

A unified systems model for evolution

Implications for human behaviour and survival

ML Lamoreux¹ and DC Bennett²

¹Department of Veterinary Pathobiology, Texas A&M University, College Station, Texas, USA (retired).

✉ marylytnn@gmail.com ² Department of Molecular & Biomedical Sciences, City St George's, University of London, Cranmer Terrace, London SW17 0RE, UK. ✉ dbennett@citystgeorges.ac.uk

ABSTRACT: Here we present a systems-based and unified theory of evolution, more consistent with biological complexity than previous unified models, and addressing popular misconceptions about 'survival of the fittest' that have contributed to overcompetitive and overaggressive attitudes in our social and economic systems. These attitudes have played an important part in the global metacrisis of today. We show here how evolution not only of life on earth, but also of matter and energy ever since the Big Bang, shows common features. These features can be understood in terms of natural systems increasingly nesting into higher systems, with net increases in complexity, diversity and information over very long times, within the lineage leading to our present terrestrial biosphere. These increases were energized initially by the expansion of the universe and the resulting ongoing fall in temperature, and later on Earth by local energy from the sun and the planetary core. The relationship of every evolving system to its environment is also crucial in evolution. To date we know of no other life in the Universe, making our biosphere immeasurably rare and precious, yet its life is now in danger from human activity and ecological overshoot. While better understanding does not always lead to better decisions, still if some of those with power over our commercially oriented, global human social system (which we call the **corposystem**) can gain an appreciation of the unified working of evolution and the colossal complexity and interdependence of this planet's living systems, on which we entirely depend, humanity and higher life on earth may have a better chance of surviving the current global crises.

Keywords: corposystem, biosystem, evolution, model, selectable information, metacrisis, overshoot

GLOSSARY OF TERMS

System: two or more linked and interacting units that together produce emergent properties (properties not possessed by the parts).

First type of system: nucleons and atomic nuclei; systems bonded by the strong and weak forces.

Second type: atoms and molecules; systems bonded by electromagnetic forces.

Third type: systems that fall into classes or species (of macromolecules, organisms etc) with varying emergent properties. They are sustained through selectable information (defined below).

Autopoiesis: self-organization and regeneration.

Biosystem: the system of all life on Earth.

Corposystem: our commercially oriented, global human social system.

Emergent properties: properties of a system not possessed by its component parts.

Evolution: Those processes that over time have generated the increase in maximal complexity and diversity of natural systems in the universe.

Information (general): What is perceived, conveyed or represented by a particular arrangement or sequence of things.

Information (selectable): the emergent properties of a Type 3 system that mediate interactions with its environment.

Informational selection: all evolutionary selection within Type 3 systems (see above), including life.

Living system: a Type 3 system that can replicate and maintain itself accurately and sustainably in a suitable environment.

Metacrisis: multiple crises arising from a common cause.

Naturally evolved systems: systems that arose through evolution in nature rather than by human design.

Unit of selectable information: a Type 3 system within and as a component of its environment.

INTRODUCTION

Humanity, and the planet in general, are encountering an expanding range of simultaneous crises, including unprecedented climate change, social unrest, wars, widespread refugee migration, widespread hunger and water-shortages among humans, and accelerating extinction of diverse other species. We (Lamoreux and Bennett, 2024) and others (for example Suzuki 2003; Wackernagel et al., 2002; Hagens, 2025) have argued that all these ills ultimately have a common cause, namely humanity's **overshoot** (Catton, 1980; Rees, 2024): a combination of overpopulation and overconsumption that together are changing the trajectory of evolution and overwhelming the capacity of the living world to regenerate itself and support us. The situation can be called a **metacrisis**, meaning multiple crises arising from a common cause (Hagens, 2024a). [This is more specific than the related term **polycrisis**, which simply means many crises happening at once (Hodgson, 2025).]

We will discuss here some human attitudes and beliefs that may have contributed to the development of that common cause. In particular, human misinterpretation of the nature of evolution may have played a surprisingly notable part in the wide-ranging harms we have perpetrated towards ourselves and the rest of life on Earth. Rees (2025) has quoted Dobzhansky (1973): 'Nothing in biology makes sense except in the light of evolution.' If we do not understand the concept of evolution, then our efforts to survive within it will not succeed. Accordingly, we aim to provide here a more accurate and deeper understanding of evolution, with potential bearing on some major questions. These include: what is life, and how did sufficient complexity evolve to generate life; how can complexity of systems increase in a universe with increasing total entropy; and how does biological evolution generate a sustainable balance in life? A particular interest in complexity was generated by propositions that the pool of molecules available for the generation of life was not sufficiently complex to explain that event (Walker, 2024, 2025).

