very low mass red giant and asymptotic giant branch stars	.01
richness or density of galaxies in the supercluster of galaxies	.1
misalignment angle between the magnetic and rotational axes of the star during the planet formation era	.1
infall velocity of matter into the dark matter halo of the potential life support galaxy	.05
migration speed of Jupiter early in its history	.01
migration speed of Saturn early in its history	.02

migration speed of Uranus early in its history	.05
migration speed of Neptune early in its history	.05
quantity of hydroxyl (OH) in the planet's troposphere	.1
variation in the quantity of hydroxyl in the planet's troposphere	.3
quantity of hydroxyl (OH) in the planet's stratosphere	.02
variation in the quantity of hydroxyl in the planet's stratosphere	.2
level of magnetization of the spiral disk for the potential life support galaxy	.05
percentage of the Milky Way Galaxy's halo that is comprised of MACHOs	.2
metallicity of the galaxy's halo	.1
strength of the wind emanating from the galaxy's nuclear core	.05
variation in the strength of the wind emanating from the galaxy's nuclear core	.05
mass of the initial or primordial galaxy	.005
magnetization of the protoplanetary disk	.1
level of mixing of the elements and chemicals in the protoplanetary disk	.02
strength of the vertical magnetic field emanating from the galactic center	.1
level of radial differential rotation during the sun's youth	.1
level of enhanced mixing in the interiors of low-mass red giant s tars that were in the vicinity of the solar system's protoplanetary disk	.1
date when half the stars in the galaxy would have already been formed	.02
density of dwarf dark matter halos in the vicinity of the Milky Way Galaxy	.01
metallicity enrichment by dwarf galaxies of the intergalactic medium in the vicinity of the potential life support galaxy	.1
average star formation rate throughout cosmic history for dwarf galaxies that are in the vicinity of the potential life support galaxy	.02
quantity of heavy elements infused into the intergalactic medium by dwarf galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
quantity of heavy elements infused into the intergalactic medium by the superwinds of large galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
average size of cosmic voids in the vicinity of the potential life support galaxy	.5
number of cosmic voids per unit of cosmic space in the vicinity of the potential life support galaxy	.5
number of galaxies per unit of dark matter halo virial mass in the vicinity of the potential life support galaxy	.1
ratio of the number density of dark matter subhalos to the number density of dark matter halos in the vicinity of the potential life support galaxy	.1
quantity of diffuse, large-grained intergalactic dust in the	

vicinity of the potential life support galaxy	.1
ratio of baryonic matter to exotic matter in dwarf galaxies in the vicinity of the potential life support galaxy	.1
ratio of baryons in the intergalactic medium relative to baryons in the circumgalactic medium for the potential life support galaxy	.1
intergalactic photon density in the vicinity of the potential life support galaxy	.4
quantity of baryons in the warm-hot intergalactic medium in the vicinity of the potential life support galaxy	.2
frequency of mega-volcanic eruptions on the life support planet	.3
average pore pressure at subduction zones	.01
average rate of migration of aqueous fluids through the planet's upper crust	.002
radiative thermal conductivity level of the lower mantle	.01
abundance of olivine in the upper mantle	.1
trace element abundance in atmospheric dust	.3
rate of atmospheric dust deposition to the surfaces of oceans	.05
variation in the level of dust supply to the surfaces of oceans	.2
rate at which dissolved organic matter cycles through the oceans	.01
level of chemical heterogeneities throughout the lower mantle	.1
level of deep ocean convection	.1
variation in level of deep ocean convection	.3
rate of remineralization of particulate organic matter	.1
quantity of marine methanotrophic archaea	.0001
variation in quantity of marine methanotrophic archaea	.01
diversity of prokaryote microorganisms	.0001
level of synergistic interactions among bacterial species	.00001
variation in level of synergistic interactions among bacterial species	.01
rate at which the planet's inner core rotates faster than the mantle and the crust	.1
quantity of phosphonate-mining bacteria in the oceans	.00001
variation in quantity of phosphorate-mining bacteria in the oceans	.01
quantity and diversity of siderophore-secreting bacteria in the oceans	.0001
variation in quantity and diversity of siderophore-secreting bacteria in the oceans	.01
quantity of carbon dioxide extracted from the mantle by melting beneath mid-ocean ridges	.1
quantity of carbon dioxide extracted from the mantle by volcanic eruptions	.2
quantity of marine snow (dead cells, shreds of plankton, bits of faeces, and mineral grains) in the oceans	.01
quantity of Trichodesmium bacteria in the oceans	.0001
depth distribution of Trichodesmium bacteria in the oceans	.02
variation in quantity and distribution of Trichodesmium bacteria in the oceans	.01
date for the beginning of significant plate tectonic activity	.2
rate of decline in seawater temperature over the past four billion years	.01

quantity of hydrated minerals in the mantle	.001
quantity of hydrogen peroxide produced in the atmosphere	.5
level of mixing in the early protoplanetary disk of the solar nebula	.05
distance of the Magellanic Clouds from the Milky Way Galaxy	.5
timing of the movement of the main asteroid belt from its place of birth (much closer to the sun) to its present location (between Mars and Jupiter)	.1

Probability for occurrence of all 676 parameters $\approx 10^{-859}$
dependency factors estimate $\approx 10^{303}$
longevity requirements estimate $\approx 10^{-22}$

Probability for occurrence of all 676 parameters $\approx 10^{-578}$
Maximum possible number of life support bodies in observable universe $\approx 10^{22}$

Thus, less than 1 chance in 10^{556} exists that even one such life-support body would occur anywhere in the universe without invoking divine miracles.

C. Requirements to sustain intelligent <u>physical</u> life in a globally distributed high-technology civilization

Parameter	Probability that feature will fall in the required range
relative abundances of different exotic mass particles	.01
decay rates of different exotic mass particles	.05
density of quasars in the local volume of the universe during early cosmic history	.1
density of giant galaxies in the local volume of the universe during early cosmic history	.03
galaxy size	.01
galaxy type	.1
galaxy mass distribution	.02
size of galactic central bulge	.05
galaxy location	.01
variability of local dwarf galaxy absorption rate	.1
quantity of galactic dust	.1
giant star density in galaxy	.1
star location relative to galactic center	.1
star distance from corotation circle of galaxy	.005
ratio of inner dark halo mass to stellar mass for galaxy	.1
star distance from closest spiral arm	.1
z-axis extremes of star's orbit	.02
proximity of solar nebula to a normal type I supernova eruption	.01
timing of solar nebula formation relative to a normal type I supernova eruption	.01
proximity of solar nebula to a type II supernova eruption	.01
timing of solar nebula formation relative to type II supernova eruption	.01
timing of hypernovae eruptions	.2
number of hypernovae eruptions	.1
masses of stars that become hypernovae	.1
flux of cosmic ray protons	.1
variability of cosmic ray proton flux	.1
gas dispersal rate by companion stars, shock waves, and molecular cloud expansion in the Sun's birthing star cluster	.1
number of stars in birthing cluster	.01
star formation rate in parent star vicinity during history of that star	.1
variation in star formation rate in parent star vicinity during history of that star	.1
birth date of the star-planetary system	.01
number of stars in planetary system	.7

