On Ecological Ethics

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Abstract The topic of this chapter is how Ethics and Earth Ecology relate to each other. Given the dynamics of the Earth's ecological system, ethics takes the meaning of an emergent layer of quality control on human's actions in the organic global Earth environment. Fittingly, the paper starts out with a brief account of how System Dynamics characterizes the behavior of complex large-scale systems and how the characterization applies to the Earth's biosphere. *Chaos* and subsequent *emergence* play a central role in this characterization. They provide the scene on which human behavior has to evolve, using, in particular, intelligence as the ability to imagine, estimate, plan, influence, and to some extent control the Earth's development. The human interaction with the Earth's ecological system obviously needs direction toward insuring sustainability of its actions, and preferably even generating a high global quality (QoL) of the symbiosis of humans with their environment. The paper, therefore, develops a theory of ecological ethics based on insights from medical ethics and the striving toward achieving individual human health. This approach leads to the identification of classes of "diseases of ethics" and their incidence on Earth's global health. It motivates the unequivocal choice for a new type of humanism extended to the Earth's global ecology, as the basis for this "emerging" ethics. The paper then ends with applying these ideas specifically to the future organization of economics in a healthy, sustainable way, and the discussion of potential measures to achieve this.

Keywords Ethics · Ecology · Emergence · System dynamics · Quality of life · Health

1 Introduction

In the Iliad, Homeros shows how wrath and vengeance leads to the destruction not only of enemies, but of the protagonists themselves, in this case Achilles and

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Agamemnon. Wrath benefits nobody, nor does vengeance create justice: they mainly destroy people and their values. Homeros makes thereby a strong case of political ethics, some 900 years BC. According to Socrates, ethics is *the formulation of an answer to the question "what is a good life?", where "good" is to be understood in the ancient Greek sense as "true to nature"* [21]. In our last and present centuries, we are faced with the very pertinent question of "what would be a *good* Anthropocene?", or more precisely, "what does it mean for humanity to behave in a *good way* with respect to their habitat, the Earth?". An answer to this question hinges on the meaning given to the word "good" in the global context of the Earth's system *including humanity and its actions*. This will be the goal of the present chapter: the development of what may be called ecological ethics. At a first glance, it might seem difficult to approach the ill-defined and abstract term "good" in a systematic way, but that is precisely the task ethics is facing, necessarily based on present-day understanding of the dynamics underlying the evolution of our Earth's system, and the role "goodness" plays as a common term in societal, medical, and engineering practice. Any sensible ecological ethics has to recognize that the Earth and its biosphere (including humans) form one highly integrated organism in need of continuously fostered health [19]. Effective health of an organism requires at least sustainability, but needs the fostering of a high *Quality of Live (QoL)* in addition. This is as in medicine: it is not enough to keep the patient alive! If we, humans, want to give meaning to Aocrates' call for "goodness," QoL is what we have to aim at. This endeavor leads to a pretty precise theory of ecological ethics, very much applicable to the present situation, and in particular to attractive new forms of economic practice that foster ecological health by sustainability and QoL.

2 System Dynamics

The place to start is an up-to-date understanding of system dynamics as it applies to a large ecological system like Earth's biosphere. The ecological system of our Earth shows some pertinent global characteristics: it is extremely complex, with an almost infinite number of state variables, and billions of different types of interactions between them—so it would seem impossible of ever describing it in a comprehensive way! Nonetheless, and of course given the limits of human understanding, system Earth has recognizable and important global behavioral characteristics. *Behavior* is: how the system's evolution appears to outside observers, making abstraction from its detailed internal laws.[1] In this paper, I highlight in some detail two of the main

[1] The "behavioral" point of view is typically the level at which understanding can be achieved between a lay person, who only knows about appearances, and a specialist, who knows about internals. For example, the depletion of the ozone layer has produced effects that can be experienced by

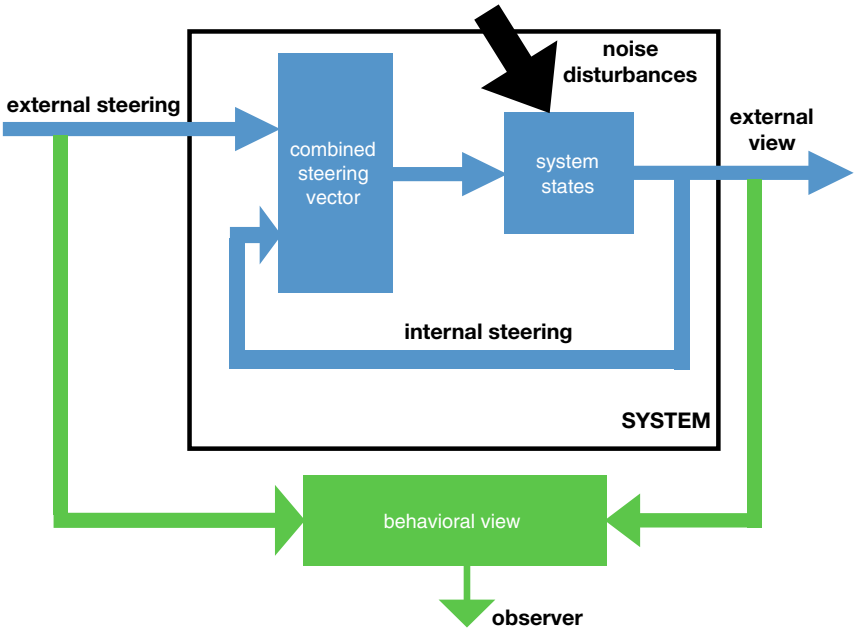

Fig. 1 Schematic model of a dynamical system. The heart of the system are the state variables, which evolve dynamically, steered by a variety of influences, both external and internal (in the Newtonian model, the steering consists of forces that influence the derivatives of the quantities characterizing the state). The *behavioral view* observes both the states and the external influences and deduces from it its (necessarily colored) view on the system. The arrows in the diagram indicate information flow: from information source to user. An ecological model of the earth will have a great variety of types of states: positions, velocities, pressures, temperatures, chemical concentrations, etc...

properties of (non-linear) large-scale dynamic systems in general and our global Earth system in particular: *chaos* and *emergence*. It is important to understand what these notions mean precisely and how they affect the system's dynamics. We shall see that the two are intimately related like opposite sites of the same coin.

The first characteristic of large-scale, non-linear, and highly distributed systems like most biological and natural systems is the incidence of *chaos* and *emergence* [16]. By definition, *chaos is extreme sensitivity to "initial" conditions, i.e., to the*

anybody, while the mechanisms involved require specialized knowledge of chemistry. The potential lack of understanding between lay observers and scientists is a major obstacle to sensible ecological policies. It can only be bridged by what I call *semantic alignment*, i.e., agreeing on how effects can be understood from their outside appearance, without knowledge of the underlying mechanisms.

state of the system existing at the moment when one starts observing (see explanation in Fig. 1).

High sensitivity means: given the state at some specific time, the further evolution from that state on is potentially very different from what it would be when started from a slightly different state (for example, most people living in Europe nowadays are genetically connected to Charles the Great, and would not exist if Pepin the Short had not met Bertrada of Laon—and the same can be said of many other couples living at that time). This effect, ubiquitous in large non-linear systems, has been inaccurately characterized as the "butterfly effect."[2] There are a number of mechanisms that produce chaos. Let me just mention "arrival times" (many evolutions are dependent on some events happening more or less at the same time and same place, e.g., your parents having accidentally met somewhere, or some signals coinciding in your brain at the site of a specific neuron), and "bifurcations" due to "saddle points" (as is the famous symmetry breaking in fundamental physics or the propagation of neural signals, also a ubiquitous phenomenon in biology).

Reasons for chaos to occur systematically are manifold: non-linearities, in particular, saturation effects, combined with instability forced by fluctuations, near simultaneities of influences between autonomous agents (e.g., cells in the brain, humans meeting each other, cells acting on each other), and the ubiquitous occurrence of noise in any system, due to many unrelated events influencing each other in tiny ways. Already ubiquitous noise will insure that no state in the system is precisely defined, and close-by states will lead to very different evolutions thanks to high sensitivity. A large-scale highly distributed system, like the Earth's ecology, the mammal brain, or human society, cannot be described by classical dynamics based on just a few state variables and a stable predictable environment.

