Fine-Tuning of Physical Life Support Body

by Hugh Ross

Evidence for the Fine-Tuning of the Galaxy-Sun-Earth-Moon System for Life Support

The environmental requirements for life to exist depend quite strongly on the life form in question. The conditions for primitive life to exist, for example, are not nearly so demanding as they are for advanced life. Also, it makes a big difference how active the life form is and how long it remains in its environment. On this basis there are six distinct zones or regions in which life can exist. In order of the broadest to the narrowest they are as follows:

for unicellular, low metabolism life that persists for only a brief time period

for unicellular, low metabolism life that persists for a long time period

for unicellular, high metabolism life that persists for a brief time period

for unicellular, high metabolism life that persists for a long time period

for advanced life that survives for just a brief time period

for advanced life that survives for a long time period

Complicating factors, however, are that unicellular, low metabolism life is more easily subject to radiation damage and it has a very low molecular repair rate. The origin of life problem also is much more difficult for low metabolism life. The following parameters of a planet, its planetary companions, its moon, its star, and its galaxy must have values falling within narrowly defined ranges for physical life of any kind to exist.

galaxy cluster type

if too rich: galaxy collisions and mergers would disrupt solar orbit

if too sparse: insufficient infusion of gas to sustain star formation for a long enough time

galaxy size

if too large: infusion of gas and stars would disturb sun's orbit and ignite too many galactic eruptions.

if too small: insufficient infusion of gas to sustain star formation for long enough time.

galaxy type

if too elliptical: star formation would cease before sufficient heavy element build-up for life chemistry.

if too irregular: radiation exposure on occasion would be too severe and heavy elements for life chemistry would not be available.

galaxy mass distribution

if too much in the central bulge: life-supportable planet will be exposed to too much radiation.

if too much in the spiral arms: life-supportable planet will be destabilized by the gravity and radiation from adjacent spiral arms.

galaxy location

if too close to a rich galaxy cluster: galaxy would be gravitationally disrupted

if too close to very large galaxy(ies): galaxy would be gravitationally disrupted.

if too far away from dwarf galaxies: insufficient infall of gas and dust to sustain ongoing star formation

decay rate of cold dark matter particles

if too small: too few dwarf spheroidal galaxies will form which prevents star formation from lasting long enough in large galaxies so that life-supportable planets become possible.

if too great: too many dwarf spheroidal galaxies will form which will make the orbits of solar-type stars unstable over long time periods and lead to the generation of deadly radiation episodes.

hypernovae eruptions

if too few not enough heavy element ashes present for the formation of rocky planets.

if too many: relative abundances of heavy elements on rocky planets would be inappropriate for life; too many collision events in planetary system

if too soon: leads to a galaxy evolution history that would disturb the possibility of advanced life; not enough heavy element ashes present for the formation of rocky planets.

if too late: leads to a galaxy evolution history that would disturb the possibility of advanced life; relative abundances of heavy elements on rocky planets would be inappropriate for life; too many collision events in planetary system

supernovae eruptions

if too close: life on the planet would be exterminated by radiation

if too far: not enough heavy element ashes would exist for the formation of rocky planets.

if too infrequent: not enough heavy element ashes present for the formation of rocky planets.

if too frequent: life on the planet would be exterminated.

if too soon: heavy element ashes would be too dispersed for the formation of rocky planets at an early enough time in cosmic history

if too late: life on the planet would be exterminated by radiation.

white dwarf binaries

if too few: insufficient fluorine would be produced for life chemistry to proceed.

if too many: planetary orbits disrupted by stellar density; life on planet would be exterminated.

if too soon: not enough heavy elements would be made for efficient fluorine production.

if too late: fluorine would be made too late for incorporation in protoplanet.

proximity of solar nebula to a supernova eruption

if farther: insufficient heavy elements for life would be absorbed.

if closer: nebula would be blown apart.

timing of solar nebula formation relative to supernova eruption

if earlier: nebula would be blown apart.

if later: nebula would not absorb enough heavy elements.

number of stars in parent star birth aggregate

if too few: insufficient input of certain heavy elements into the solar nebula.