number and timing of close encounters by nearby stars	.01
proximity of close stellar encounters	.01
masses of close stellar encounters	.03
density of brown dwarfs in neighborhood of life support planet	.1
absorption rate of planets and planetismals by parent star	.1
star age	.0001
star metallicity	.01
ratio of ^{40}K, $^{235,238}U$, ^{232}Th to iron in star-planetary system	.001
star orbital eccentricity	.1
star mass	.001
star luminosity change relative to speciation types & rates	.000001
star color	.1
star rotation rate	.3
rate of change in star rotation rate	.3
star magnetic field	.05
star magnetic field variability	.1
stellar wind strength	.05
stellar wind variability	.1
short period variation in parent star diameter	.1
star's carbon to oxygen ratio	.01
star's space velocity relative to Local Standard of Rest	.05
star's short term luminosity variability	.02
star's long term luminosity variability	.05
amplitude and duration of star spot cycle	.1
number & timing of solar system encounters with interstellar gas clouds and cloudlets	.01
galactic tidal forces on planetary system	.1
white dwarf binary types, rates, & locations	.002
structure of comet cloud surrounding planetary system	.03
planetary distance from star	.001
inclination of planetary orbit	.1
axis tilt of planet	.1
rate of change of axial tilt	.01
period and size of axis tilt variation	.1
planetary rotation period	.01
rate of change in planetary rotation period	.05
planetary revolution period	.2
planetary orbital eccentricity	.05
rate of change of planetary orbital eccentricity	.1
rate of change of planetary inclination	.2
period and size of planetary eccentricity variation	.01
period and size of planetary inclination variation	.02
precession in planet's rotation	.3
rate of change in planet's precession	.3
polycyclic aromatic hydrocarbon abundance in solar nebula	.01
number of moons	.1
surface gravity (escape velocity)	.001
tidal force from sun and moon	.1
magnetic field of planet	.01
rate of change & character of change in magnetic field	.1

albedo (planet reflectivity)	.05
density of planet	.01
density of interstellar and interplanetary dust particles in vicinity of life-support planet	.1
reducing strength of planet's primordial mantle	.3
thickness of crust	.01
timing of birth of continent formation	.02
oceans-to-continents ratio	.05
rate of change in oceans to continents ratio	.1
global distribution of continents	.01
frequency, timing, & extent of ice ages	.1
frequency, timing, & extent of global snowball events	.1
silicate dust annealing by nebular shocks	.02
asteroidal & cometary collision rate	.05
change in asteroidal & cometary collision rates	.1
rate of change in asteroidal & cometary collision rates	.1
mass of planet colliding with primordial Earth	.001
timing of planet colliding with primordial Earth	.02
location of planet's collision with primordial Earth	.02
average rainfall precipitation	.0001
variation and timing of average rainfall precipitation	.001
atmospheric transparency	.01
atmospheric pressure	.002
atmospheric viscosity	.05
atmospheric temperature gradient	.005
carbon dioxide quantity in atmosphere	.0001
total quantity of water vapor in the atmosphere	.0001
percentage of the atmosphere comprised of water vapor	.01
methane quantity in the atmosphere	.001
rates of change in carbon dioxide levels in atmosphere throughout the planet's history	.00001
rates of change in water vapor levels in atmosphere throughout the planet's history	.00001
rates of change in methane level in atmosphere throughout the planet's history	.0001
oxygen quantity in atmosphere	.000001
rate of change in oxygen level in atmosphere throughout the planet's history	.0000001
nitrogen quantity in atmosphere	.001
carbon monoxide quantity in atmosphere	.01
chlorine quantity in atmosphere	.01
aerosol particle density emitted from forests	.05
cobalt quantity in crust and/or soil	.1
arsenic quantity in crust and/or soil	.05
copper quantity in crust and/or soil	.1
boron quantity in crust and/or soil	.1
cadmium quantity in crust and/or soil	.1
calcium quantity in crust and/or soil	.4
fluorine quantity in crust and/or soil	.1
iodine quantity in crust and/or soil	.05

magnesium in crust and/or soil	.2
manganese quantity in crust and/or soil	.1
nickel quantity in crust and/or soil	.1
phosphorus quantity in crust and/or soil	.01
potassium quantity in crust and/or soil	.4
tin quantity in crust and/or soil	.1
zinc quantity in crust and/or soil	.1
molybdenum quantity in crust and/or soil	.05
vanadium quantity in crust and/or soil	.1
chromium quantity in crust and/or soil	.1
selenium quantity in crust and/or soil	.1
iron quantity in oceans	.01
tropospheric ozone quantity	.01
stratospheric ozone quantity	.01
mesospheric ozone quantity	.01
oxygen to nitrogen ratio in atmosphere	.01
quantity of greenhouse gases in atmosphere	.01
rate of change in greenhouse gases in atmosphere	.01
poleward heat transport in atmosphere by mid-latitude storms	.2
quantity and extent of forest fires	.001
quantity and extent of grass fires	.01
quantity of sea salt aerosols in troposphere	.03
soil mineralization	.01
quantity of anaeorbic bacteria in the oceans	.001
quantity of aerobic bacteria in the oceans	.00001
quantity of anaerobic nitrogen-fixing bacteria in the early oceans	.0001
quantity, variety, and timing of sulfate-reducing bacteria	.0000001
quantity of geobacteraceae	.001
quantity of aerobic photoheterotrophic bacteria	.0000001
quantity of decomposer bacteria in soil	.001
quantity of mycorrhizal fungi in soil	.01
quantity of nitrifying microbes in soil	.001
quantity & timing of vascular plant introductions	.0001
quantity, timing, & placement of carbonate-producing animals	.00001
quantity, timing, & placement of methanogens	.00001
phosphorus and iron absorption by banded iron formations	.01
ratio of electrically conducting inner core radius to radius of the adjacent turbulent fluid shell	.2
ratio of core to shell (see above) magnetic diffusivity	.2
magnetic Reynold's number of the shell (see above)	.2
elasticity of iron in the inner core	.2
electromagnetic Maxwell shear stresses in the inner core	.2
core precession frequency for planet	.1
rate of interior heat loss for planet	.1
quantity of sulfur in the planet's core	.1
quantity of silicon in the planet's core	.1
quantity of water at subduction zones in the crust	.005
quantity of high pressure ice in subducting crustal slabs	.1