As a consequence and given some state the world[3] is in, it appears that billions of billions different new worlds can potentially arise at any moment, while only one becomes our actual world, although those billion++ others are all equally likely. Chaos allows all free dimensions (and there are billions++ of them) to exercise their freedom at any given moment and steer the system in unpredictable directions. It also means that causality completely evaporates: there is no such thing as the "necessary

[2] A butterfly beats its wings somewhere on a Pacific Island, producing a cyclone a couple of months later. It may be true that if that butterfly had not beaten its wings, the cyclone would not have arisen in the same way, but the same can be said from an almost infinite number of possible parallel "causes" (like other butterflies). The cyclone can be influenced by myriad "causes" like wind directions, clouds, temperature differences, etc.

[3] In system theory, a *world* is defined as the global object of study. In our case, it is the Earth as a global ecological system. However, due to the intrinsic limitations of the possibility of analysis, the whole Earth cannot remotely be captured in its full complexity. Every study will be limited to a schematic view on it, based on a limited number of assumptions and focusing only on certain, mostly "emergent" aspects.

causality" of classical (or even modern) philosophy.[4] The world gets recreated at every moment in one of myriad possible directions thanks to ubiquitous chaos.

Where then does the apparent stability of the world come from (apparent because we survive in it, at least temporarily)? The explanation may seem counter-intuitive, but there is an equally ubiquitous complementary phenomenon responsible for the perceived stability, intrinsic in chaotic systems, namely, what is called *emergence* or *emergent behavior*—a terminology that, although quite common, may be criticized, and therefore requires careful definition. *Emergence* is defined as *properties or laws of the system that are not derivable from its structural dynamics, but exercise a controlling influence on its global evolution*.[5]

Although emergence is the normal mode of world's functioning, the notion seems difficult to understand, because we are used to take for determining what we discover as "basic laws" of physics, chemistry, biology, or economics. Those are what we believe define "reality." The fundamental flaw of our reasoning is: it is not because "reality" (only accessible through what we are able to observe) behaves according to a law we constructed that the laws we are able to discover define nature's total reality. The "laws we construct" only produce models for the specific situations, properties, and variables we are able to experience consistently. Most of our observations involve either very detailed, localized, and microscopic effects, or a limited number of emergent and stable globalized quantities. Most happenings in nature could never have been predicted with any precision (such as the arising of a specific novel species).

Emergence is best approached and understood via examples and description of effects. I mention three important and related ones:

– Darwin's "natural selection": *natural selection of a species happens due to adaptivity to external circumstances*. Natural selection has been dubiously characterized as "survival of the fittest," better would be to call it "survival of the best adapted to its environment", although this last formulation also has its weakness, since the organism in question adaptively changes that environment as well, sometimes dramatically—so a better expression would be "the most resilient." Species originate in a chaotic fashion, their survival is characterized by their adaptivity to

[4] It is remarkable that many modern scientists and philosophers believe in generalized causality and evolution being deterministic because basic physical laws appear deterministic. This turns out to be a serious systemic—and scientific—error: these natural laws are deterministic only if infinite precision in space and time were possible. It also amounts to a logical mistake: it is not because causality can be observed in a number of cases that all dynamic evolution is necessarily causal.

[5] Perhaps not on the detailed local evolution of its constituents, which can often not even be assessed. For example, in a kettle of boiling water the tracks of individual molecules of water appear fully random, although one knows that after a while every molecule has disappeared in the atmosphere. Similarly with the fate of individual atoms or molecules in a human body, although the constituency of specific organs will be pretty stable over a relatively large time.

circumstances independent of their creation mechanism and is hence emergent (as was very patently observed by Darwin in his *On the Origin of Species* [3]);
- in a totally different direction: *semantics* or the ability to attach "meaning" to phenomena, e.g., a meaning to a sound (and this in many layers of understanding): *sounds, words, sentences, and formulas do not contain meaning by themselves*. The act of giving meaning is emergent with respect to the physical means used. The human ability to use natural phenomena for its own purposes leads to "ideological control" on the environment and is hence fully emergent with respect to it. For example, the way we use animals for our own benefit has nothing to do with the natural evolution of these species. However, this type of semantic emergence is not limited to humans and is effectively used by any system that possesses sensors and is capable to interpret the result by actuating self-serving control on its environment. The faculty of sensing and controlling can be found even in very primitive organisms, which over paleontological times succeeded in reorganizing the biosphere, testimony of which is the large geological layers of bio-generated material (e.g., limestone or carbon layers);
- most control on the evolution of a dynamical system is due to an *outside*, interpreting agent. The brain (human or the brain of other mammals) constructs models of what it considers "reality" and then uses these conceptual models to make predictions, devise strategies, etc. to control its environment for what it perceives as benefit. All this control is, of course, emergent and requires an external, analyzing agent capable of actuating its conclusions and decisions (often via proxies, see further for this).

Once understood, emergence is seen to be ubiquitous and an essential ingredient of nature, if not the most important driving force of the dynamic evolution of the biosphere of system Earth. However, to be effective, any emergent agent needs structural steering methods of its own, and hence becomes a dynamic system in its own right, in which novel, again emergent, laws appear that steer its own dynamic evolution. For example, the evolution of a bacterium is determined by certain interactions with its environment: how it feeds itself, how it keeps its homeostasis, how it reproduces, etc. These laws will most likely produce chaos in turn, which provokes emergent control at a next level, like triggering a latent defense mechanism in the affected organ—effectively generating second, third, and further orders of emergence with respect to the original (see Fig. 2). And the hierarchy of emergence will tend to produce ever higher levels of control, as is testified by the cultural history of humanity.

The global occurrence of emergence has enormous consequences for the overall dynamics of what turns out to be a multilayered system of emergences like our Earth's biosphere. Each emergent layer has its own type of states and develops its own dynamics according to whatever possibilities it has, thereby using what lower layers, which they perceive as their "environment," offer. In turn, each layer is being controlled by "higher" layers that use or misuse the possibilities of the lower

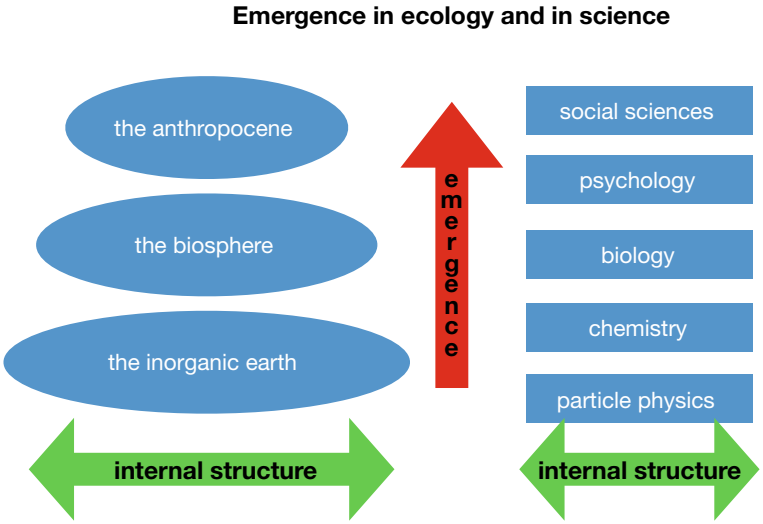

Fig. 2 Two relevant examples of emergence: in earth's ecology and in science. Each of these emergent layers can be decomposed further in sub-layers with their own internal structure and emergent connections. Emergence produces a semantic relationship between the layers, whereby effects of one layer are interpreted by a layer that uses the effect for its own benefit. E.g., humans use sound to communicate ideas

layer. Ecology describes how emergent layers compromise with each other to the benefit of their joint system. A *symbiosis* is necessary for the ultimate survival of the participating species. Ecology happens in a natural way by trial-and-error and natural selection, but can also be steered by intelligence, as explained further. Species that arise, thanks to their ability to organize their life in their direct environment, may disappear when their adaptation starts failing in a larger context. Reasons for this may be depletion of resources, overwhelming or competition by other species, climate change, destructive habits of the very species concerned, poisons, what have you.

The ability of a species to keep adapting to changing environments has been called *resilience* [18]. This notion is akin to the very notion of existence, as "existence as a species" is contingent on the ability to maintain the emergent characteristics of that species. In the case of the general Earth's ecology, the issue would be the continued existence of the human species in the Earth's environment, even though that very species is destroying many of its most vital, life-supporting features.