if too many: planetary orbits will be too radically disturbed.

star formation history in parent star vicinity

if too much too soon: planetary orbits will be too radically disturbed.

birth date of the star-planetary system

if too early: quantity of heavy elements will be too low for large rocky planets to form.

if too late: star would not yet have reached stable burning phase; ratio of potassium-40, uranium-235 & 238, and thorium-232 to iron will be too low for long-lived plate tectonics to be sustained on a rocky planet.

parent star distance from center of galaxy

if farther: quantity of heavy elements would be insufficient to make rocky planets; wrong abundances of silicon, sulfur, and magnesium relative to iron for appropriate planet core characteristics.

if closer: galactic radiation would be too great; stellar density would disturb planetary orbits; wrong abundances of silicon, sulfur, and magnesium relative to iron for appropriate planet core characteristics.

parent star distance from closest spiral arm

if too large: exposure to harmful radiation from galactic core would be too great.

z-axis heights of star’s orbit

if more than one: tidal interactions would disrupt planetary orbit of life support planet

if less than one: heat produced would be insufficient for life.

quantity of galactic dust

if too small: star and planet formation rate is inadequate; star and planet formation occurs too late; too much exposure to stellar ultraviolet radiation.

if too large: blocked view of the Galaxy and of objects beyond the Galaxy; star and planet formation occurs too soon and at too high of a rate; too many collisions and orbit perturbations in the Galaxy and in the planetary system.

number of stars in the planetary system

if more than one: tidal interactions would disrupt planetary orbit of life support planet

if less than one: heat produced would be insufficient for life.

parent star age

if older: luminosity of star would change too quickly.

if younger: luminosity of star would change too quickly.

parent star mass

if greater: luminosity of star would change too quickly; star would burn too rapidly.

if less: range of planet distances for life would be too narrow; tidal forces would disrupt the life planet's rotational period; uv radiation would be inadequate for plants to make sugars and oxygen.

parent star metallicity

if too small: insufficient heavy elements for life chemistry would exist.

if too large: radioactivity would be too intense for life; life would be poisoned by heavy element concentrations.

parent star color

if redder: photosynthetic response would be insufficient.

if bluer: photosynthetic response would be insufficient.

galactic tides

if too weak: too low of a comet ejection rate from giant planet region.

if too strong too high of a comet ejection rate from giant planet region.

H_3^+ production

if too small: simple molecules essential to planet formation and life chemistry will not form.

if too large: planets will form at wrong time and place for life.

flux of cosmic ray protons

if too small: inadequate cloud formation in planet's troposphere.

if too large: too much cloud formation in planet's troposphere.

solar wind

- if too weak: too many cosmic ray protons reach planet’s troposphere causing too much cloud formation.
- if too strong: too few cosmic ray protons reach planet’s troposphere causing too little cloud formation.

parent star luminosity relative to speciation

- if increases too soon: runaway green house effect would develop.
- if increases too late: runaway glaciation would develop.

surface gravity (escape velocity)

- if stronger: planet’s atmosphere would retain too much ammonia and methane.
- if weaker: planet’s atmosphere would lose too much water.

distance from parent star

- if farther: planet would be too cool for a stable water cycle.
- if closer: planet would be too warm for a stable water cycle.

inclination of orbit

- if too great: temperature differences on the planet would be too extreme.

orbital eccentricity

- if too great: seasonal temperature differences would be too extreme.

axial tilt

- if greater: surface temperature differences would be too great.
- if less: surface temperature differences would be too great.

rate of change of axial tilt

- if greater: climatic changes would be too extreme; surface temperature differences would become too extreme.

rotation period

- if longer: diurnal temperature differences would be too great.
- if shorter: atmospheric wind velocities would be too great.

rate of change in rotation period

- if longer: surface temperature range necessary for life would not be sustained.
- if shorter: surface temperature range necessary for life would not be sustained.

planet age

if too young: planet would rotate too rapidly.

if too old: planet would rotate too slowly.

magnetic field

if stronger: electromagnetic storms would be too severe; too few cosmic ray protons would reach planet's troposphere which would inhibit adequate cloud formation.