hydration rate of subducted minerals	.1
water absorption capacity of planet's lower mantle	.1
tectonic activity	.005
rate of decline in tectonic activity	.05
volcanic activity	.02
rate of decline in volcanic activity	.1
location of volcanic eruptions	.05
continental relief	.1
viscosity at Earth core boundaries	.01
viscosity of lithosphere	.2
thickness of mid-mantle boundary	.1
rate of sedimentary loading at crustal subduction zones	.05
biomass to comet infall ratio	.01
regularity of cometary infall	.1
intensity of primordial cosmic superwinds	.05
number of smoking quasars	.05
formation of large terrestrial planet in the presence of two or more gas giant planets	.01
total mass of Oort Cloud objects	.1
mass distribution of Oort Cloud objects	.1
air turbulence in troposphere	.05
quantity of sulfate aerosols in troposphere	.05
quantity of actinide bioreducing bacteria	.001
quantity of phytoplankton	.00001
hydrothermal alteration of ancient oceanic basalts	.01
quantity of iodocarbon-emitting marine organisms	.001
location of dislocation creep relative to diffusion creep in and near the crust-mantle boundary (determines mantle convection dynamics)	.1
size of oxygen sinks in the planet's crust	.05
size of oxygen sinks in the planet's mantle	.05
mantle plume production	.1
number & mass of planets in system suffering significant drift	.002
mass of the galaxy's central black hole	.01
date for the formation of the galaxy's central black hole	.05
timing of the growth of the galaxy's central black hole	.1
rate of in-spiraling gas into galaxy's central black hole during life epoch	.02
distance from nearest giant galaxy	.4
distance from nearest Seyfert galaxy	.9
amount of mass loss by star in its youth	.1
rate of mass loss of star in its youth	.3
rate of mass loss by star during its middle age	.1
quantity of magnetars (proto-neutron stars with very strong magnetic fields) produced during galaxy's history	.05
variation in coverage of star's surface by faculae	.4
ratio of galaxy's dark halo mass to its baryonic mass	.2
ratio of galaxy's dark halo mass to its dark halo core mass	.2
galaxy cluster formation rate	.1
proximity of supernovae and hypernovae throughout history	

of planet and planetary system	.002
tidal heating from neighboring galaxies	.5
tidal heating from dark galactic and galaxy cluster halos	.5
intensity and duration of galactic winds	.3
density of dwarf galaxies in vicinity of home galaxy	.02
amount of photoevaporation during planetary formation from parent star and other nearby stars	.1
in-spiral rate of stars into black holes within parent galaxy	.5
strength of magnetocentrifugally launched wind of parent star during its protostar era	.2
degree to which the atmospheric composition of the planet departs from thermodynamic equilibrium	.01
delivery rate of volatiles to planet from asteroid-comet belts during epoch of planet formation	.05
Q-value (rigidity) of planet during its early history	.2
variation in Q-value of planet during its early history	.3
injection efficiency of shock wave material from nearby supernovae into collapsing molecular cloud that forms star and planetary system	.01
number of giant galaxies in galaxy cluster	.1
number of large galaxies in galaxy cluster	.1
number of dwarf galaxies in galaxy cluster	.1
number and sizes of planets and planetesimals consumed by star	.3
distance of galaxy's corotation circle from center of galaxy	.03
rate of diffusion of heavy elements from galactic center out to the galaxy's corotation circle	.1
outward migration of star relative to galactic center	.2
viscosity gradient in protoplanetary disk	.1
long and medium period variations in star's diameter	.1
average quantity of gas infused into the universe's first star clusters that reside in the vicinity of the potential life support galaxy	.1
frequency of late impacts by large asteroids and comets	.05
level of supersonic turbulence in the vicinity of the potential life support galaxy during the infancy of the universe	.05
number and sizes of intergalactic hydrogen gas clouds in galaxy's vicinity	.05
average longevity of intergalactic hydrogen gas clouds in galaxy's vicinity	.1
minimization of chloromethane production by rotting plants and fungi that are exposed to the atmosphere (life's survival demands very efficient burial mechanisms and relatively low temperatures)	..01
avoidance of apsidal phase locking in the orbits of planets in the planetary system	.03
number density of the first metal-free stars to form in the vicinity of the future life support galaxy	.02
epoch at which the first metal-free stars form in the vicinity of of the future potential life support galaxy	.1

level of spot production on star's surface	.1
variability of spot production on star's surface	.2
size of the carbon sink in the deep mantle of the planet	.05
average circumstellar medium density for white dwarf red giant pairs in the vicinity of the potential life support planet's protoplanetary disk	.1
number densities of metal-poor and extremely metal-poor galaxies in vicinity of potential life support galaxy	.1
rate of growth of central spheroid for the galaxy	.01
amount of gas infalling into the central core of the galaxy	.05
level of cooling of gas infalling into the central core of the galaxy	.1
ratio of dual water molecules, $(H_2O)_2$, to single water molecules, H_2O, in the troposphere	.03
heavy element abundance in the intracluster medium for the early universe in the vicinity of the potential life support galaxy	.1
quantity of volatiles on and in Earth-sized planet in the habitable zone	.0001
rate of infall of intergalactic gas into emerging and growing galaxies during first five billion years of cosmic history in the vicinity of the potential life support galaxy	.1
pressure of the intra-galaxy-cluster medium in the vicinity of the potential life support galaxy	.1
proximity of solar nebula to a type I supernova whose core underwent significant gravitational collapse before carbon deflagration	.01
timing of solar nebula formation relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion	.005
proximity of emerging solar nebula relative to a nearby type I supernova whose core underwent significant gravitational collapse before carbon deflagrataion	.005
sizes of largest cosmic structures in the local region of the universe	.01
level of spiral substructure in spiral galaxy	.1
Kozai oscillation level in planetary system	.7
triggering of El Nino events by explosive volcanic eruptions	.1
efficiency of stellar mass loss during final stages of stellar burning for old stars in vicinity of potential life support planet	.1
efficiency of flows of silicate melt, hypersaline hydrothermal fluids, and hydrothermal vapors in the upper crust	.1
supernova eruption rate when galaxy is young	.2
range of rotation rates for stars in the galaxy that are on the verge of becoming supernovae	.2
quantity of dust formed in the ejecta of Population III supernovae in vicinity of future life support galaxy	.1
chemical composition of dust ejected by Population III stars in vicinity of future life support galaxy	.3
epoch when the merging of galaxies peaks in the vicinity of	