A dramatic mechanism of creation of an emergent realm is called a *tipping point*. A tipping point [6] occurs when an original small fluctuation gets massively amplified quickly.[6] The tipping point creates an emergence when it succeeds in establishing

[6] Fast relative to the underlying processes.

a novel phenomenon as a recurrent feature, so that, almost all of a sudden, a new order appears out of the blue. Very often, the emergence is due to *reproduction*, i.e., to the ability of the phenomenon to generate copies of itself exponentially, as happens in cell division, in meiosis, or through the propagation of memes, i.e., pieces of information that are understood and communicated further. Due to its almost unlimited reproducibility, the novel phenomenon forces a reorganization of that portion of nature in which it is active, because all the individual "copies" it produces act as a new type of agent interacting with each other and their environment in novel ways. The link with semantics and control should be clear: the tipping point forces a dramatic, unexpected but also recognizable structural change. This kind of emergence is responsible for most of what we are able to recognize as identifiable structure in our biological and even physical world.[7]

Much of living beings (humans, trees) originate out of a tipping point when male gametes meet female gametes (this is one level of emergence), but the way this emergence is established is specific for each species and determines the characteristics of the species (a next level of emergence), etc. It is not hard to understand tipping points when you discover a family of bed bugs under your mattress (and the chaos that produced it)!

Tipping points and emergence perpetually create new worlds, new "universes" with a new order utilizing the existing structures. The new emergent world that so arises is, in turn, subject to chaotic developments itself (unless the phenomenon destroys itself exponentially, what also happens, and the species disappears). In traditional reasoning, the emergence and further development of the new world it creates have been modeled by cyclic processes, like the Schumpeter model [15], with a "fore loop" of growth and consolidation (r-Phase and K-Phase) and a "back loop" of disintegration and reorganization (Ω-phase and α-phase), but cyclic models represent only one level of emergence, while the crux of the game is the evolution from one unpredictable emergence to the next.

While fast growth and final disintegration is to be found in many emergent processes, the Schumpeter model is just too simple to be generally valid and it does not render the ecological situation well, except in specific cases where only a few parameters appear relevant. Proponents of the Schumpeter model claim that in most cases only a few parameters dominate and are therefore relevant [18]. What is actually true is the opposite: the Schumpeter model only applies in low-dimensional cases, and does not apply when the condition on a limited number of relevant parameters is not satisfied. In complex systems, the Schumpeter condition is rarely if ever satisfied. What will derail an emergent phenomenon will likely be another emergent

[7] The relation between chaos and emergence may be difficult to understand, but the notions are two sides of the same coin. An organism will only then be relatively successful if (1) it reproduces exponentially (a chaotic effect), but, on the other hand, (2) it reproduces itself as an ordered organism (otherwise it would not be recognizable: an emergent effect).

phenomenon. Every so-called "equilibrium" or homeostasis will eventually slide into the abyss of unforeseen dimensions.[8] The Schumpeter model can be improved by considering the simultaneity of many cycles that encroach on one another, often with very different time scales. Such co-existing cycles can destroy one another in many different ways, by disintegration, merging, splitting, re-grouping, etc. The history of world politics can serve as a good example, but the origin of species and their evolution is perhaps a better one: species do not move in cycles, either they succeed in preserving their identity by continuously adapting and keeping in balance with their environment (i.e., by resilience) or they appear unable to sustain their needs in that permanently changing environment, where the change is often due to their own behavior. In the latter case, they disappear, mostly by relinquishing their assets to other, more resilient species, which, in turn, may be threatened by ill-adaptation.

Chaos makes creation possible, emergence in its many aspects turns creation into "existence"—that is: what can be observed, because of recurrence and consistency. This, however, is in turn a highly chaotic process, which is itself subject to continuous dynamic evolution. There is no general predictive causality in global evolutionary processes. A priori or predictive causality is a limited phenomenon restricted to specific circumstances and with a relatively narrow time horizon. However, the recognition of evident structure in the world allows for *a posteriori causality*. A posteriori causality is not forward predictive but backward deductive. It explains events by finding conditions that must be satisfied for the tipping point to happen, leaving the actual happening to chance.[9] For example, a woman meeting a man may or may not produce a child, but a child is the result of a woman meeting a man (in some way, perhaps via IVF).

An emergent system needs control on its environment to keep existing and hence power. From our present insights, we know of two main types of control: immediate or natural control (like natural selection or like most instinctive control in the various organs of our body), and intelligent control, which is "model based" thanks to the models our intelligence is able to construct for what it sees as existence, reality, or nature. Intelligent control on a system typically uses *proxies* for control: it does not act directly but utilizes a borrowed power agent and deviates the action of that agent into a different direction forced by the emergent system, like a mahout using the power of an elephant to lift a trunk, or a car driver using a steering wheel to make a turn (in other words, an emergent layer uses power unwittingly provided by a lower layer). All power may lead to violence, i.e., excessive ill-directed force, in

[8] Often a "bowl model" is used to explain the evolution from one equilibrium to another, with a "tipping point" seen as the crossing of the boundary of the bowl. In one or two dimensions, this is an appealing model. It is very unlikely to be valid when many more dimensions and generalized chaos is the case, except for phenomena where the few-dimension model is indeed credible, which are exactly the situations the proponents of the bowl model use to prove their case.

[9] In logic parlance, it determines necessary, not sufficient conditions. In a large distributed system, many more parameters are influential than those one is able to account for.

turn requiring control at a new level to check the violent controller. The relation of control versus power is a very important ingredient of behavior that we shall consider in the (next) section on ethics.

Achieving *resilience*, namely, adaptivity to changing environmental circumstances and the ability to overcome potential threats by natural phenomena, competitors, or even one's own deleterious actions, is a central characteristic of a successful species. But there is more. Resilience is necessary for survival, but it is a defensive property. A pro-active attitude or, if you want, an offensive behavior is often how a successful species deals with its environment. Pro-active behavior can have many forms. It can aim at preventing threatening emergent phenomena, much like the defensive features of our immune system (try to) prevent infections and even cancer (both being examples of emergences in our body environment). The resilience of our body is due in a large part to our immune system, and is certainly necessary for survival, but there is much more: what we use our body for, namely, our goals in life, is at least equally important, because they provide motivation and gumption. This ranges from keeping our body healthy to creating "value" for ourselves and our environment, i.e., our ethics. Offensive and defensive behaviors have to be evaluated in function of their effects on the total environment, in particular, other members of the own species, other species, and our general surrounding ecology. This is what *ecological ethics* amounts to. It will be the topic of the next section.

In conclusion of our brief treatment of system dynamics, it should appear that any ecological action or attitude will only be effective if it immerses itself in the total environment and becomes an integrative part of the Earth's ecological process. From experience, we know that emergent agents may control their environment even so far as destroying it altogether and destroying themselves in the process as well. To avoid this to happen, emergent agents have to intimately mesh their methods with the "natural" proceedings of the overall system, understand them, respect them, let the combined system flourish, and accomplish their goals in a permanently evolving *mutual self-realization*. This process will never converge or become static (stable), but will have to move at each juncture into new forms of dynamic sustainability, adapting to change caused by competing emergences, and this often by creating new emergences of its own. This is the challenge humanity must meet in its relation to the Earth: *we belong to the Earth at least as much as the Earth belongs to us; we should act with nature and not against nature*.

3 Ecological Ethics

Succinctly, the ecology-ethical question for humanity is: *what is a good design of our actions as members of the Earth systems' ecology, given the Earth's natural dynamics, the incidence, and the possibilities of human control on it?* Ecological

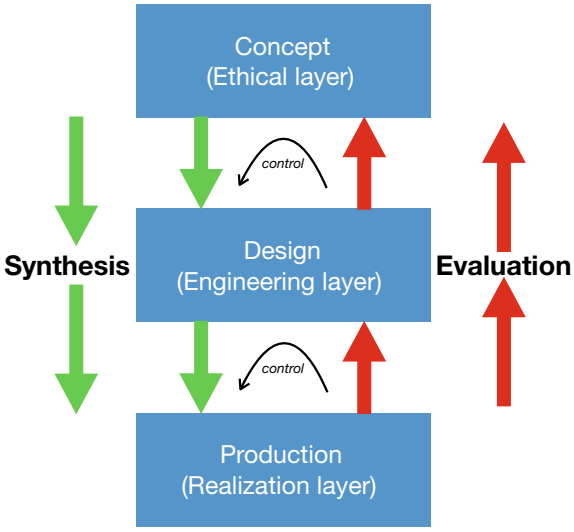

Fig. 3 Emergent control layers in design engineering (a rough sketch: the layers decompose further in a stack of organized sub-layers). Arrows indicate information or control flow

ethics is about defining and implementing quality in the way humanity influences the evolution of the Earth.