if weaker: ozone shield would be inadequately protected from hard stellar and solar radiation.

thickness of crust

if thicker: too much oxygen would be transferred from the atmosphere to the crust.

if thinner: volcanic and tectonic activity would be too great.

albedo (ratio of reflected light to total amount falling on surface)

if greater: runaway glaciation would develop.

if less: runaway greenhouse effect would develop.

asteroidal and cometary collision rate

if greater: too many species would become extinct.

if less: crust would be too depleted of materials essential for life.

mass of body colliding with primordial Earth

if smaller: Earth's atmosphere would be too thick; moon would be too small.

if greater: Earth's orbit and form would be too greatly disturbed.

timing of body colliding with primordial Earth.

if earlier: Earth's atmosphere would be too thick; moon would be too small.

if later: sun would be too luminous at epoch for advanced life.

collision location of body colliding with primordial Earth

if too close to grazing: insufficient debris to form large moon; inadequate annihilation of Earth's primordial atmosphere; inadequate transfer of heavy elements to Earth.

If too close to dead center: damage from collision would be too destructive for future life to survive.

oxygen to nitrogen ratio in atmosphere

if larger: advanced life functions would proceed too quickly.

if smaller: advanced life functions would proceed too slowly.

carbon dioxide level in atmosphere

if greater: runaway greenhouse effect would develop.

if less: plants would be unable to maintain efficient photosynthesis.

water vapor level in atmosphere

if greater: runaway greenhouse effect would develop.

if less: rainfall would be too meager for advanced life on the land.

atmospheric electric discharge rate

if greater: too much fire destruction would occur.

if less: too little nitrogen would be fixed in the atmosphere.

ozone level in atmosphere

if greater: surface temperatures would be too low.

if less: surface temperatures would be too high; there would be too much uv radiation at the surface.

oxygen quantity in atmosphere

if greater: plants and hydrocarbons would burn up too easily.

if less: advanced animals would have too little to breathe.

nitrogen quantity in atmosphere

if greater: too much buffering of oxygen for advanced animal respiration; too much nitrogen fixation for support of diverse plant species.

if less: too little buffering of oxygen for advanced animal respiration; too little nitrogen fixation for support of diverse plant species.

ratio of ^{40}K, $^{235,238}U$, ^{232}Th to iron for the planet

if too low: inadequate levels of plate tectonic and volcanic activity.

if too high: radiation, earthquakes, and volcanoes at levels too high for advanced life.

rate of interior heat loss

if too low: inadequate energy to drive the required levels of plate tectonic and volcanic activity.

if too high: plate tectonic and volcanic activity shuts down too quickly.

seismic activity

if greater: too many life-forms would be destroyed.

if less: nutrients on ocean floors from river runoff would not be recycled to continents through tectonics; not enough carbon dioxide would be released from carbonates

volcanic activity

if lower: insufficient amounts of carbon dioxide and water vapor would be returned to the atmosphere; soil mineralization would become too degraded for life.

if higher: advanced life, at least, would be destroyed.

rate of decline in tectonic activity

if slower: advanced life can never survive on the planet.

if faster: advanced life can never survive on the planet.

rate of decline in volcanic activity

if slower: advanced life can never survive on the planet.

if faster: advanced life can never survive on the planet.

timing of birth of continent formation

if too early: silicate-carbonate cycle would be destabilized.

if too late: silicate-carbonate cycle would be destabilized.

oceans-to-continents ratio

if greater: diversity and complexity of life-forms would be limited.

if smaller: diversity and complexity of life-forms would be limited.

rate of change in oceans-to-continents ratio

if smaller: advanced life will lack the needed land mass area.

if greater: advanced life would be destroyed by the radical changes.

global distribution of continents (for Earth)

if too much in the southern hemisphere: seasonal differences would be too severe for advanced life.

frequency and extent of ice ages

if smaller: insufficient fertile, wide, and well-watered valleys produced for diverse and advanced life forms; insufficient mineral concentrations occur for diverse and advanced life.

if greater: planet inevitably experiences runaway freezing.

soil mineralization

if too nutrient poor: diversity and complexity of life-forms would be limited.

if too nutrient rich: diversity and complexity of life-forms would be limited.

gravitational interaction with a moon

if greater: tidal effects on the oceans, atmosphere, and rotational period would be too severe

if less: orbital obliquity changes would cause climatic instabilities; movement of nutrients and life from the oceans to the continents and vice versa would be insufficient; magnetic field would be too weak.