potential life support galaxy	.03
efficiency of ocean pumps that return nutrients to ocean surfaces	.1
sulfur and sulfate content of oceans	.2
density of extragalactic intruder stars in solar neighborhood	.2
density of dust-exporting stars in solar neighborhood	.2
average rate of increase in galaxy sizes in the local region of the universe	.05
change in average rate of increase in galaxy sizes throughout cosmic history in the local region of the universe	.1
proximity of solar nebula to asymptotic giant branch stars	.05
timing of solar nebula formation relative to its close approach to asymptotic giant branch stars	.05
orientation of continents relative to prevailing winds	.2
quantity and proximity of gamma-ray burst events relative to emerging solar nebula	.01
proximity of superbubbles to planetary system during life epoch of life-support planet	.02
proximity of strong ultraviolet emitting stars to planetary system during life epoch of life-support planet	.02
quantity and proximity of galactic gamma-ray burst events relative to time window for intelligent life	.1
infall of buckminsterfullerenes from interplanetary and interstellar space upon surface of planet	.3
quantity of silicic acid in the oceans	.1
water absorption by planet's mantle	.01
timing of star formation peak for the local part of the universe	.2
timing of star formation peak for the galaxy	.2
quantity of mountains on land	.2
average height of mountains on land	.2
density and thickness of atmosphere	.001
degree of continental land mass barrier to oceans along planet's rotation axis	.04
flux of extrasolar dust into atmosphere	.5
oxygen quantity in oceans	.01
nitrogen quantity in oceans	.03
magnitude of non-volcanically triggered El Nino and El Nina events	.2
rate of non-volcanically triggered El Nino and El Nina events	.2
oxygen quantity in inner core	.01
oxygen quantity in outer core	.01
dwarf galaxy merger rate with home galaxy	.03
methane emissions from living plants	.001
methane emissions from plant litter	.2
methane emissions from animals	.01
methane emissions from fossil fuel production	.01
lifetimes of methane in different atmospheric layers	.01
density of black holes, neutron stars, and plerionic supernova remnants in the galaxy	.1
inclination of the planes of the planetary system's asteroid	

belts	.1
variations in the inclinations of the planes of the planetary system's asteroid belts	.3
epoch at which metal-free (pop III) stars cease forming in vicinity of potential life support galaxy	.1
average mass of metal-free (pop III) stars in vicinity of potential life support galaxy	.1
epoch in cosmic history at which number density of gamma ray burst events peak in the local volume of the universe	.3
rate at which protoplanetary disk photoevaporates	.05
density of molecular hydrogen in the galaxy	.1
rate of release of biogenic bromides into the atmosphere	.001
decomposition rate of biogenic bromides in the atmosphere	.01
angle of planet's collision with primordial Earth	.05
velocity of planet's collision with primordial Earth	.01
depth of terrestrial water at point of planet's collision with primordial Earth	.02
size of the planet's core relative to planet size	.01
number of gas giant planets in planetary system	.1
position & mass of Jupiter relative to Earth	.002
position & mass of Saturn relative to Earth	.01
position & mass of Uranus relative to Earth	.01
position & mass of Neptune relative to Earth	.01
ratio Saturn to Jupiter mass	.01
ratio of Uranus to Jupiter mass	.05
ratio of Neptune to Jupiter mass	.05
eccentricity and inclination of Jupiter's orbit	.05
eccentricity and inclination of Saturn's orbit	.05
eccentricity and inclination of Uranus's orbit	.1
eccentricity and inclination of Neptune's orbit	.1
major planet orbital variations and instabilities	.001
inward drift and rate of inward drift in major planet orbital distances during planetary system's formation history	.01
distance of gas giant planets from zones of mean motion resonances	.001
amount of outward migration by Jupiter during early solar system history	.01
amount of outward migration by Saturn during early solar system history	.01
amount of outward migration by Uranus during early solar system history	.1
amount of outward migration by Neptune during early solar system history	.1
initial mass of Kuiper Belt asteroids and comets	.1
initial mass distribution of Kuiper Belt asteroids and comets	.2
initial average orbital distance of Kuiper Belt asteroids and comets	.1
reduction of Kuiper Belt mass during planetary system's early history	.05

outward displacement of average orbital distance of Kuiper Belt asteroids and comets	.1
number of terrestrial planets in planetary system	.1
position and mass of other terrestrial planets in planetary system relative to Earth	.01
inclination and eccentricity of other terrestrial planets in planetary system	.01
distance of other terrestrial planets from zones of mean motion resonances	.01
planetary formation site within the circumstellar disk	.01
type, degree, and duration of interaction between the protoplanet and the circumstellar disk	.01
amount of migration from initial formation site for potential life support planet	.01
solar nebula exposure to stellar winds from expanding asymptotic giant branch stars	.05
number density of clumpuscules (dense cold clouds of molecular hydrogen gas) in the vicinity of the galaxy	.1
average mass of clumpuscules in the vicinity of the galaxy	.1
location of clumpuscules in the vicinity of the galaxy	.01
level of dislocation creep of the lower mantle's silicate perovskite	.1
pressure at planet's core-mantle boundary	.03
temperature at planet's core-mantle boundary	.1
quantity of iron in planet's core	.001
long term water loss from planet due to photodissociation	.01
height of the tallest trees	.1
diameter of ordinary dark matter halo surrounding the galaxy	.1
mass of ordinary dark matter halo surrounding the galaxy	.1
diameter of exotic dark matter halo surrounding the galaxy	.1
mass of exotic dark matter halo surrounding the galaxy	.1
upper mantle viscosity	.05
lower mantle viscosity	.1
mantle temperature	.1
relative abundance of perovskite in lower mantle	.1
relative abundance of mangesiowüstite in lower mantle	.1
radiative conductivity of lower mantle	.05
average degree of plate subduction at plate boundaries	.05
average longevity of plate subduction at plate boundaries	.05
average inclination of inner asteroid belt objects after the accretion era	.1
average inclination Kuiper Belt objects after the accreation era	.1
average magnetic field strength in star's atmosphere	.1
anisotropy level of radiation field in star's atmosphere	.1
density of ultra-dwarf galaxies (or supermassive globular clusters) in vicinity of the galaxy	.05