The method to deal with *ethics* I adopt and propose in this paper has three sources of inspiration:

- The Socratic ethical question *what is a good life?*—in the present case: *what is a good Anthropocene?* "Good" to be made concrete and explicit as a quality criterion for our behavior as part of the Earth's ecological system.
- The definition of ethics as *the choices a person (or a society) makes to guide their behavior*, following the considerations on ethics by the late Bernard Williams, Professor of Ethics at Oxford University [21].
- The *methodology* engineers use to design a good product, and what the notion "good" means in that context: what is "quality" and how can it be realized?—see Fig. 3.

Notice that "no ethics" or "no quality control" is paradoxically a form of control as well: you just leave things to natural selection and do whatever you wish. It is not hard to guess what natural selection is going to do with our present treatment of nature. Inaction is no option, since action is a central characteristic of life. But we should realize that whatever we do, we shall be subjected to nature's effective criticism and, in particular, natural selection, so we better take the control exercised by nature into account when devising our actions, knowing that all have ecological effects. Nature is at the same time a benevolent and a severe master. Nature gives us many goods and opportunities. When it punishes our inconsiderate actions, the

punishment will be the result of our own ill-advised behavior, so we better get serious and develop the necessary ethics as quality control on what we do. We have no choice in this matter. We do not have to be romantic about nature. To take proper care of the Earth's ecological future is a matter of survival as a species, even in a relatively short term, like a few generations.

The connection between sustainability, natural selection, and ethics provides for a powerful criterium to assess the quality of the ethics one may try to develop.[10] Therefore "Ecological Ethics" can best be characterized as how an agent (be it a person, a society, a government) deals with the *health* of the Earth system seen as a global organism, both in the basic sense of sustainability (health and sustainability go together almost pleonastically), *and* in the sense of the *intrinsic quality* of the chosen options—that is: whether these options make the chosen evolutionary course "better" than other choices (here the definition of quality, i.e., what is "better," comes into play.). A potentially disturbing factor is that there is no single notion of "best" or "better," as these notions originate in the ethical process itself. This is like in engineering: quality is measured by criteria such as performance, so a major issue is the definition of performance in the light of ecological necessities of the Earth's healthy evolution.[11]

The health analogy (or paradigm) allows for the definition of what may be considered "ethical illnesses." These are behaviors that do not meet criteria of good quality structurally. Following the analogy with personal health, here are, in my view, the main types of ethical illnesses, which should be avoided or cured as they lead to unsustainability:

- sickness of goals (teleological diseases), when set goals do not aim at quality improvement but at achieving a devious effect (for example, profit optimization, economic dominance, or maximal growth [14], power as a goal instead of a means);
- sickness of means (functional diseases), when the means used are demonstrably contradictory to the aims (e.g., misguided practices, which cause unintended and perhaps fatal harm. For example, the use of most chemical pesticides or the seeding of the atmosphere with harmful chemicals in order to create clouds, the use of disposable plastic bags to improve food hygiene);
- structural incompatibilities (faulty structural arrangements), when the various means used do not harmonize (one effect can be good for the atmosphere while

[10] Quality evaluation of an ethical system is a kind of "ethics of ethics," as it is an effort to evaluate various ways to realize quality, including actual behavior. In the design world, it consists in evaluating the quality rules and practices of a company, while the actual ethics is whatever designers practice.

[11] Some people measure the performance of a car in terms of acceleration, reliability, or even just economy. Present-day measures of performance require the gauging of the car's environmental impact, an issue one would not even have thought of 60 years ago!

detrimental for species diversity, and vice versa, unconsiderate exploitation of human or physical resources, massive soya production for biofuel);
- semantic incompatibilities (lack of mutual understanding) lead to contradictory behavior and cooperating parties not capable of aligning their semantics (for example, partial optimization leading to a best solution at one level incompatible with another, inadequate assignment of responsibilities, faulty interpretation of scientific results, miscommunication, or even deceit).

Examples can be mixtures of the four categories mentioned.[12] One may wonder whether such a classification is necessary and/or useful. I claim that it produces a systematic way to motivate a judgment on the desirability and adequacy of proposed ecological decisions and actions. It provides a method for assessing "meta-ethics", i.e., comparing the quality obtained by one system against another or against common practice.

Ecological ethics as the top "quality control layer" on Earth system management is a new, emergent evolutionary layer needed to insure the future health of our planet. As any system aiming at guaranteeing or improving health, Earth ecology is again subject to evolution itself, dependent, in particular, on increasing knowledge (science) and technology (engineering abilities). For every new technology, there will have to be new ethics, which, again, has to be evaluated for ecological health (effects and consequences). Conversely, every new ethical endeavor will need the necessary means, i.e., power and technology, to achieve its purposes. This dialectical process is never to end and will need permanent societal, managerial, political, and economic support.

As ethical basis for a healthy ecological development of the biosphere-cum-Anthropocene, I want to argue next that an *integrative humanistic* program[13] is the only option capable of achieving sustainable quality, requiring basic respect for all humans to be extended to respect for the total ecological environment, in recognition of the organic integrity of the Earth.[14] The striving toward best quality for the overall ecological health cannot be discriminatory with respect to its living recipients. All humans must be allowed to participate in it, as well as the whole Earthly environment, all species and all natural resources, understanding and respecting their participation

[12] These categories are based on the recognition of two main logical types of classification, namely, structure versus semantics (or equivalently, aggregation versus generalization) and internal dynamics versus (emergent) control. Each of these carries its own type of disease.

[13] *Humanism* to be understood generically as an ethics based on the respect of the individual value of each human being extended here to respect for the value of the total Earth as an integrated organism, and not as a desire of humans to be "God" as incorrectly defined by some authors. Most, if not all, major religions in the world are profoundly humanistic, although the term has been misused to oppose religion, which certainly is a historical error, since the term is rooted in ancient religious thinking and the revival of the notion in the Renaissance. See also the Catholic stance in the Encyclical *Laudato si*.

[14] Globalization is not a choice, it is reality. Nature is global.

in the healthy functioning of our whole Earth. This also means disallowing unhealthy behavior, based on the best of our ecological understanding, which can be no other than our best justified scientific insights.

This may seem a complicated task, but it functions much like fostering the health of a person's own body, which cannot be discriminatory with respect to the organs that constitute it, because a body needs all its organs to be healthy. This issue is of vital importance and requires careful meta-ethical argumentation (i.e., what is a good ethical system?), as it goes against much practical ethics and much economic practice, which tend to favor the most powerful or strongest at the detriment of the common good of all constituents. The resulting malpractice has lead to the dire predicament our whole Earth including humanity is in presently. We have to get serious about our Earth system being one highly interconnected organism [10]. This is a matter of proper understanding of what *ecology* or inter-dependency means, and the *integrative thinking* provided by humanism-cum-ecology is the way. It is the *Way of Life* [2].

I cannot give further argumentation in this paper on the issue of why an ethics based on supremacy[15] (personal or racial) is badly misguided, as this is a different topic, see, e.g., the book [5] for this, but here are a few further observations on the necessity of properly understood integrative humanism:

- Each human has a unique contribution to make and each human is subject to the same (life and death) predicament. One cannot separate life into "productive" and "unproductive" phases, or people into "valuable" and "not valuable" without destroying the basis of life itself with its intricate dependencies between all participants (see in this respect the view of modern genetics as described by Siddharta Mukherjee in [12]).
- All ecologically meaningful ethics has to be based on respectful sensitivity for the *whole world* we live in and *all* other humans. Caring selectively is not an option. Due to intrinsic limitations of human knowledge, selective care always degenerates into social irresponsibility, often even into downright crime, as was the case with Nazism, Stalinism, Mao-ism, Racism, and many other forms of discrimination. Respect for all living beings, their ecological role and their respective sensitivity is a reciprocal property[16] and therefore uniquely capable of achieving global health.
- The higher layers in the intelligent control hierarchy (societal control layers) are dependent on and need the input of individual humans: "higher" authorities, like governments or corporations, may try to control their underlings and the environment but are de facto primarily controlled by and serve the interests of selected people. These higher authorities may have a lot of power, but that power has often proven to be destructive toward the common environment.