Jupiter distance

if greater: too many asteroid and comet collisions would occur on Earth.

if less: Earth’s orbit would become unstable.

Jupiter mass

if greater: Earth’s orbit would become unstable.

if less: too many asteroid and comet collisions would occur on Earth.

drift in major planet distances

if greater: Earth’s orbit would become unstable.

if less: too many asteroid and comet collisions would occur on Earth.

major planet eccentricities

if greater: orbit of life supportable planet would be pulled out of life support zone.

major planet orbital instabilities

if greater: orbit of life supportable planet would be pulled out of life support zone.

mass of Neptune

if too small: not enough Kuiper Belt Objects (asteroids beyond Neptune) would be scattered out of the solar system.

if too large: chaotic resonances among the gas giant planets would occur.

Kuiper Belt of asteroids (beyond Neptune)

if not massive enough: Neptune’s orbit remains too eccentric which destabilizes the orbits of other solar system planets.

if too massive: too many chaotic resonances and collisions would occur in the solar system.

separation distances among inner terrestrial planets

if too small: orbits of all inner planets will become unstable in less than 100,000,000 million years.

if too large: orbits of the most distant from star inner planets will become chaotic.

atmospheric pressure

if too small: liquid water will evaporate too easily and condense too infrequently; weather and climate variation would be too extreme; lungs will not function.

if too large: liquid water will not evaporate easily enough for land life; insufficient sunlight reaches planetary surface; insufficient uv radiation reaches planetary surface; insufficient climate and weather variation; lungs will not function.

atmospheric transparency

if smaller: insufficient range of wavelengths of solar radiation reaches planetary surface if greater: too broad a range of wavelengths of solar radiation reaches planetary surface.

magnitude and duration of sunspot cycle

if smaller or shorter: insufficient variation in climate and weather.

if greater or longer: variation in climate and weather would be too much.

continental relief

if smaller: insufficient variation in climate and weather.

if greater: variation in climate and weather would be too much.

chlorine quantity in atmosphere

if smaller: erosion rates, acidity of rivers, lakes, and soils, and certain metabolic rates would be insufficient for most life forms.

if greater: erosion rates, acidity of rivers, lakes, and soils, and certain metabolic rates would be too high for most life forms.

iron quantity in oceans and soils

if smaller: quantity and diversity of life would be too limited for support of advanced life; if very small, no life would be possible.

if larger: iron poisoning of at least advanced life would result.

tropospheric ozone quantity

if smaller: insufficient cleansing of biochemical smogs would result.

if larger: respiratory failure of advanced animals, reduced crop yields, and destruction of ozone-sensitive species would result.

stratospheric ozone quantity

if smaller: too much uv radiation reaches planet’s surface causing skin cancers and reduced plant growth.

if larger: too little uv radiation reaches planet’s surface causing reduced plant growth and insufficient vitamin production for animals.

mesospheric ozone quantity

if smaller: circulation and chemistry of mesospheric gases so disturbed as to upset relative abundances of life essential gases in low atmosphere.

if greater: circulation and chemistry of mesospheric gases so disturbed as to upset relative abundances of life essential gases in lower atmosphere.

quantity and extent of forest and grass fires

if smaller: growth inhibitors in the soils would accumulate; soil nitrification would be insufficient; insufficient charcoal production for adequate soil water retention and absorption of certain growth inhibitors.

if greater: too many plant and animal life forms would be destroyed.

quantity of soil sulfur

if smaller: plants will become deficient in certain proteins and die.

if larger: plants will die from sulfur toxins; acidity of water and soil will become too great for life; nitrogen cycles will be disturbed.

biomass to comet infall ratio

if smaller: greenhouse gases accumulate, triggering runaway surface temperature increase.