galaxy cluster size	.01
galaxy cluster density	.03
galaxy cluster location	.02
diversity of herbivore species	.0001
degree of feeding specialization by herbivore species	.01
diversity of plant species	.0001
diversity of carnivore species	.001
degree of feeding specialization by carnivore species	.01
diversity of plant parasite species	.0001
quantity of plant parasites	.001
diversity of animal parasite species	.0001
quantity of animal parasites	.001
degree of feeding specialization by parasite species	.01
pebble density in solar nebula's protoplanetary disk	.005
rate at which solar nebula ran away from its birth cluster	.01
diffuse x-ray emission from nearest spiral arms	.05
magnitude of air movement at the boundaries of water vapor clouds in planet's atmosphere	.01
formation rate of molecular hydrogen on dust grain surfaces when the galaxy is young	.1
number of medium- or large-sized galaxies merging with the galaxy since the formation and stabilization of its thick galactic disk	.2
quantity of large-celled nitrogen fixing cyanobacteria in the oceans	.001
quantity of small-celled nitrogen fixing cyanobacteria in the oceans	.001
quantity of nitrogen fixing bacterioplankton in the oceans	.001
time window between the peak of kerogen production and the appearance of intelligent life	.01
time window between the production of cisterns in the planet's crust that can effectively collect and store petroleum and natural gas and the appearance of intelligent life	.05
coupling strength between local soil moisture and precipitation	.1
mean soil depth	.05
mean percentage of clays in soil	.3
mean percentage of sands in soil	.3
intensity of far ultraviolet radiation from nearby stars when the circumsolar disk was condensing into planets	.001
phosphorus abundance in solar nebula	.03
average size of hurricanes	.1
average wind velocity of hurricanes	.1
average lifespan of hurricanes	.1
frequency of hurricanes	.1
location of hurricanes	.1
magnitude of chemical exchange occurring at the liquid core-deep mantle boundary of planet	.1
amount of methane generated in upper mantle of planet	.03
amount of buildup of heavy elements in the galaxy	.03

timescale for the buildup of heavy elements in the galaxy	.02
average width of the light spectrum utilized by phyto-plankton species throughout life's history on the planet	.001
rate at which the planet's biosphere is oxygenated	.001
level of biogenic mixing of seafloor sediments	.0001
planet's silicate abundance	.1
diversity of soil-dwelling invertebrates	.001
cicada resource pulses in forest ecosystems	.01
salinity of the deep ocean	.1
convection in the deep ocean	.1
ventilation of oxygen and carbon dioxide in the deep ocean	.1
production of organic aerosols in the atmosphere	.01
lifetimes of organic aerosols in the atmosphere	.01
timing of the 1:2 resonance event for Jupiter and Saturn	.005
quantity of chlorinated-toxins-consuming bacteria	.0001
quantity of sub-seaflour hypersaline anoxic bacteria	.0001
variation in quantity of sub-seaflour hypersaline anoxic bacteria	.05
intensity of superwinds generated by primordial supermassive black holes	.03
number of superwind events generated by primordial supermassive black holes	.03
mass of moon orbiting life support planet	.001
galaxy mass	.02
density of galaxies in the local volume around life-support galaxy	.1
average galaxy mass in the local volume around life-support galaxy	.1
rate at which the triple-alpha process (combining of three helium nuclei to make one carbon nucleus) runs inside the nuclear furnaces of stars	.002
average mass of cold dark gas-dust clouds in the galaxy	.1
number density of cold dark gas-dust clouds in the galaxy	.1
proximity of cold dark gas-dust clouds to life-support planet	.05
masses of nearest cold dark gas-dust clouds to life support planet	.05
time in galactic history when cold dark gas-dust clouds form	.1
*timing of late heavy bombardment	.02
intensity of the late heavy bombardment	.02
chemical composition of the late heavy bombarders	.1
level and frequency of ocean microseisms	.1
average slope of the coastline land masses	.1
depth of Earth's primordial ocean	.01
rate of quartz re-precipitation on Earth	.1
rate of release of cellular particles (fur fiber, dandruff, pollen, spores, bacteria, etc.) into the atmosphere	.001
rate of release of protein and viral particles into the atmosphere	.001
rate of leaf litter deposition upon soils	.01
availability of fossil fuels to humanity	.1
upper mantle seismic anisotropy	.1
lower mantle seismic anisotropy	.1

date of star formation shutdown in the galaxy	.02
ratio of baryons in galaxy clusters to baryons in between galaxy clusters within the Local Volume of the universe	.1
ratio of baryons in galaxies to baryons in between galaxies in the Local Volume of the universe	.1
degree of central concentration of light-emitting ordinary matter for the life-support galaxy	.05
degree of flatness for the light-emitting ordinary matter for the life-support galaxy	.05
degree of sphericity for the distribution of ordinary dark matter for the life-support galaxy	.1
degree of sphericity for the distribution of exotic dark matter for the life-support galaxy	.1
average albedo of Earth's surface life	.001
level of carbon abundance in the galaxy	.05
gradient of carbon abundance with respect to distance from galactic center	.05
level of oxygen abundance in the galaxy	.05
gradient of oxygen abundance with respect to distance from galactic center	.05
level of nitrogen abundance in the galaxy	.1
gradient of nitrogen abundance with respect to distance from galactic center	.1
infall velocity of galaxy toward center of nearest grouping of galaxies	.05
infall velocity of galaxy toward center of nearest supercluster of galaxies	.1
distance that primordial supernovae dispersed elements heavier than helium	.03
number of gamma ray burst events in the galaxy during life history on the life support planet	.1
proximity of gamma ray burst events to the life-support planet during the planet's life history	.1
velocity of planet colliding with primordial Earth relative to Earth	.002
collision angle relative to Earth of planet colliding with primordial Earth	.05
photo erosion by nearby giant stars during planetary formation phase	.005
dust extinction of that region of the spiral disk where the potential life support planet forms	.03
surface density of the protoplanetary disk	.01
ratio of mass in the form of debris relative to mass in the form of planetesimals for the protoplanetary disk	.1
width of the primordial Kuiper Belt	.1
average mass of the primordial Kuiper Belt objects	.1
mass of the Sun's primordial gas-dust disk	.03
longevity of the Sun's primordial gas-dust disk	.05
initial orbital distance of Jupiter	.01
initial orbital distance of Saturn	.02