[15] Sometimes erroneously called "social Darwinism," but there are many other varieties that posit the right of the strongest, in theory if not in actually practice.

[16] People will care for you if you care for them.

- Empathy and cooperation are the only methods for societal progress that respect the Earth's ecology.[17] Competition and respect have to go hand in hand, otherwise competition gets destructive due to its uni-directionality and hence becomes violent. Competition is necessary as an inducement to action and a guarantee for quality, but it has to be mitigated by commonly shared integrative goals.
- An essential but often overlooked argument for integrative humanism is skepticism about the comprehensiveness of any worldview the human mind may harbor, even using the best of science available. Any "fundamental" theory or vision our minds and science are capable of constructing necessarily results in a limited view (a model) rather than an exact rendition of "reality," due to the intrinsic limitations of our brain and our thinking processes. Nature and "reality" (that is, how nature presents itself to our experience) appear to be much more diverse and more complex than our laws and thinking are able to conceive and our models for reality are able to construct. The same can be said about personal or societal views on people and their behavior. This necessary skepticism is in stark contrast to the overly optimistic view of science propagated by modernist philosophy in the eighteenth century, but it is consistent with our present view on system dynamics, as described in a previous section of this paper.[18]

Well-understood humanism[19] is much more than an ideology, it is an attitude necessary to achieve global through personal health, whereby the well-being of humans in their environment is chosen as the primary goal of personal and societal ethics. Human health *needs* and at the same token *procures* societies' health, but can only be achieved through full ecological health of the Earth.

Nonetheless, all ethics must develop adequate controls to achieve its aims, and all control has to use some kind power. As we discussed in the section on system

[17] Predators have a precarious existence. The cooperative mode is the mainstream method of survival of many species, even when unwittingly. For example, the symbiosis of plants and insects, or plants and mammals, not to talk of the symbiosis of mammals and bacteria, or plants and fungi, etc. Humans cooperate much more than they compete, if one considers all the cooperative effort that goes into education, household activities, care, culture, science, medicine, even in politics and business. We mainly compete to cooperate, but we also cooperate to compete although competition is mostly not the end goal, as it is in the Olympic Games—although even in that case one can argue that the end goal is the profit made by advertising agencies. Predation is not necessarily ecologically harmful, it is an element in keeping the ecological balance. It gets harmful when unchecked, and is then in danger of not only destroying the victims but the predators as well.

[18] It should be mentioned that the skeptical viewpoint is as old as philosophy, and perhaps its most essential ingredient, cf. Socrates' view on the deficiencies of language and Lao Tzu's warning on humans being "sorcerer's apprentices" as related to the accomplishments of nature.

[19] As conceived by its originators like Erasmus and Thomas More.

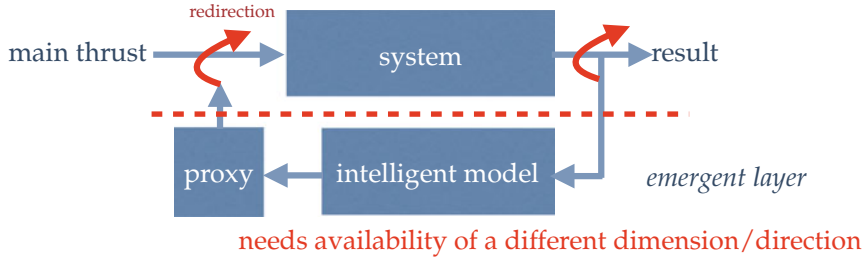

Fig. 4 Intelligence as an emergent layer using a proxy to control a process by deviating a main stream of power for its own benefit

dynamics, each level of control has structural and semantic relationships (it interprets and controls accordingly). It is dependent on its connections to "higher" and "lower" levels of emergence and on potential modes of interaction with those (e.g., via hierarchy, contracts, shared intelligence, semantic alignment) and on its own structural capabilities (sensing, interpretation, actuation). Control happens mostly through proxies, necessitating a different generic model than the traditional direct feedback control model, namely, a model that includes the contribution of intelligence, see Fig. 4 for a schematic. In this short paper, we cannot discuss most levels of intelligent control active in the Earth's ecology further. I have singled out the most important one for further discussion: economics.

4 Economics and Hard Measures for Sustainability

Economics provides the levers for the detailed management of our ethical future: there is no other sufficiently comprehensive control method available to humanity. As we know, economics is largely "ethically neutral" (although not everybody might agree), but it can be steered in many directions and by various mechanisms—a complex topic in need of intense exploration. If our ethical goal is to achieve sustainability, we need economics to achieve it. As we have experienced in the last three centuries, economics can easily produce tipping points and running away developments. Control on run-away economic effects requires countermeasures that not only aim at realizing sustainability (health) goals, but also mesh with the specific dynamics of the economic system to be effective. An economy has to be organized so that it is able to control itself.

Although the establishment of a sustainable economic system needs an outside authority to enforce the economic rules of the game, the economic system should largely run in an autonomous and distributed fashion, since that is its great strength. A "good" economic system is capable of embodying its own regulatory power, once well defined and implemented. Although authority is needed to establish rules of conduct, no dictator is needed to authorize operations, quite on the contrary: only

general acceptance and automatic enforcement of the rules, with potential recourse to arbitration or judiciary in case of abuse or conflicts.[20]

This being accepted, economics provides for a long list of further potential choices, i.e., choices we make collectively at the various levels of societal activities and stratification ranging from the local private to worldwide global. These choices condition or even determine how we can realize our ethical goals. Let me mention a few (to properly detail them all, a much more elaborate treatment is needed, see, e.g., [14]):

- how to deal with "property," entailing rights to be claimed and responsibilities to be fulfilled?
- what are the rewards for labor and effort versus the provision of capital?
- how free are capital owners on the use and purpose of their financial potential?
- which economic activities are harmful and how should they be curtailed?
- how do public authorities participate in the economy versus private initiative?
- what is being taxed by public authorities and how?
- what proportion of public outlay should go to education, health care, commons, civil protection, defense? how does economics deal with social security, pensions, human rights (what are they?), the rights of future generations?, etc.

How all these choices are made is of course a highly political affair, involving large numbers of people messily organized in a great variety of constituencies and roles: a perfect breeding ground for chaos and emergence, where control is grasped by various agents and in various directions through tipping points that re-orient the focus of attention and determine the course of events competitively. This process is already highly "ethical" in that the participants try to establish what the course of events should be in their view. Ecological ethics has no other choice than to try to grab the attention of the human community with all its diverse constituencies to its concern for the well-being of the Earth, and strive at establishing proxies at the various available levels of potential control, from the local private environment all the way up to the whole world community.

Short of a utopian worldview, society needs means and power to achieve its ethics, whatever it is. What is called a "capitalistic economy" allows economic agents (persons, companies, authorities) to act independently, while providing the possibility of control through exchange of capital (costs, rewards)—we know of no other effective method to achieve such distributivity and versatility on a large scale. However, many of the economic means available in an open capitalistic system can become goals in themselves and violently subvert the process. Becoming "good" economists in the global ecological meaning of "good" has to be a necessary societal priority [14]. Without a clear definition of ethical goals and their translation in concrete economic action there shall be no viable sustainable ecology. Ecological ethics as a design

[20] This is in stark contrast to a system where every action or transaction must be authorized by a central authority.

strategy for the Earth's well-being has to go hand in hand with adequate (and even optimized) economic practice.

Similar to health and ethics, economics shows characteristic diseases. Here is a shortlist of what I see as some of the most important ones in present-day economics:

- large masses of ineffective capital (a huge proportion of moving capital is speculative) [sickness of means],
- accumulation of capital by economically ill-directed actors[21] [sickness of goals],
- "supply-side economics" instead of "demand driven" [structural incompatibility],
- ill-directed demand [semantic incompatibility],
- the whole list of ethical diseases we discussed before. The classification shows clearly in which directions solutions have to be searched: preventing disease *and* producing new healthy perspectives.

The effectiveness of economics is due to a good collection of potential controlling proxies available to economically active agents. To mention:

- rewards, subsidies, taxes, fines;
- availability of capital;
- the stock market;
- international associations and meetings;
- entrepreneurship;
- political activism;
- dedicated research;
- public opinion, social media;
- individual actions, customer's behavior.