Life has evolved on Earth. The evolution of life is indeed what is suggested to many people by the term, and yet we do also speak of evolution of the universe. We propose here that what is commonly recognized and taught as evolution, that is, heritable change in living systems over time, is actually a subset of a common process of evolution that began with the generation of the first naturally evolved systems, just after the Big Bang. We touched upon this previously (Lamoreux and Bennett, 2024), while others (Pross, 2011; Cronin and Walker, 2016; Wong et al., 2023; Duran-Nobreda et al., 2024; Abel, 2025; Walker, 2025) have also discussed various ideas of universal evolution. However, we present here a novel (to our knowledge), unified and radically different concept of evolution that simultaneously fits our current understanding of both biological evolution and physicochemical evolution in the early universe.

Our model is based on what we call systems. Expanding from a previous definition (Lamoreux and Bennett, 2024), we will use here a broad definition of a system that covers the whole spectrum of compound entities, from subatomic particles to life: **A system consists of two or more linked and interacting units that together produce emergent properties – properties not possessed by the parts.** Thus, the universe is composed of systems. A helium atom has interacting protons, neutrons and electrons. A pond ecosystem has many interacting

components. On the other hand, a pile of stones is not a system. The stones are not linked and the pile has no emergent properties (not shared by the component stones).

It can be seen that systems are not only matter but entities combining matter and energy. There are vast numbers of different specific types of system, each with its own unique emergent properties. For example, water is liquid at 0-100°C in our atmospheric pressure, an emergent property not possessed by either of its components, hydrogen and oxygen. Systems often interact through their emergent properties. For example, salt molecules (systems) can ionize and dissolve (interaction) in liquid water (system). The emergent properties of both molecules – charge, shape etc. – enable this interaction. Emergent properties of a butterfly and a flowering plant (two systems) can include respectively possession of a proboscis and production of nectar in flowers, whereby the two interact (the butterfly feeds; and via other emergent properties it pollinates).

This article will focus on **naturally evolved systems**: those that arose through evolution in nature rather than by human design, whether living or not. The framework is holistic and based on the following considerations, to be expanded and discussed below:

- 1) The universe has been expanding and therefore cooling since the Big Bang, resulting in the generation and evolution of matter, forces and systems.
- 2) Increasingly complex natural systems can evolve over time through random interactions between/among systems: subatomic particles, atoms, molecules, aggregates such as stars and planets, then the evolution of life.
- 3) Systems emerge within specific environments, depending upon conditions in those environments.
- 4) Evolution operates upon whatever entities are available at any given time and place.

We propose that our evolutionary framework can explain the origin of the complexity and diversity of living systems. We will describe how the cumulative nesting of simpler subsystems by the action of universal forces, finally incorporating the power of natural information and genetic selection, has been able to generate life. We will argue that the implications of this model, as applied to our half-hearted and inappropriate responses to today's metacrisis, include the potential extinction of humanity.

WHAT IS EVOLUTION AND HOW DID LIFE GET HERE?

What is evolution? Bringing together physical and biological processes, we will define evolution here as those processes that over time have generated the increase in maximal complexity and diversity of natural systems in the universe (see Figure 1).

Evolution in this sense does not necessarily involve genes, important as these are among living organisms, but can operate on whatever is available at any given time and place. That includes subatomic particles and molecules, as will now be explained.

The question arises of how it is possible to generate system complexity in a universe that is overall expanding, cooling on average (Figure 1), and increasing its total entropy ('disorder'), according to the second law of thermodynamics.

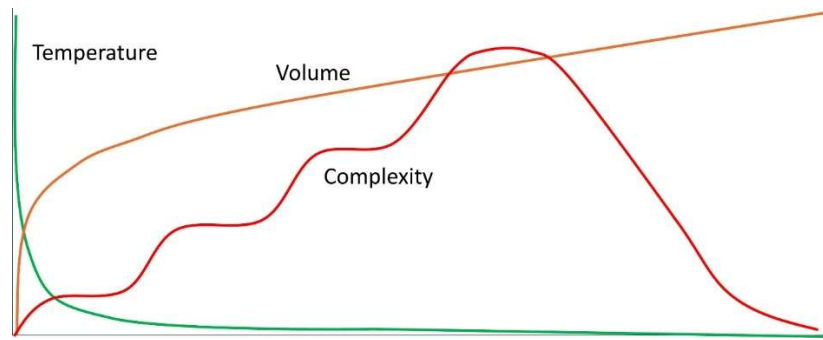


Figure 1. Complexity and the universe, over billions of years. Not to scale. Illustrating the broad trends of falling temperature and expansion of the universe after the Big Bang, while increasingly complex systems of matter evolved: for example, protons within seconds of the Big Bang and life on Earth 10 billion years later. More complexity appears (overall) over long times, with particular increases happening at particular phases of expansion and cooling, and later the appearance of life, although in the extremely distant future the continued cooling and expansion are predicted (under the currently most favoured model) to dissolve matter back to simple particles (NASA, 2025; Wikipedia, 2025b, 2025c).