initial orbital distance of Uranus	.04
initial orbital distance of Neptune	.05
quantity of terrestrial lightning	.01
type of terrestrial lightning	.05
variation in quantity and type of terrestrial lightning	.1
timing of solar system's last crossing of a spiral arm	.02
percentage of galaxies containing stars with planets in stable orbits	.1
percentage of stars in galaxy with planets in stable orbits	.02
date for the beginning of deposition of petroleum	.05
date for the beginning of deposition of coal	.05
amount of iron-60 injected into Earth's primordial core from a nearby type II supernova eruption	.03
thickness of iron-rich silicate layer between the lower mantle and outer liquid core	.1
diffusivity of iron-rich silicate layer between the lower mantle and outer liquid core	.1
magnetism of iron-rich silicate layer between the lower mantle and outer liquid core	.1
elastic anisotropy of iron-rich silicate layer between the lower mantle and outer liquid core	.1
quantity of arbuscular mycorrhizal fungi in continental soils	.00001
location of arbuscular mycorrhizal fungi in continental soils	.001
variation in quantity and location of arbuscular mycorrhizal fungi in continental soils	.01
quantity of plants using C_3 photosynthesis	.01
quantity of plants using C_4 photosynthesis	.01
variation in quantity of plants using C_3 photosynthesis	.1
variation in quantity of plants using C_4 photosynthesis	.1
timing of humanity's arrival relative to a magnetic reversal event	.03
interval between magnetic reversals during epoch of human occupation	.002
Ekman number (relative importance of viscosity to rotation rate) for Earth's interior	.03
quantity of molecular hydrogen formed by the supernova eruptions of population III stars (the first born stars) in the vicinity of the potential life-support galaxy	.01
quantity of soil sulfur	.01
level of oxidizing activity in the soil	.02
variation in level of oxidizing activity in the soil	.2
date of onset of efficient subduction tectonic activity	.02
quantity of uranium in the inner core	.01
quantity of uranium in the outer core	.01
quantity of uranium in the bottom mantle	.01
quantity of uranium in middle and upper mantle layers	.01
quantity of uranium in the crust	.01
quantity of thorium in the inner core	.01
quantity of thorium in the outer core	.01
quantity of thorium in the bottom mantle	.01

quantity of thorium in the middle and upper mantle layers	.01
quantity of thorium in the crust	.01
quantity of potassium-40 in the bottom mantle	.01
quantity of potassium-40 in the middle and upper mantle layers	.01
level of nitrogen fixation by marine organisms	.0001
variation in level of nitrogen fixation by marine organisms	.01
level of water soluable heavy metals in soils	.001
quantity of methanotrophic symbionts in wetlands	.001
timing of the rise in oxygen content in the atmosphere relative to mass extinction/speciation events	.001
ratio of asteroids to comets for the late heavy bombardment of Earth	.03
rate of destruction and dispersal of dust as a result of supernova eruptions in the potential life-support galaxy	.1
quantity of viruses in the oceans	.0001
diversity of viruses in the oceans	.001
variation in the quantity and diversity of viruses in the oceans	.01
percent of baryons processed by the first stars (population III stars) in the vicinity of and inside the primordial Milky Way Galaxy	.04
solar system's orbital radius about the center of the Milky Way Galaxy	.01
quantity amommox bacteria (bacteria exploiting anaerobic ammonium oxidation reactions) in the oceans	.005
variation in the quantity of amommox bacteria	.1
quantity of soluble zinc in the oceans	.05
quantity of soluble silicon and silica in the oceans	.05
quantity of phosphorous and phosphates in the oceans	.01
availability of light to upper layers of the oceans	.1
average cell size of marine phytoplankton	.02
amount of summer ground foliage in the arctic	.2
proximity of emerging solar system nebula to red giant stars	.05
number of red giant stars in close proximity to emerging solar system nebula	.1
masses of red giant stars in close proximity to emerging solar system nebula	.1
proximity of emerging solar system nebula to fluorine-ejecting planetary nebulae	.05
number of fluorine-ejecting planetary nebulae in close proximity to emerging solar system nebula	.1
rate at which the sun loses masses during its first 1.0 to 1.5 billion years	.1
number of large galaxy collisions with the Milky Way Galaxy during the past ten billion years	.03
number of large galaxy collisions in the near vicinity of the Milky Way Galaxy during the past ten billion years	.05
methane production and release to the atmosphere by plants	.1
variation in methane production and release to the	

atmosphere by plants	.2
quantity of dissolved calcium in lakes and rivers	.1
quantity of suspended calcium in lakes and rivers	.1
frequency of core collapse supernovae	.1
level of rock melting during tectonic fault movements	.01
shape of the Milky Way Galaxy's ordinary dark matter halo	.1
timing of continental growth spurts	.02
mass of the potential life support planet	.002
eccentricity of sun's orbit about the galactic center	.05
inclination of sun's orbit about the galactic center	.05
quantity and diversity of life forms that enhance clay production	.00001
timing of the introduction of life forms that enhance clay production	.001
quantity of clay production on continental land masses	.001
timing of advent of clay production on continental land masses	.003
quantity of bacteriophages	.0001
diversity of bacteriophages	.0001
variation in the quantity and diversity of bacteriophages	.01
timing of potential life-support planet's birth relative to spiral substructure formation	.1
luminosity variability of the primordial sun	.1
level of turbulence in the sun's primordial planetary disk	.1
level of warping in the Milky Way Galaxy's spiral disk	.1
date for opening of the Drake Passage (between South America and Antarctica)	.01
frequency of long-lasting gamma ray bursts	.1
proximity of long-lasting gamma ray bursts	.01
frequency of gamma ray burst events in the galaxy	.01
density of the galaxy	.01
impact energy of moon-forming collidor event	.0001
Earth formation date relative to the formation date for the solar system nebula	.02
flux of interplanetary dust into atmosphere	.7
density of particulates in the atmosphere	.01
frequency of giant volcanic eruptions	.01
timing of giant volcanic eruptions relative to time window for advanced life	.1
degree of suppression of dwarf galaxy formation by cosmic reionization in the local volume of the universe	.02
rate at which abiotic processes deplete nitrogen from the atmosphere by converting that nitrogen into ocean-deposited nitrates	.2
rate at which biological organisms convert nitrates in the ocean into free nitrogen that is subsequently released into the atmosphere	.0001
silicon abundance in planetary system's primordial nebula	.01
rate of decrease of the thickness of the gas disk in the life-support galaxy	.1
level of upward stirring of ocean water by krill	.001
variation in level of upward stirring of ocean water by krill	.05

production and release of ammonium sulfate aerosols into the atmosphere	.1
timing of the first great oxygenation event	.001
timing of the second great oxygenation event	.002
timing of the third great oxygenation event	.002
hydrogen escape from the atmosphere to outer space	.01
variation in the rate of hydrogen escape from the atmosphere to outer space	.1
magnitude of the change in eccentricity of Earth's orbit in the 2.37 million year eccentricity cycle	.03
magnitude of the change in obliquity of Earth's orbit in the 1.2 million year obliquity cycle	.03
oxygen abundance in the galactic bulge	.1
production of H_3^+ by the galaxy's population III (first generation) stars	.05
production of H_3^+ by the galaxy's population II (second generation) stars	.05
intensity of ultraviolet radiation arriving from the sun at the time and shortly after life's origin on Earth (before photosynthesis can establish a significant ozone shield)	.002
wavelength response pattern of ultraviolet radiation arriving from the sun at the time or shortly after life's origin on Earth	.02
gas density of the local interstellar medium	.05
degree of oxidation of the phosphorus compounds in the protoplanetary disk of the solar nebula	.05
mass of the disk of dust, asteroids, and comets for the primordial planetary system	.01
degree to which the solar wind penetrates Earth's magnetosphere	.03
magnitude of tidal Coulomb stresses (stress imparted by tides on tectonic fault zones)	.1
frequency of Heinrich events (liberation of iceberg armadas)	.1
intensity of Heinrich events	.1
timing of Heinrich events relative to global human civilization	.1
amount of methane stored in ocean clathrates	.1
ratio of viscous to rotational forces in the planet's liquid core	.01
planet's oxygenation time (time for atmospheric oxygen to reach a level capable of supporting advanced life)	.00001
inward migration of pebble-sized and smaller icy rubble from the outer primordial planetary disk	.01
timing of the appearance of methanogenic bacteria relative to the timing of the appearance of photosynthetic bacteria	.0001
relative abundance of methanogenic life compared to photosynthetic life	.003
variation in the relative abundance of methanogenic life compared to photosynthetic life	.01
ratio of iron to chondritic meteorites at the time and place of Earth's birth	.01
number of ultracompact dwarf galaxies in the vicinity of the potential life support galaxy during that galaxy's youth	.1
number of starless hydrogen gas clouds in the near vicinity of the	