All these proxies (and more) can be used for ecological profit. Here are some examples:
– the emission of CO_2 certificates has created a valuable economic proxy for the interests of the atmosphere. Admittedly, it is a beginning, but its value is undeniable, although it shows undesirable side effects that may worsen instead of improving the situation;
– guarantees of sustainability in the exploitation and marketing of natural resources such as wood and fish have influenced customer behavior, but, again admittedly, much more has to be done;
– the successes of bio-agriculture and bio-induced diversification have produced both a new attitude towards biologically sound production and consumer demand for it,

[21] Are we returning to a kind of *Ancien Régime*, whereby 2% of the population owns 98% of the wealth, while supply-side economists tell us irresponsibly that the remaining 98% of the population will profit from such a concentration because of a "trickle down" effect, the Earth's resources are being squandered for profit of the few, and a large proportion of the population struggles to come by? We know from history to which kind of disasters this leads.

creating a new type of diversified agricultural economy with its markets and profits;
– investments in both scientific and industrial research in alternative methods to harvest and store solar energy have dramatically changed the energy economy, in ways that were unthinkable only 15 years ago, clearly demonstrating the power of technology when well addressed and supported by industrial momentum;
and there are many more examples of successful development of economic proxies acting in name of the interests of the Earth, but much stronger action is urgently needed.

Which proxies and how to steer them in the right direction will be the core of the full throttle ecological ethics we need to develop. In particular, economic growth (necessary for economic health: economic growth should be seen as a *measure of effort* rather than a *measure of profiteering from nature*[22])—can be achieved by a strong emphasis on ecologically sound innovation, redirection of production methods, and the development of sustainable new products and services. Growth should not to be understood as "more goods and more commodities," but as intensified efforts to create "higher quality of life in a healthier environment" (such an increased level of activity translates in growth when measured financially).

The sky is the limit here: we can always aim at a higher quality of life, sustainable production and agriculture, better health services, ecologically sound mobility, a more attractive human environment, improved development of arts and culture, not to talk about enhancing our natural green environment with respect for the manifold of species that surround us, etc. There is no end in sight how we can obtain economic growth when we apply our economic and technical potential in the right direction. The key is *to generate tipping points in ecologically attractive directions*: our human intelligence should be able to create those (as it succeeded in creating the agricultural, industrial, and digital revolutions. Our next challenge is the ecological revolution).

[22] Economic growth is strictly speaking not a systemic necessity, but we all know what a recession means in terms of societal disruption. Economic bubbles are caused by a chaotic run away of ill-advised actions, and, from an environmental point of view, investments in unsustainable depletion of nature or causing run-away pollution. Such investments are obnoxious and should be prevented by law. On the other hand, humanity has to put substantial effort in ecologically useful activities, hence creating economic growth in a desirable direction, which proves even more economically rewarding, since it involves a lot of people in meaningful activities, e.g., measured by the reward for their contributions. Nature does not get properly rewarded for its contributions, but people who exploit nature do, and this must change. But, similarly, people who contribute to nature's and people's well-being should get rewarded, which with nature profiting from it—*that* has to be the basis of economic growth.

How can such desirable sustainability be achieved? Inspired by the ideas of Amar Bidhé [1], Kate Raworth o.c., Michael von Hauff [17], Martin Grambow [7], Peter A. Wilderer [20], authors in this volume, and many others, here are some ideas on how the use of proxies applies to sustainability. One may distinguish hard measures to achieve sustainability and soft measures (not to be confused with "hard and weak sustainability" as described by Solow and Hartwick in the 1970s[23]). Hard measures consist of the whole gamut of governmental (and sometimes private) actions aiming at guaranteeing ecologically sound production and consumption, enhancing the economic position through public investments in sustainable infrastructure via public works and public services, preservation of natural heritage (forests, species, water supplies, research), development of the "commons" (all the public areas), tax breaks and subsidies for ecologically meaningful activities, and many more. All these involve judicious use of public money (tax payers' money!), but one should not forget that somebody's cost is somebody else's profit. Money is cost/reward neutral: it does not disappear, it just changes hands. The whole economico-political game is about achieving the right balance, and, of course, keeping the books in the black and achieving sustainability at the same token. All this cannot be done without a massive redirection of economic activity, and will require great economic expertise and political acumen to realize, but it is the way to go.

It is not the place here to make an inventory of economic measures that can be taken to steer our economic policies into an ecologically sound direction. Quite a few economists have produced recipes for this, let me just mention Raworth again, but also Piketty [13] and Stiglitz [9], and many others in their tracks.[24] Let me suffice with making arguments on the economic value of an ethical approach in which quality control is given priority, as exemplified by some selected cases. One only has to look carefully at what happened with modern industrial production, in particular, in the manufacturing industry. Competition on quality has become global, meaning that only the very best products make it on the market. Inferior quality is easily pushed out of the market by a qualitatively better product. Just think of the massive increase in quality of computers, mobile phones, cars, televisions, not to speak about a variety of services like banking services and transportation. Increase in quality has tremendous economic value, and companies like *Apple* or *Samsung* have built their market position on the quality they offer, squeezing out lesser players or players who did not succeed in catching up with the quality race. The issue we face with Earth ecology is not the economic value of "quality," it is *what is considered "quality" by the market and the human community. We badly need a quantum change in ecological quality awareness throughout our global human society, from personal habits to companies and governments.*

There is an intrinsic, functional component in the quality of a product, but also, and very importantly but often neglected or ignored altogether, an external one, namely, the impact a product has on the environment. Many modern products may be very good technically, but poisonous or toxic when considering the ecological footprint

[23] I am grateful to Michael von Hauff for pointing this out to me.

[24] Even Adam Smith stated that capital should not be hoarded, but invested in productive activities.

they leave behind. Similar to how the use of mercury or lead has been found to be highly poisonous and unhealthy, we are now realizing how poisonous the use of plastic packaging is, the burning of fossil fuel, the mining and use of various toxic minerals, agriculture based on monocultures, etc. It is eminently clear that we all must extend the scope of our concern for health to our whole environment, if only to keep ourselves healthy. This means that the ecological impact must come to the foreground in almost any economic activity: we must require a *cradle to cradle* sustainability of the products we buy or the services we get, i.e., sustainability throughout the whole lifetime of a product or process [11].

Let me mention a non-exhaustive set of measures that help to achieve this transformation:

– strict regulations on acceptable materials, their mining, usage and disposals, as well as strict standards on production processes, requiring industry to use sustainable materials and production methods throughout. Products may temporarily become more expensive because of this, due to necessary research and development, but typically end up being both ecologically sound *and* cheaper;

– the mining industry needs strict regulation so as to create a level playing field for non-destructive competition in this ecologically highly sensitive area. Ecologically dubious materials (like Cobalt or Uranium) have to be replaced with sound alternatives (e.g., Cobalt is gradually being replaced by less harmful materials in Lithium-ion batteries, and better alternatives are actively being researched). Finding adequate low cost and sustainable replacements (like functional organic material) may be costly initially, but the rewards are great in the longer term. A tipping point effect may be produced here when the potential future rewards of alternative investments are understood and communicated;

– the nefarious effects of various types of ubiquitous pollution (gasses in the atmosphere, plastics in the oceans, water pollution on land, increasing warming) are forming a major threat to the health of individual people and the ecological health of the planet. Producers and distributors (the packaging industry, supermarkets, transportation systems) must change the ways in which they are offering their goods and services so that they do not produce wastes that end up to be unredeemable toxic. Such practices must be forbidden categorically;

– a similar argument has to be made concerning large parts of agricultural practice: mono-cultures (be it of crops or animals) on a massive scale must be systematically discontinued. Technology may bring at least a partial solution. The development of large mono-cultural areas is motivated by economic arguments, in particular efficiency of production and low cost. But the resulting products are qualitatively inferior (often having low or dubious nutritional value), the massive use of industrial fertilizers is poisoning aquifers and rivers, and the mono-cultural mass production generates

all sorts of nasty ecological side-effects like the need for poisonous chemical "pest" control on a large scale, not to talk about the loss of a lot of bio-diversity, with, again, nefarious additional side effects. Massive use of chemicals threaten the general health of the population as well. The industrial production of meat, fish or eggs results in hugely inferior quality of life of the concerned animals themselves and dubious quality of the products. This whole sector is not only a disgrace to humanity, but also a threat to it. Strong regulation of agricultural practice systematically preventing unhealthy practices is evidently needed, whereby the notion of "unhealthy" has to be expanded to "ecologically harmful". Hence, not only the use of noxious chemicals or the production of unsustainable wastes is unhealthy and has to be unequivocally forbidden, but also massive incarceration of animals, large monocultures etc.