We propose that universal evolution up to now, in the systems that led to life on earth, can be divided into three major stages that produced increasingly complex types of system. This model is distinct from that of Wong et al. (2023), who also classified three basic types of system but only according to their physical characteristics. It is distinct also from the models of Cronin and Walker (2016) and Walker (2024, 2025), who classified systems according to the minimum number of steps that would be required to construct them. Our three major types of system are defined according to the historical sequence of natural evolution, their nesting as subsystems of each other, generating the increasing complexity, and importantly the type of force or driver that generated and sustains them.

First type of system: Nuclei evolve

The physical increases in complexity in the early universe, following the Big Bang, are reasonably well understood (Felder, 2022; NASA, 2025; Wikipedia, 2025b). Here we summarize the proposed early changes that resulted in the first systems.

At the Big Bang it is thought that there was a vast quantity of energy in a virtually zero volume at a colossal temperature. Thermodynamics permits the conversion of one form of energy to another. The expansion of the early universe after the Big Bang, resulting in falling temperature, allowed conversion of energy to matter and forces, forces that then drove progressive increases in complexity (evolution) of material systems, as we now summarize.

Within the first picosecond after the Big Bang, the temperature had cooled from around 10^{32}C to around 10^{15}C . A rapid succession of changes, some still unclear, ended with the formation of quarks and the strong and weak nuclear forces that bound them together by self-assembly, to form the first and simplest systems, **protons and neutrons**. Then, within 20 min and with further cooling, protons and neutrons were combined further by the same forces to form atomic nuclei. Electrons and photons had appeared by this time, but under prevailing environmental conditions they remained separate from nuclei.

In short, our first-evolved type of systems were **nucleons and atomic nuclei**, which we define as **systems bonded by the strong and weak forces**.

Second type of system: Atoms and molecules evolve

It was not until about 370,000 years later, when the universe [still surprisingly uniform until then (Felder, 2022)] had expanded greatly and cooled to about 3,000K (~2,700C), that it changed from largely plasma to largely gas. That is, the electromagnetic force (carried by photons) was now able to bond electrons to nuclei to form atoms: mostly hydrogen and helium. With further time and cooling, atoms could combine into molecules, also bound by electromagnetism (Hazen, 2013). **Atoms and molecules** together are thus our second type of system, defined by the electromagnetic force that bonds them.

Over the next hundreds of millions of years and thereafter, the force of gravity became important, increasing the complexity of the environments within which atoms and molecules evolved, a process well described by Hazen (2013), with the first stars appearing at around 400 million years, followed by galaxies. Nuclear fusion in stars generated all the natural elements that we know today, with the formation of another generation of stars and yet more diverse combinations of material systems, including planets.

In summary, our second main type of system is defined as **systems bonded by electromagnetic forces**. In evolutionary history (the sequence that led to life on Earth), they incorporated type 1 systems (nucleons and nuclei).

Type 2 systems on Earth were clearly not living. We agree with others (for example Abel, 2025) that life is based on information and the manipulation of information, but (we add,) using primarily emergent properties of its component systems, where matter and energy interact. We will use the following definition of **information in general**, based on dictionary definitions:

What is perceived, conveyed or represented by a particular arrangement or sequence of things. Examples are a heard sound, a genetically encoded structure or a hormone molecule detected by its receptor. Information of a specific type will be a defining feature of our third type of system. In particular, we discuss how information can become selectable within evolution, and the consequences for complexity.

For clarity therefore, we first consider the idea of information in evolution. We propose that the following scenario could explain the relatively rapid increase in complexity and diversity that allowed the emergence of life.

Third type of system: Informational systems evolve

Selectable units and selectable information

Many kinds of information are used in living systems, in particular in interactions between a system at any level (macromolecule, organ, organism) and its environment. In the evolution of life, these interactions will involve emergent properties of the said systems, and are subject to natural selection. For example, the system might be an enzyme, and the properties those of interacting more or less well with other systems in its environment including a substrate(s). Or at a more complex level, the system might be a buck with antlers, so that the size and hardness of the antlers are emergent properties of the buck. Each of these emergent properties is subject to evolutionary selection through a range of interactions with other systems in the environment: with other male and female deer, with predators and with the energy expenditure to grow them.

Moreover, a vast number of further emergent properties arise from each of those diverse interactions between the system and its environment: in the case of the buck, the size of the deer population and the distributions of deer food plants and other competing plants, to name

just a few. All of these further interactions may be or may become subject to evolutionary selection.

It can be seen that a system, its emergent properties and diverse components of the environment all contribute to what gets selected by evolution. Thus, for type 3 systems (defined below), we can envisage a **unit of selectable information**, defined as a **Type 3 system within and as a component of its environment**.