if larger: greenhouse gases decline, triggering a runaway freezing.

density of quasars

if smaller: insufficient production and ejection of cosmic dust into the intergalactic medium; ongoing star formation impeded; deadly radiation unblocked.

if larger: too much cosmic dust forms; too many stars form too late disrupting the formation of a solar-type star at the right time and under the right conditions for life.

density of giant galaxies in the early universe

if smaller: insufficient metals ejected into the intergalactic medium depriving future generations of stars of the metal abundances necessary for a life-support planet at the right time in cosmic history.

if larger: too large a quantity of metals ejected into the intergalactic medium providing future stars with too high of a metallicity for a life-support planet at the right time in cosmic history.

giant star density in galaxy

if smaller: insufficient production of galactic dust; ongoing star formation impeded; deadly radiation unblocked.

if larger: too much galactic dust forms; too many stars form too early disrupting the formation of a solar-type star at the right time and under the right conditions for life.

rate of sedimentary loading at crustal subduction zones:

if smaller: too few instabilities to trigger the movement of crustal plates into the mantle thereby disrupting carbonate-silicate cycle.

if larger: too many instabilities triggering too many crustal plates to move down into the mantle thereby disrupting carbonate-silicate cycle

poleward heat transport in planet’s atmosphere

if smaller: disruption of climates and ecosystems; lowered biomass and species diversity; decreased storm activity and precipitation.

if larger: disruption of climates and ecosystems; lowered biomass and species diversity; increased storm activity.

polycyclic aromatic hydrocarbon abundance in solar nebula

if smaller: insufficient early production of asteroids which would prevent a planet like Earth from receiving adequate delivery of heavy elements and carbonaceous material for life, advanced life in particular.

if larger: early production of asteroids would be too great resulting in too many collision events striking a planet arising out of the nebula that could support life

phosphorus and iron absorption by banded iron formations

if smaller: overproduction of cyanobacteria would have consumed too much carbon dioxide and released too much oxygen into Earth's atmosphere thereby overcompensating for the increase in the Sun's luminosity (too much reduction in atmospheric greenhouse efficiency).

if larger: underproduction of cyanobacteria would have consumed too little carbon dioxide and released too little oxygen into Earth's atmosphere thereby under compensating for the increase in the Sun's luminosity (too little reduction in atmospheric greenhouse efficiency).

silicate dust annealing by nebular shocks

if too little: rocky planets with efficient plate tectonics cannot form.

if too much: too many collisions in planetary system.; too severe orbital instabilities in planetary system.

size of galactic central bulge

if smaller: inadequate infusion of gas and dust into the spiral arms preventing solar type stars from forming at the right locations late enough in the galaxy's history.

if larger: radiation from the bulge region would kill life on the life-support planet.

total mass of Kuiper Belt asteroids

if smaller: Neptune's orbit would not be adequately circularized.

if larger: too severe gravitational instabilities generated in outer solar system.

solar magnetic activity level

if greater: solar luminosity fluctuations will be too large.

number of hypernovae

if smaller: too little nitrogen is produced in the early universe, thus, cannot get the kinds of stars and planets later in the universe that are necessary for life.

if larger: too much nitrogen is produced in the early universe, thus, cannot get the kinds of stars and planets later in the universe that are necessary for life.

timing of hypernovae production

if too early: galaxies become too metal rich too quickly to make stars and planets suitable for life support at the right time.

if too late: insufficient metals available to make quickly enough stars and planets suitable for life support.

masses of stars that become hypernovae

if not massive enough: insufficient metals are ejected into the interstellar medium; that is, not enough metals are available for future star generations to make stars and planets suitable for the support of life.

if too massive: all the metals produced by the hypernova eruptions collapse into the black holes resulting from the eruptions; that is, none of the metals are available for future generations of stars.

quantity of geobacteraceae

if smaller or non-existent: polycyclic aromatic hydrocarbons accumulate in the surface environment thereby contaminating the environment for other life forms.