– a related problem is the economic tendency of "running to the bottom", which has to be prevented when it is threatening ecological health. For example, due to the remarkable upcoming of sustainable energy production (thanks to the upcoming of photo voltaics (PV) and wind energy) an unhealthy competition has arisen between sustainable energy production and the oil-mining industry, resulting in slowing down the swift deployment of sustainable energy. The consumer may get cheaper energy this way, but at the cost of poisoning the earth's atmosphere much longer than needed. There should be no competition that pits healthy solutions against unhealthy ones, and the use of fossil fuel in an unsustainable way should be strictly prohibited by law. It has been an incredible luck that sustainable energy production has become so lucrative so quickly (who would have thought of it fifteen years ago?), but that has also an undesirable cost, namely that only massive production of generators (PV cells or wind mills) with perhaps dubious means achieves the low cost aim. Similar "running to the bottom" pits sustainable agriculture against monocultures. The solution is only possible via "hard measures for sustainability", namely the enforcement by law of ecologically acceptable production standards for all sectors of industry. It is not unusual to force industry to adopt standards, e.g., safety standards. Sustainability standards deserve the same status. The advantage of enforced standards is that they create a "level playing field" for all participants.

– capital, which is presently phantom-ing around the world purely speculatively, should instead be channeled into ecologically sound and productive activities. Economists have an essential contribution to make here. Our financial system has to be reformed so that investments in ecologically sound infrastructure is rewarded (energy distribution, mobility, public and green spaces, community services, education, research) on the one hand, and speculation discouraged on the other. (An idea is to use alternative payment systems, different kinds of currency like vouchers to achieve specific ecological effects. Another is to systematically reward ecologically useful contributions by the public at large, thereby offsetting eventual costs of ecologically better products—but I have to leave this area of thinking to economists.). There is also a role here for public authorities to devise schemas that make investments in ecologically sound technology less risky. To achieve such endeavors, we need,

according to D. Holemans, a new social contract, let us call it a "socio-ecological contract" and start working at it [8].

It should be clear that economics for an ecologically healthy world requires strong public regulations. Some people see this as "preventing freedom" both for entrepreneurs and consumers. It is a foolish idea that economy can flourish without strong regulations, just like it would be a foolish idea to assume that you can have good mobility by car without well-organized roads and traffic rules, or global capitalism without protection of capital and property. No freedom without discipline!

Our Earth baths in solar energy. The supply is inexhaustible, and we have all the technical know-how to harvest it directly, without recourse to harmful secondary processes, like fuel burning or nuclear energy. *Ecologically sound energy production should not be a problem at all for our technologically savvy humanity!* We are also creating other, sometimes extremely dangerous, shortages of resources, and we have a number of incredibly valuable gifts of nature that we are squandering without consideration as well. We have, for example,

- a great variety of fellow species that make up our ecosystem. We badly need their contributions and should keep our overall environment attractive for them as well;
- pristine sources of water, air, and other essential materials that we should use in a considerate manner by recycling them properly after use, to perpetuate their value for the future;
- natural resources such as oceans, forests, great varieties of plants, glaciers, rivers, skies, all of which must be kept in sustainable balance with each other and are threatened by our inconsiderate activities;
- the gift of intelligence, of culture and of ethics, which allows us to be conscious of the value of our Earth, and which pushes us to take the right actions to make our planet healthy, sustainable, resilient, and therefore beautiful again.

In theory, the ecological problem of the Anthropocene is not impossible to solve. It is a question of societal engagement, courage, and entrepreneurship. Some adequate measures are under way (as already mentioned), but what is being done is largely insufficient, and, moreover, it is being countered by ill-advised and even criminal actions by all sorts of sick side interests that use similar control mechanisms as those at our disposal, like a cancer attacking a healthy body. Economy is not there to prevent healthy developments, but, on the contrary, to facilitate them.

5 Soft Measures for Sustainability

All the hard economic measures to achieve sustainability will, in the final analysis, be critically dependent on what are necessarily soft measures. These are measures

that aim at a global *cognitive change* concerning humanity's perception of the state of our Earth and the necessity of adequate ethics as a new layer of quality control on humanity's behavior. This is a fertile area for *tipping points* as was so beautifully illustrated by the single high school girl Greta Thunberg on *Skolstrejk för Klimatet* causing a worldwide revolution, much like a butterfly "causing" a tornado (think about chaos and emergence!).

Political and economic measures only go so far as public awareness of the main issues and acceptance of the consequences go. To achieve any kind of effective behavior, large *semantic alignment* between all constituents of society (or, equivalently, mutual understanding) is needed, based on a shared perception of truth, open communication channels, education, and cultural sharing, all to be carefully fostered using human intelligence, respect, and technical know-how—see Fig. 5.

Hard measures for sustainability are also hard to take, because they are experienced as coercive and often disturb the existing order, even when that order is demonstrably harmful. People do not like to change, neither their ideas nor their habits, especially when they are perceived as beneficial to themselves. People might even go to war to preserve their privileges. It is a sad corollary of humanity's recent history that the systematic destruction of nature (including many lives of inhabitants) in what is called "developing countries" has been the instrument of economic prosperity of "first world countries." Financial interests have been for a long time the prime and foremost object of public protection, no matter what the cost to nature

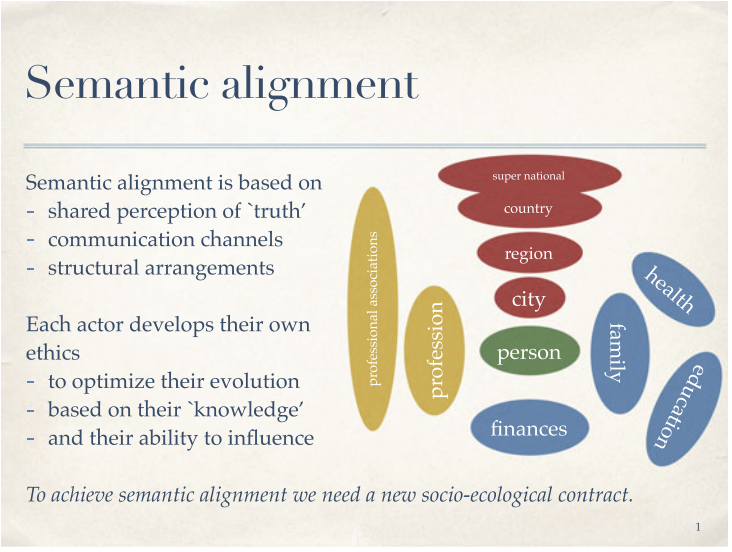

Fig. 5 Semantic alignment across many actors and many modes per actor

and humans was. We now understand that this is a fundamental if not foolish error, because nature's health (including human health) is a much more basic necessity. Nature's health is too precious and should not be made subservient to the quest for opportunities, gain, and profit, but this is an insight that is not yet largely shared by the powers in place, even nowadays after so much evidence of a run-away ecological health crisis.

Semantic alignment is a necessary condition for a successful transition to a sustainable Earth. As indicated in the previous section, more is needed, in particular hard measures, but without semantic alignment, many necessary measures and efforts will find insufficient support, and the end result will be nature running out of control, at least as a benign habitat for humanity (as already mentioned, nature has its own ways to deal with human insufficiencies, the recent pandemic being one "good" example.).

In the section on system dynamics, we saw the role semantics, as giving meaning to observations, plays in system control. Intelligence controls an underlying system by accurate sensing and careful evaluation of the consequences of its control actions, which often happen through proxies. Intelligence hence plays a central role as an emerging controlling layer (there are, of course, other controlling agents, often even outside our perception or knowledge, but intelligence is the one we are endowed with). Correctness and trustworthiness of evaluations and resulting actions by humanity as intelligent agents influencing Earth's ecology become a paramount necessity and criterium of quality.