The Type 3 system in question will be whatever type of system informational selection acts upon at a given time and place. In the prebiotic age, it would have been a prebiotic, information-bearing molecule, and/or a set of molecules. As more-complex systems gradually emerged, and eventually living cells with DNA, they (with their environment etc.) would also be units of selectable information. In the present, organisms, co-operating sets of organisms, and whole ecosystems (each with its environment etc.,) can all rate as such units.

The entire terrestrial biosystem (system of all ecosystems) also evolves, through variation and selection over time of its innumerable components. Thus, it too can be seen as a unit of selectable information, since no part is totally cut off and uninfluenced by the rest.

Type 3 systems evolve

To reiterate, our types 1 and 2 systems are defined by the physical forces that bond them. Their evolution has been through self-assembly into structures that are stable and thereby sustained within a given environment. Type 3 systems however are sustained not only by physical forces. **We define type 3 systems as systems that fall into classes or species (of macromolecules, organisms etc.) with varying emergent properties, and sustained through selectable information.** The basic unit of Type 3 (information-based) evolution is the system-environment complex and particularly its emergent properties, rather than the system alone, as explained above.

Living systems (cells, organisms, ecosystems etc) are Type 3 systems. The information to generate a living organism clearly could not have arisen all at once though, which is why our concept of type 3 systems is not restricted to life itself. There must have been non-living systems (molecules or sets of molecules) in prebiotic Earth that could carry such information and use it in some primeval way; these would also be Type 3 systems.

We know that some kinds of organic molecules (e.g. nucleotides, amino acids), can be organized into non-repetitive chains (nucleic acids and peptides/proteins) that can hold information and are widely used by current life-forms. In the pre-life era, there must have been a stage when such molecules developed diversity through random combinations, whereby (in one or more places on Earth), some of them both gained and somehow stored responsiveness to some kind of environmental cue(s) that was selective – beneficial to their continuation (Luisi, 2006; Wilson et al., 2008; Grisogono 2017). In other words, they both ‘read’ information and began to store selectable information that could be used for self-maintenance (perhaps through interaction with other complex molecules), and thus for further evolution. In a sense, such molecules were themselves selectable information. These molecules are often suggested to have been RNA (Higgs and Lehman, 2015; Attwater et al., 2025), and/or proteins (Guseva et al., 2017).

For these Type 3 systems, we argue that the unit of evolutionary selection was/is the system within its environment, including the emergent properties of that complex, as explained above. This can be placed in the context of a debate about “units of (natural) selection”, at least in biology. Dawkins (1976) proposed that rather than organisms, it was the individual gene upon which selection acts, adding (Dawkins, 1982, 2024) that this happens through “the extended phenotype” – effects of a gene not only on the phenotype (characteristics) of the organism

carrying it (like pigmentation) but also on the environment (like dam-building behaviour of beavers). G. Bateson (1972) similarly concluded that the smallest unit of inheritance must be the system inclusive of its environment. These authors did not address the preceding physical and chemical evolution, but others have done so (for example Wilson et al., 2008; Hazen, 2013; Cronin and Walker, 2016; Smith-Carpenter et al., 2017; Wong et al., 2023; Duran-Nebreda et al., 2024). As further context, Walker (2024, 2025) discusses the importance of information in explaining the emergence and enormous complexity and flexibility of living systems.

Returning to our proposed unit of selectable information, the emergence of this kind of unit potentially permits a vast increase in complexity and diversity of such systems, as well as an increase in the potential array of subtle, selectable variations in interactions between the environment and the system.

We began with the question of how enough complexity became available to give rise to life – how life evolved from the starting point of much simpler and less diverse type 2 systems? Part of the answer may be that in type 3 systems the complexity and diversity of the units of selection, and the selection of emergent properties of systems rather than their structural components, adds additional layers of complexity, a layer based primarily on function and information-flows rather than on material structure as in the first two types of systems.

There is also a difference in energy flows. In systems limited to types 1 and 2, the flows of energy are simply thermodynamic transitions (between potential energy, kinetic energy, light, heat etc). Within life however, and any prebiotic type 3 systems, energy can be converted also into information [it will always require energy to create information (Bérut et al., 2012)], and information can direct flows of chemical energy (for example in photosynthesis, muscle movement or biological growth and development), and the storage of energy and information.

With this new layer of complexity, evolution was able to interact with systems in a new way, with the unit of selection, the ‘package’ being selected, growing ever more complex. Starting from nuclei within atoms, through atoms in molecules and molecules in diverse aggregates and mixtures, molecular assemblies could eventually form and be selected, which had the capacity for autopoiesis (self-regeneration). That capacity is definitive of life (Varela et al., 1974), which we can now discuss.