potential life support galaxy	.05
average mass of starless hydrogen gas clouds in the near vicinity of the potential life support galaxy	.05
dust to gas ratio in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
gas temperature in and near the core of the potential life support galaxy during that galaxy's youth	.1
dust to gas ratio in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
dust temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
gas temperature in the mid to outer parts of the potential life support galaxy during that galaxy's youth	.1
quantity of carbon monoxide in the potential life support galaxy early in its history	.1
quantity of carbon monoxide in the potential life support galaxy late in its history	.1
number density of dark matter minihalos in the primordial Local Group	.01
intensity or speed of high-velocity galactic outflows during the youth of the potential life support galaxy	.01
thickness of the thick disk for the potential life support galaxy	.03
rate at which the thick disk for the potential life support galaxy grows thinner	.1
epoch of peak production of type I supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type I supernovae in the potential life support galaxy	.1
epoch of peak production of type II supernovae in the potential life support galaxy	.1
average frequency of the different kinds of type II supernovae in the potential life support galaxy	.1
virial radius of the exotic matter halo surrounding the potential life support galaxy	.02
mass of the corona surrounding the potential life support galaxy	.1
diameter of the corona surrounding the potential life support galaxy	.1
average strength of local gravitational instabilities in the potential life support galaxy	.03
level of magnetic turbulence in the galactic interstellar medium	.1
saltiness of the planet's surface crustal layers	.1
thermal pressure of the planet's ionosphere	.01
stability of the thermal pressure of the planet's atmosphere	.001
quantity of phosphorus mononitride and carbon monophosphide in the gas-dust cloud from which the solar system formed	.03
shape of the galaxy cluster	.5
shape of the galaxy supercluster	.5
outer radius of the "dead zone," the low-viscosity, very-low-ionization zone for the primordial planetary disk	.01

cooling efficiency of the protoplanetary disk	.1
outer protoplanetary disk lifetime	.005
solid to gas ratio in the outer protoplanetary disk	.01
level of large scale turbulence in the protoplanetary disk	.02
timing for the formation of the first stars in the vicinity of the Local Group of galaxies	.05
timing for the complete reionization of the local intergalactic medium	.05
average magnetic energy density in the quiet solar photosphere	.02
number of tectonic plates making up the surface crust	.05
number density of spicules on the solar surface	.05
proximity of the primordial solar system nebula to the remnants of eruptions of novae	.05
number density of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
average mass of accreted intergalactic clouds in the vicinity of the emerging solar system nebula	.3
number density of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
average mass of accreted intergalactic clouds in the vicinity of the solar system during its life history	.1
number of supernova remnants in the vicinity of the life-support planet	.05
variation in the number of supernova remnants in the vicinity of the life support planet	.2
supernova rate in the life support galaxy	.1
timing of outward migration of Jupiter	.03
timing of outward migration of Saturn	.05
timing of outward migration of Uranus	.1
timing of outward migration of Neptune	.1
number of extrasolar planets and planetesimals captured from the outer planetary disks of near-passing stars	.1
timing of the initiation of enrichment of the interstellar medium with s-process elements for the potential life-support galaxy	.1
proximity of the emerging solar system nebula to either a white dwarf or a neutron star that is accreting hydrogen gas or to the stellar winds blowing out from a neutron star or a collapsar disk	.002
density of matter in and about the environs of the Local Group of galaxies	.1
density of baryons in the Local Volume of the universe	.05
density of baryons in the Local Group of galaxies	.05
ratio of baryons in galaxies to baryons in between galaxies in the Local Group of galaxies	.1
epoch of peak star formation in the potential life support galaxy	.01
ratio of type I to type II supernovae in the potential life support galaxy	.02
ratio of polycyclic aromatic hydrocarbons to stars in the galaxy	.05
closest proximity of the solar system to a black hole during the history of life	.5

quantity of warm dust in the interplanetary medium	.5
level of coronal mass ejections from the solar surface	.05
birthrate of massive stars in the solar neighborhood	.02
variation in birthrate of massive stars in the solar neighborhood	.1
number density of intracluster clouds in and around the Local Group of galaxies	.1
average mass of intracluster clouds in and around the Local Group of galaxies	.1
peak-to-peak amplitude in the solar magnetic cycle	.01
metallicity of the galaxy's halo	.02
shape of the galactic dark matter halo	.1
temperature of the hot intracluster medium for the Local Group of galaxies	.05
inward migration of icy meter-sized rubble from the outer part of the protoplanetary disk	.001
density of stars in the sun's birthing star cluster	.01
carbon abundance in the protoplanetary disk of the potential life support planetary system	.001
number density of dark matter subhalos surrounding the galaxy	.1
average mass of the dark matter subhalos surrounding the galaxy	.1
formation times for the dark matter halo and subhales surrounding the galaxy	.01
planet formation time scale in the protoplanetary disk	.03
ratio of average surface magnetic field strength to the expansion factor of open magnetic flux tubes on the sun	.1
rate of growth of the galactic bulge in the spiral galaxy	.03
strength of the ultraviolet background for the protogalaxy	.1
extent of the warp of the galactic disk	.1
proximity of the emerging solar system nebula to very low mass red giant and asymptotic giant branch stars	.01
richness or density of galaxies in the supercluster of galaxies	.1
misalignment angle between the magnetic and rotational axes of the star during the planet formation era	.1
infall velocity of matter into the dark matter halo of the potential life support galaxy	.05
migration speed of Jupiter early in its history	.01
migration speed of Saturn early in its history	.02
migration speed of Uranus early in its history	.05
migration speed of Neptune early in its history	.05
quantity of hydroxyl (OH) in the planet's troposphere	.01
variation in the quantity of hydroxyl in the planet's troposphere	.1
quantity of hydroxyl (OH) in the planet's stratosphere	.01
variation in the quantity of hydroxyl in the planet's stratosphere	.1
level of magnetization of the spiral disk for the potential life support galaxy	.05
percentage of the Milky Way Galaxy's halo that is comprised of MACHOs	.2
metallicity of the galaxy's halo	.1
strength of the wind emanating from the galaxy's nuclear core	.05
variation in the strength of the wind emanating from the	