density of brown dwarfs

if too low: too many low mass stars are produced which will disrupt planetary orbits

if too high: disruption of planetary orbits

quantity of aerobic photoheterotrophic bacteria

if smaller: inadequate recycling of both organic and inorganic carbon in the oceans

average rainfall precipitation

if too small: inadequate water supplies for land-based life; inadequate erosion of land masses to sustain the carbonate-silicate cycle.; inadequate erosion to sustain certain species of ocean life that are vital for the existence of all life.

if too large: too much erosion of land masses which upsets the carbonate-silicate cycle and hastens the extinction of many species of life that are vital for the existence of all life.

variation and timing of average rainfall precipitation

if too small or at the wrong time: erosion rates that upset the carbonate-silicate cycle and fail to adjust adequately the planet's atmosphere for the increase in the sun's luminosity.

if too large or at the wrong time: erosion rates that upset the carbonate-silicate cycle and fail to adjust the planet's atmosphere for the increase in the sun's luminosity

average slope or relief of the continental land masses

if too small: inadequate erosion.

if too large: too much erosion.

distance from nearest black hole

if too close: radiation will prove deadly for life

absorption rate of planets and planetismals by parent star if too low: disturbs sun's luminosity and stability of sun's long term luminosity.

if too high: disturbs orbits of inner solar system planets; disturbs sun's luminosity and stability of sun's long term luminosity.

water absorption capacity of planet's lower mantle

if too low: too much water on planet's surface; no continental land masses; too little plate tectonic activity; carbonate-silicate cycle disrupted.

if too high: too little water on planet's surface; too little plate tectonic activity; carbonate-silicate cycle disrupted.

gas dispersal rate by companion stars, shock waves, and molecular cloud expansion in the Sun's birthing star cluster

if too low: too many stars form in Sun's vicinity which will disturb planetary orbits and pose a radiation problem; too much gas and dust in solar system's vicinity.

if too high: not enough gas and dust condensation for the Sun and its planets to form; insufficient gas and dust in solar system's vicinity.

decay rate of cold dark matter particles

if too low: insufficient production of dwarf spheroidal galaxies which will limit the maintenance of long-lived large spiral galaxies.

if too high: too many dwarf spheroidal galaxies produced which will cause spiral galaxies to be too unstable.

ratio of inner dark halo mass to stellar mass for galaxy

if too low: corotation distance is too close to the center of the galaxy which exposes the life-support planet to too much radiation and too many gravitational disturbances.

if too high: corotation distance is too far from the center of the galaxy where the abundance of heavy elements is too sparse to make rocky planets.

star rotation rate

if too slow: too weak of a magnetic field resulting in not enough protection from cosmic rays for the life-support planet.

if too fast: too much chromospheric emission causing radiation problems for the life-support planet.

rate of nearby gamma ray bursts

if too low: insufficient mass extinctions of life to create new habitats for more advanced species

if too high: too many mass extinctions of life for the maintenance of long-lived species

aerosol particle density emitted from forests

if too low: too little cloud condensation which reduces rainfall, lowers the albedo (planetary reflectivity), and disturbs climates on a global scale.

if too high: too much cloud condensation which increases rainfall, raises the albedo (planetary reflectivity), and disturbs climate on a global scale; too much smog.

density of interstellar and interplanetary dust particles in vicinity of life-support planet

if too low: inadequate delivery of life-essential materials

if too high: disturbs climate too radically on life-support planet

thickness of mid-mantle boundary

if too thin: mantle convection eddies become too strong; tectonic activity and silicate production become too great.

if too thick: mantle convection eddies become too weak; tectonic activity and silicate production become too small.

galaxy cluster density

if too low: insufficient infall of gas, dust, and dwarf galaxies into a large galaxy that eventually could form a life-supportable planet.

if too high: gravitational influences from nearby galaxies will disturb orbit of the star that has a life-supportable planet thereby exposing that planet either to deadly radiation or to gravitational disturbances from other stars in that galaxy.

star formation rate in solar neighborhood during past 4 billion years

if too high: life on Earth will be exposed to deadly radiation or orbit of Earth will be disturbed.

variation in star formation rate in solar neighborhood during past 4 billion years

if too high: life on Earth will be exposed to deadly radiation or orbit of Earth will be disturbed.

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