WHAT IS LIFE?

Life is a quality of certain naturally evolved systems that has been surprisingly difficult to define, especially as it is not usually difficult to recognize living systems when we see them walking around or growing out of the ground. We know that the totality of life on Earth, which we call the biosystem (Lamoreux and Bennett, 2024), forms a gigantic hierarchy of systems and subsystems: ecosystems comprising organisms, which successively comprise organ systems, organs, tissues, cells, molecules, and their components (Capra and Luisi, 2014). Most would agree that no one molecule would be described as living, but that something that can metabolize and reproduce itself in a suitable environment can be called living, from bacteria to trees. Life as a whole can also recycle its natural components without creating pollution, sustaining its own habitable environment.

A key aspect is that no individual organism can metabolize and reproduce in isolation. These functions require a suitable environment, typically an ecosystem with its many types of interacting component organisms as subsystems, and its physical environment. Every living system depends both upon its history (its chain of creation or genealogy in time) and ultimately

upon the evolved, balanced, interactive complexity of millions (or more) of information-rich systems. The biosystem of Earth is the system of all ecosystems, and it sustains itself using selectable information. Smith-Carpenter et al. (2017) stated that 'Life has been defined as information flowing in molecular streams and cycles (Dawkins, 1996)'. It may be more accurate, usually, to think of life as selectable information flowing in autopoietic cycles.

So can a living system be defined as something that can metabolize and that belongs to a species that can reproduce? Possibly, and we could identify other specific features of current terrestrial life (replicates through nucleic acid, can make proteins, ribosomes and phospholipid membranes, etc). However, it may be more robust, fundamental and general (potentially applicable to extraterrestrial life) to define a living system as follows: **a Type 3 system that can replicate and maintain itself accurately and sustainably in a suitable environment.** Reflecting the above comment by Smith-Carpenter and Dawkins, we can note that these functions use streams and cycles of information. Streams of information are found for example in gene transcription, in sensory perception, neural transmission and in inheritance. Biological cycles that all depend on and/or propagate information include biochemical cycles, cell cycles, life cycles and annual cycles.

A similar concept was expressed as far back as the Axial Age (some centuries BCE), when it was referred to as Indra's Web (Science and Nonduality, 2025). We have put it into the context of today's science.

These streams and cycles include the temporal flow (evolution) of selectable information: primarily the genetic information stored in nucleic acids, but also the rich information carried in many other types of organelles, molecules and molecular cycles within cells and their components. Most organelles cannot be grown or generated without themselves as a template. The chromosomes alone cannot generate a new cell; only an entire cell can do that.

Each living system perpetuates itself in its environment using information. The exact set of properties generated by the genes of an organism is called its phenotype: colour, size, shape etc. Biological evolution itself can be pictured as a flow of information through changing phenotypes over time. So long as these flows of information are not interrupted, life will continue to cycle and evolve. If such a flow is interrupted however, life ends, whether in a subsystem, species, ecosystem or in the whole. Extinct life cannot resuscitate itself.

SUMMARY OF THE HYPOTHESIS

We can envisage evolution towards life on Earth as a unified process, with common features across physical, chemical and biological evolution. This process has overall generated systems with increasing levels of complexity and diversity over time since the Big Bang: levels eventually high enough for the appearance of living systems. This increase in organization has depended on energy flows that were initially (in the early universe) automatic thermodynamic transitions in response to the environment, but later (on Earth) included flows of incoming solar and terrestrial energy. Among type 3 systems, this energy became directed through manipulation and transmission of selectable information, to support the generation and sustenance of autopoietic living systems. Overall, evolution can be seen as arising from random molecular processes [from physical self-assembly to the random genetic/molecular variations and saltatory leaps (Margulis, 1998) upon which informational selection acts]. Its overall trend towards increasing complexity and diversity counters the tendency of individual systems towards persistence.

IMPLICATIONS

The above view of evolution is consistent with current scientific understanding of biological evolution, but differs from a popular misunderstanding of Darwin's description of 'survival of the fittest'. Darwin proposed that individuals best **fitted to their environment** would produce the most progeny that survive to reproduce, so that their characteristics would be selected to accumulate in subsequent generations (Darwin, 1859). However, importantly, there is a widespread misconception that instead he meant selection of the strongest or most aggressive individuals. This error has surely helped to foster human esteem for aggressive competition, with corporate success measured in terms of growth (apparently forever) and domination. This growth drive includes growth of many kinds (Rees, 2022; Hagens 2024b), notably in GDP (gross domestic product). That means growing consumption and production per nation. This approach has been profitable for a period, but ultimately implies infinite growth of the corposystem and consequently the human population, obviously impossible on a finite planet. As mentioned (Introduction), many have argued that the current human overshoot is the prime cause of climate change, political distress, famines, droughts, land wars – most elements of the metacrisis.