galaxy's nuclear core	.05
mass of the initial or primordial galaxy	.005
magnetization of the protoplanetary disk	.1
level of mixing of the elements and chemicals in the protoplanetary disk	.02
strength of the vertical magnetic field emanating from the galactic center	.1
level of radial differential rotation during the sun's youth	.1
level of enhanced mixing in the interiors of low-mass red giant s tars that were in the vicinity of the solar system's protoplanetary disk	.1
date when half the stars in the galaxy would have already been formed	.02
density of dwarf dark matter halos in the vicinity of the Milky Way Galaxy	.01
metallicity enrichment by dwarf galaxies of the intergalactic medium in the vicinity of the potential life support galaxy	.1
average star formation rate throughout cosmic history for dwarf galaxies that are in the vicinity of the potential life support galaxy	.02
quantity of heavy elements infused into the intergalactic medium by dwarf galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
quantity of heavy elements infused into the intergalactic medium by the superwinds of large galaxies in the vicinity of the potential life support galaxy during the first two billion years of cosmic history	.03
average size of cosmic voids in the vicinity of the potential life support galaxy	.5
number of cosmic voids per unit of cosmic space in the vicinity of the potential life support galaxy	.5
number of galaxies per unit of dark matter halo virial mass in the vicinity of the potential life support galaxy	.1
ratio of the number density of dark matter subhalos to the number density of dark matter halos in the vicinity of the potential life support galaxy	.1
quantity of diffuse, large-grained intergalactic dust in the vicinity of the potential life support galaxy	.1
ratio of baryonic matter to exotic matter in dwarf galaxies in the vicinity of the potential life support galaxy	.1
ratio of baryons in the intergalactic medium relative to baryons in the circumgalactic medium for the potential life support galaxy	.1
intergalactic photon density in the vicinity of the potential life support galaxy	.4
quantity of baryons in the warm-hot intergalactic medium in the vicinity of the potential life support galaxy	.2
frequency of mega-volcanic eruptions on the life support planet	.01
timing of the introduction of the equivalent of a human species relative to the last mega-volcanic eruption	.05

percentage of the planet's surface covered by forests	.001
variation in percentage of the planet's surface covered by forests	.05
high latitude precipitation	.01
duration of El Nino events	.1
average depth of oxygenated marine sediments	.001
variation in average depth of oxygenated marine sediments	.05
habitat space for land mammals	.01
timing of the spread of fungal species on the continental land masses	.01
quantity and diversity of fungi on the continental land masses	.0001
date for onset of crust formation for the planet	.1
date for onset of sediment recycling for the planet	.1
quantity and diversity of oxygen-tolerant anerobes	.001
variation in quantity and diversity of oxygen tolerant anerobes	.1
quantity of volatile organic compounds released into the atmosphere by trees	.01
average pore pressure at subduction zones	.01
average rate of migration of aqueous fluids through the planet's upper crust	.002
radiative thermal conductivity level of the lower mantle	.01
abundance of olivine in the upper mantle	.1
trace element abundance in atmospheric dust	.05
rate of atmospheric dust deposition to the surfaces of oceans	.05
variation in the level of dust supply to the surfaces of oceans	.2
quantity of nitrogen-fixing cyanobacteria in corals	.001
rate at which dissolved organic matter cycles through the oceans	.01
level of chemical heterogeneities throughout the lower mantle	.1
level of deep ocean convection	.05
variation in level of deep ocean convection	.2
rate of remineralization of particulate organic matter	.1
quantity of large-celled sulfur bacteria in the oceans	.00001
variation in quantity of large-celled sulfur bacteria in the oceans	.01
quantity of sulfuric acid in the troposphere	.01
quantity of ammonia in the troposphere	.1
quantity of iodine oxide in the troposphere	.1
level of atmospheric oxidation of aromatics	.1
quantity of fallen leaf litter	.1
quantity and extent of wetland ecosystems	.01
quantity of endophytic methanotrophic bacteria in freshwater wetland ecosystems	.0001
quantity of marine methanotrophic archaea	.0001
variation in quantity of marine methanotrophic archaea	.01
diversity of prokaryote microorganisms	.0001
diversity of eukaryote microorganisms	.0001
level of synergistic interactions among bacterial species	.00001
variation in level of synergistic interactions among bacterial species	.01
rate at which the planet's inner core rotates faster than the mantle and the crust	.1
quantity of phosphonate-mining bacteria in the oceans	.00001
variation in quantity of phosphorate-mining bacteria in the oceans	.01

quantity and diversity of siderophore-secreting bacteria in the oceans	.0001
variation in quantity and diversity of siderophore-secreting bacteria in the oceans	.01
quantity of carbon dioxide extracted from the mantle by melting beneath mid-ocean ridges	.1
quantity of carbon dioxide extracted from the mantle by volcanic eruptions	.2
quantity of soil nitrogen	.05
variation in quantity of nitrogen	.2
quantity of marine snow (dead cells, shreds of plankton, bits of faeces, and mineral grains) in the oceans	.01
average size of aerosol particles in the troposphere	.1
quantity of Trichodesmium bacteria in the oceans	.0001
depth distribution of Trichodesmium bacteria in the oceans	.02
variation in quantity and distribution of Trichodesmium bacteria in the oceans	.01
date for the beginning of significant plate tectonic activity	.01
rate of decline in seawater temperature over the past four billion years	.01
quantity of hydrated minerals in the mantle	.001
quantity of hydrogen peroxide produced in the atmosphere	.5
level of mixing in the early protoplanetary disk of the solar nebula	.05
distance of the Magellanic Clouds from the Milky Way Galaxy	.5
timing of the movement of the main asteroid belt from its place of birth (much closer to the sun) to its present location (between Mars and Jupiter)	.1

Probability for occurrence of all 816 parameters $\approx 10^{-1333}$
dependency factors estimate $\approx 10^{324}$
longevity requirements estimate $\approx 10^{-45}$

Probability for occurrence of all 816 parameters $\approx 10^{-1054}$
Maximum possible number of life support bodies in observable universe $\approx 10^{22}$

Thus, less than 1 chance in 10^{1032} exists that even one such life-support body would occur anywhere in the universe without invoking divine miracles.

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