The biosystem sustains life and is life. It depends on an optimal equilibrium among its systems at every level, using colossal amounts of information. The corposystem is both dependent on and in competition with the biosystem, for energy, materials and food (Lamoreux and Bennett, 2024). Our technologies will never match the extraordinary efficiency (West, 2018) of the biosystem in sustaining us and the rest of life by creation of food and oxygen and removal of waste products, besides providing pleasant and refreshing environments. We have tragically failed to foresee the side-effects of eliminating huge numbers of other species and habitats, breaking up the evolved units of selection to replace them with human artefacts and technologies like habitation, roads, farms, monoculture plantations and polluting industries. Some technologies alleviate the situation, but technology cannot replace the selectable information of the biosystem, nor generate a 'circular economy' independent of the biosystem (Stephan, 2022). Without urgent action, the ongoing infinite-growth goal is increasingly likely to precipitate the collapse of the corposystem itself, by destroying or fragmenting its highly evolved selectable units.

The more luxurious the average lifestyle (consumption level), the fewer humans can be supported sustainably (Wikipedia 2025a, Global Footprint Network, 2025). Total consumption by a population is of course the product of average consumption and population size. We know that current total consumption by humanity exceeds what the biosystem can regenerate, currently by a large excess estimated at 75% per year (Global Footprint Network, 2025). Humans are overgrazing, progressively increasing our resource debt to the biosystem. We have used technologies to override key limiting factors (predators, weather, disease, starvation, etc), making life better and longer for some, but now resulting in this overshoot.

It will be important for high-consuming humans to learn to reduce their consumption. However, that will never be sufficient to overcome the ecological overshoot without (voluntary) reduction in the numbers of humans born. Population needs to stop rising and may well fall even without our help, perhaps rapidly, depending how much further we deplete planetary resources and disrupt the biosystem. After population growth stops, for GDP to go on rising, production and consumption **per person** would need to rise forever (obviously impossible). Thus, shocking as it may sound to some, economic growth itself must and will come to an end. Over time, human populations and economies will need to be realigned with what the biosystem and its evolutionary processes can sustain.

We have seen this human lack of response to the issue of overpopulation for decades. Because humanity has failed to agree on a global plan; because of the corposystem growth drive, and sometimes for religious reasons, a multitude of excuses circulate for not using the most obvious and feasible plan: to make fewer babies. In a number of industrialized countries, birthrate is already below the replacement level and some governments are seeing this as worrying (Peeples, 2025). This only shows how much of a change in outlook is needed, to escape and survive the metacrisis. It is admirable and desirable to improve human life and defer human death, but now we need to move quickly towards achieving sustainable planetary human population and consumption levels, using birth control and information. To help motivate this change and inform our response (Barashi, 2025), it would be invaluable for citizens, politicians, financiers, and corporate leaders learn that what works in evolution is equilibrium, with informational interaction and balance between systems, not aggressive growth.

The unfolding metacrisis is not exceptional in evolution (Benton, 2023). The vast majority of species that ever existed became extinct, sometimes by changing their environment so that they could not survive in it. Is humanity going the same way?

CONCLUSION

Our human species is now in deep overshoot debt to the biosystem. Redistributing this debt will not resolve it. The proposal of Wilson (2016) to reduce human occupation to half the Earth and leave the rest for the biosystem's diversity to recover would contribute massively, although requiring a sadly improbable level of global political cooperation and upheaval of populations. Still, somehow we need to reduce our total consumption to the point where the biosystem can restore itself, preventing the threatened extinction of *Homo sapiens* while if possible allowing future humans a reasonably comfortable lifestyle. Technological solutions to separate parts of a metacrisis known to be caused by overpopulation may help, but will not be enough: not without a lower population.

ACKNOWLEDGEMENTS

Thanks and appreciation to Upaya and Adam Frank for making available the Varela Symposium and relevant information; to Steven E Salmony, Russelyn Connor and Jessie Henshaw for referring us to further sources, and to John Feldman and all others who provided valuable comments on this manuscript. We are also grateful for the shared resources and generous feedback of the International Society for the Systems Sciences and its former president Gary Smith.

REFERENCES

- Abel, D.L. 2025. 'Assembly Theory' in life-origin models: A critical review.' *BioSystems* **247**: 105378. <https://doi.org/10.1016/j.biosystems.2024.105378>
- Attwater, J., T.L. Augustin, J.F. Curran, S.L.Y. Kwok, L. Ohlendorf, E. Gianni and P. Holliger. 2025. 'Trinucleotide substrates under pH-freeze-thaw cycles enable open-ended exponential RNA replication by a polymerase ribozyme'. *Nature Chemistry* **17** (7): 1129–1137. <https://doi.org/10.1038/s41557-025-01830-y>
- Barashi, D.P. 2025. '10 Misconceptions about Evolution'. *Nautilus* magazine, **January 21**. <https://nautil.us/10-misconceptions-about-evolution-1183733/>
- Bateson, G. 1972. *Steps to an Ecology of Mind* (Parts IV and V). Chicago: University of Chicago Press.

- Benton, M. J. 2023. *Extinctions: how life survives, adapts & evolves*. Thames & Hudson.
- Bérut, A., A. Arakelyan, A. Petrosyan, S. Ciliberto, R. Dillenschneider and E. Lutz. 2012. Experimental verification of Landauer's principle linking information and thermodynamics. *Nature* **483** (7388): 187-9. <https://doi.org/10.1038/nature10872>
- Capra, F. and P.L. Luisi. 2014. *The Systems View of Life: A Unifying Vision*. Cambridge: Cambridge University Press.
- Catton, W.R. 1980. *Overshoot: The Ecological Basis of Revolutionary Change*. Champaign, IL: University of Illinois Press.
- Cronin, L. and S.I. Walker. 2016. 'Beyond prebiotic chemistry'. *Science* **352** (6290): 1174-1175. <https://www.science.org/doi/10.1126/science.aaf6310>
- Darwin, C. 1859. *On the Origin of Species*. First edition, John Murray. Republished by Penguin Books Ltd. (Harmondsworth), 1972.
- Dawkins R. 1976. *The Selfish Gene*. Oxford: Oxford University Press.
- Dawkins, R. 1982. *The Extended Phenotype*. Oxford: Oxford University Press.
- Dawkins, R. 1996. *River Out of Eden; a Darwinian view of life*. NY: Basic Books.
- Dawkins R. 2024. *The Genetic Book of the Dead. A Darwinian Reverie*. New Haven, CT: Yale University Press.
- Dobzhansky, T. 1973. 'Nothing in Biology Makes Sense Except in the Light of Evolution'. *The American Biology Teacher* **35**: 125-129. Presented at the 1972 NABT convention.
- Duran-Nebreda, S., R.A. Bentley, B. Vidiela, A. Spiridonov, N. Eldredge, M.J. O'Brien and S. Valverde. 2024. 'On the multiscale dynamics of punctuated evolution'. *Trends in Ecology and Evolution* **39** (8): 734-744. <https://doi.org/10.1016/j.tree.2024.05.003>
- Felder, G. 2022. *The Big Bang and Beyond: Exploring the Early Universe*. Video. Smith College, Northampton, MA: The Teaching Company. #10080. <https://scholarworks.smith.edu/celebratingfacultyscholarship2021pubs/6>
- Global Footprint Network. 2025. <https://www.footprintnetwork.org/> (accessed 31 August 2025).
- Grisogono, A.-M. 2017. 'How Did Information Emerge?' In Walker, S.I., P.C.W. Davies and G.F.R. Ellis (eds.), *From Matter to Life: Information and Causality*, pp. 64-96. Cambridge: Cambridge University Press.
- Guseva, E., R.N. Zuckermann and K.A. Dill. 2017. 'Foldamer hypothesis for the growth and sequence differentiation of prebiotic polymers'. *Proceedings of the National Academy of Sciences of the United States of America* **114** (36): E7460-E7468. <https://doi.org/10.1073/pnas.1620179114>
- Hagens, N. 2024a. 'The many -isms of the Metacrisis' with Michael Every (Video). *The Great Simplification* #118. https://www.youtube.com/watch?v=F_DhZaVoflA
- Hagens, N. 2024b. 'Exceeding Earth's Safe Limits' with Johan Rockström (Video). *The Great Simplification* #134. <https://youtu.be/JaboF3vAsZs?si=h0HJhQh1fbWpMmmZ>
- Hagens, N. 2025. 'Key Blindspots of the "Walrus" Movement' (Video). *Frankly* #105. <https://www.youtube.com/watch?v=eJRfnSrY0ok> (accessed 22 August 2025).
- Hazen, R. 2013. 'The Origin and Evolution of Earth: From the Big Bang to the Future of Human Existence'. *The Great Courses* **1740**. [The Origin and Evolution of Earth: From the Big Bang to the Future of Human Existence](https://www.greatcourses.com/courses/the-origin-and-evolution-of-earth-from-the-big-bang-to-the-future-of-human-existence)

- Higgs, P.G. and N. Lehman. 2015. 'The RNA World: molecular cooperation at the origins of life'. *Nature Reviews Genetics* **16** (1):7-17. <https://doi.org/10.1038/nrg3841>
- Hodgson A. 'What is the Metacrisis?' *The New Enlightenment with Ashley*. 2025. <https://youtu.be/kgCHqyq4LHA?si=d7QBLcd78kqBJLdO> (accessed 23 August 2025).
- Lamoreux, M.L. and D.C. Bennett. 2024. 'Scientists' Warning on the Problem with Overpopulation and Living Systems'. *The Journal of Population and Sustainability* **8** (1):95-111. <https://doi.org/10.3197/JPS.63799953906873>
- Luisi, P.L. 2006. *The Emergence of Life; from chemical origins to synthetic biology*. Cambridge: Cambridge University Press.
- Margulis, L. 1998. *Symbiotic Planet*. New York: Basic Books.
- NASA. *Early Universe*. <https://science.nasa.gov/mission/webb/early-universe/> (accessed 23 August 2025).
- Peebles, L. 2025. 'People are having fewer babies: Is it really the end of the world?' *Nature* **644** (8077): 594-596. <https://doi.org/10.1038/d41586-025-02615-6>
- Pross, A. 2011. 'Toward a general theory of evolution: Extending Darwinian theory to inanimate matter'. *Journal of Systems Chemistry* **2**:1 <https://doi.org/10.1186/1759-2208-2-1>
- Rees, W.E. 2022. *The Green Interview. Measuring our Ecological Footprint*. Video. <https://youtu.be/sQIYOuelWX4?si=VbDocIEg4CBV9jL2>
- Rees, W.E. 2024. Ecological Overshoot Speaker Series Part 1. <https://www.youtube.com/watch?v=DVp5YvMemal> (accessed 22 August 2025).
- Rees, W.E. 2025. *Modern Humans: Unsustainable by Nature and Nurture*. University of Technology and Management, Poland. <https://www.youtube.com/live/wjrrww5alz4>.
- Science and Nonduality (SAND). *Indra's Net*. <https://scienceandnonduality.com/article/the-indras-net/> (accessed 23 August 2025).
- Smith-Carpenter, J.E., S. Li, J.T. Goodwin, A.K. Mehta and D.G. Lynn. 2017. 'On the Emerging Codes for Chemical Evolution'. In Walker, S.I., P.C.W. Davies, and G.F.R. Ellis (eds). *From Matter to Life*, pp 97-113.
- Stephan, G. 2022. Circular Economy: Illusion or first step towards a sustainable economy: A physico-economic perspective. *Sustainability* **14**:4778-4792. <https://doi.org/10.3390/su14084778>
- Suzuki, D. 2003. 'David Suzuki Reader'. Vancouver: Greystone Books. Pp 70-74, 344-350 and others.
- Varela, F.G., H.R. Maturana and R. Uribe. 1974. 'Autopoiesis: The organization of living systems, Its Characterization and a Model'. *Biosystems* **5**:187-196
- Wackernagel, M., N.B. Schulz, D. Deumling, A.C. Laires, M. Jenkins, V. Kapos, C. Monfreda, J. Loh, N. Myers, R. Norgaard and J. Randers. 2002. 'Tracking the ecological overshoot of the human economy'. *Proceedings of the National Academy of Sciences of the United States of America* **99**: 9266-9271. <https://doi.org/10.1073/pnas.142033699>
- Walker, S.I. 2024. *Life as No One Knows It: The Physics of Life's Emergence*. NY: Riverhead Books.
- Walker, S.I. 2025. 'An Informational Theory of Life'. The Long Now Foundation. <https://www.youtube.com/live/I0YHLR3GhqE?si=12T9o78EzSQo-h6Y>,
- West, G. 2018. *Scale*. London: Penguin Books.
- Wikipedia. 2025a. *Carrying capacity*. https://en.wikipedia.org/wiki/Carrying_capacity (accessed 23 August 2025).

Wikipedia. 2025b. *Chronology of the universe*.

https://en.wikipedia.org/wiki/Chronology_of_the_universe (accessed 28 August 2025).

Wikipedia. 2025c. *Ultimate fate of the universe*.

https://en.wikipedia.org/wiki/Ultimate_fate_of_the_universe (accessed 23 August 2025).

Wilson, D.S., M. van Vugt and R. O’Gorman. 2008. ‘Multilevel Selection Theory and Major Evolutionary Transitions: Implications for Psychological Science’. *Current Directions in Psychological Science* **17** (1), 6–9. <https://doi.org/10.1111/j.1467-8721.2008.00538.x>

Wilson, E.O. 2016. *Half Earth*. NY: Liveright Publishing.

Wong, M.L., C.E Cleland, D. Arend Jr., S. Bartlett, H.J. Cleaves, H. Demarest, A. Prabhu, J.I. Lunine and R.M. Hazen. 2023. ‘On the roles of function and selection in evolving systems’. *Proceedings of the National Academy of Sciences of the United States of America* **120** (43): e2310223120.

<https://doi.org/10.1073/pnas.2310223120>