"Semantic alignment" is no easy matter, but it is essential. There is a large number of human-related agents active in the ecological field (in alphabetical order): civil servants, companies, consumers, designers, employees, engineers, executives, entrepreneurs, farmers, governments, investors, lawyers, ministeries, parents, politicians, scientists, teachers, tribunals, workers, etc., all engaged in some form of "model-based control," all entertaining their own "models" and their own "control proxies." No doubt a very complex and chaotic environment in need of, or subjected to emergent processes, which attempt to align both their models and their proxies.

A couple of examples may illustrate some of the mechanisms:

– a prime example is the sustainable generation of electrical energy. We may perhaps be confident that a tipping point has been reached, and that most energy production in the future will be sustainable, using the immense influx of solar energy as a source (through photovoltaics, wind energy, biomass conversion, or other sustainable ways). How has this, 15 years ago almost unconceivable, been playing out? Actually through an unholy combination of technological know-how, large-scale production and low-price economics that precipitate the transition. Yes, pure scientific and business intelligence have contributed, but what has caused the tipping is clearly effective industrial policy and consumer behavior conditioned by run down pricing. Intelligence has played an important role in creating favorable conditions (like much better solar cells, or enticing subsidies), but originally unforeseen other factors like low prices, the result of massive Chinese investments, have clinched the tipping. Even

so, the tergiversations around the CO_2 tax show how important semantic alignment is (the present equivocation is to the detriment both of the economy and the ecology!). The ways of intelligence are often devious.
– Another, not yet realized but very important example, is the need for a tipping point toward sustainable agriculture and fisheries. Monocultures and large meat production facilities (I do not want to call them "farms," they are factories with production lines, where the robots have been replaced by animals) using incarcerated animals have to be stopped unequivocally, yet many new ones are being build presently, purely for economic reasons, namely, economy of scale and consumer demand for cheap meat (not withstanding the low quality). To get out of this bind, the consuming public has to start understanding: that it contributes to these evil and even criminal practices by its behavior as consumers; that, on the contrary, sustainable, distributed, bio-diverse, and animal friendly agriculture has to be promoted and developed; that politics has to create the conditions necessary for this to happen; that agricultural technology has to be developed that makes the turnover economically attractive, etc. The conjunction of all these efforts is "semantic alignment," where all parties involved develop a multi-faceted but coherent evaluation of the situation (the model building) and start agreeing on the ways to deal with it (the proxies). A big task for our collective intelligence!

Semantic alignment is often the result of an emergence. An illustrative case is provided by *Facebook*. Originally, the picture'world created by *Facebook* seemed innocuous enough, but it soon conquered the "real" world with its novel way of communication, thereby providing new ways for people to influence each other and settle opinions in their minds—it is a semantic alignment machine. One can now safely say that our youth is consulting *Facebook* and *Instagram* more than their school books, a library, *Wikipedia*, or even their teachers and parents. This is not necessarily bad, but the information chaos created by *Facebook* is in urgent need of further emergent control. Creation of new media is great, but each such creation needs novel control methods to avoid societal or ecological disintegration. We have indeed witnessed in recent times the successful misuse of social media for political purposes (think of conspiracy theories), thereby giving an impressive example of tipping points in public opinion (this is often referred to as the production of false *memes*, a fitting reference to the exponential propagation of genes in genetics [4], now *memes in "memetics"!*). This meme-reproducing ability shows both the dangers and the possibilities of our novel social media, and the challenge ecological ethics faces to anchor its vision. There is, in particular, an extreme need for education of the public at large and our young generation, in particular, since they must learn to distinguish between good and bad memes, accept what is valuable and reject what is not.

"Semantic alignment" in society should be based on the perception and propagation of "truth." Although people generally think that there is only one truth, a closer look shows that this is not the case. There are many shades of truth, because

truth is not only dependent on *what* is being considered or observed, but also on *how* the consideration or observation is made and *how it is interpreted*. There is a fundamental human limitation in this process, which is closely related to the human capacity of knowing and understanding. This capacity is always limited, because it is necessarily based on a relatively small number of priors, and is moreover dependent on the scope and status of knowledge. Knowledge and experience (experience, science, technology) is largely shared between humans, but also this process is not univocal. Knowledge is never absolute. We are highly dependent on repositories of knowledge that we are able to share and, in the best cases, represent the actual status of understanding. The quality, correctness, and relevance of common knowledge remain a central issue, which we can also call the "ethics" of knowledge, namely, how "good" is what we believe to be true? As argued before, we generally accept scientific knowledge as trustworthy, with the qualification that its validity only reaches so far as covered by the precisely circumscribed experimental environment, i.e., an environment in which the validity of the set of prior assumptions and their scope of applicability holds. In the section on system dynamics, we saw that even in such rarified circumstances (e.g., like the particle accelerator at CERN in Geneva), chaos, and emergence reigns. That is the central status of the concept of "life" in biology even more. But... there is much more than scientific knowledge that has to be shared by the human community.

We lead our lives according to a number of assumptions, believes, and precepts that have an existence of their own (like memes), although there are means to assess their trustworthiness. What we call *wisdom* is of that nature, or, for that matter, ethics (in the Socratic sense). Also, what we consider valuable, what we find beautiful, how we approach other people, how we deal with our children, how we evaluate people's behavior, our attitude with respect to nature, what we consider important, etc. Necessarily, the whole realm of culture goes way beyond the strict assertion of verifiable truth of science, although it may be based partially on science, and should likely not contradict science and experiments, if it is to remain productive. Culture is an emergent layer with respect to science and other layers of knowledge and experience. Although every type of science has to adhere to strict procedural rules to be trustworthy, much of culture is based on imagination, exploration, and experimentation (creative thinking and feedback from other people and the community). Such an emergence is a characteristic of life!

These considerations put in context what semantic alignment actually means. Humanity cannot agree on a single set of truths: such a set just does not exist. Science is not univocal: every type of science is dependent on a set of priors, namely, the definition of its object matter and prior axioms or assumptions. Particle physics deals with elementary particles. Biology deals with live and how it progresses through

procreation, etc. Every science is limited by the context of its subject matter and how that subject matter is best represented, *there is no universal science for nature with its permanently evolving and changing multilayered emergences*. Nonetheless, the scientific approach is to a large extent trustworthy, so long as its contentions respect their limited experimental context. Humanity has no other choice than to try to agree on a collective behavior that (1) respects the scientific knowledge for as far as applicable and (2) aims at overall well-being of organism Earth. Such a set of behavioral principles cannot be static, but will continuously be dependent on ever limited, adapting, and evolving scientific insights and cultural practice. This is what semantic alignment has to achieve: a dynamic cognitive coherence on the issues of global importance.

Semantic alignment has to happen across a great variety of human experiences and expertises, exemplified by the variability of human culture. There is a lot of work to be done in this respect, let me just mention some of the many issues:

- develop respect and understanding for humans across cultures and religions;
- understand the organic relationship between humans and nature;
- understand and respect nature's integrity;
- support the development of knowledge on ecology and sustainable technology;
- foster critical acceptance of scientific truth; and
- cooperate to prevent harmful actions.

Semantic alignment has to give shared meaning to all the notions mentioned (by "shared" is meant: a common context of understanding both on subject matter and resulting consequences). We cooperate effectively, not because we know everything, but because we know how to value and respect the knowledge of others, having learned to assess and integrate its trustworthiness.

In the case of ecological ethics, we dispose of a substantial body of scientific evidence on what is good behavior with respect to the Earth's ecology, i.e., good for the symbiosis of humans and the whole Earth's environment as an integrated organism. Although only few specialized people can understand the science behind global ecology, most people can understand the consequences of human actions, as carefully evaluated by science. It is then critically important that such "behavioral" information is communicated to and accepted by the human community at large. *Humanity as a whole has to become conscious of the need for global resilience and QoL-driven ecological ethics.* This means: semantic alignment across all the stratifications of human society, namely, countries, professions, political systems, religions, cultures, businesses, schools, ministries, etc., in the same way as most of us accept the necessity of freedom and safety. At the same token, we must dispense of false memes and foster convergence on what is truly important for our global future well-being.

6 Concluding Remarks

1. Ethics as "what makes a good life" is the definition of a quality design goal. In the case of "what makes a good Earth," ecological ethics aims at inducing all actors to strive at a healthy Earth, assess the ecological quality of their goals, and to act in sustainable ways.
2. Turning human, economic, and industrial activities into ecologically sound processes requires large investments, but can produce large profits and provide employment for a great number of people. Economy thrives on change. Economic growth should measure the level of productive and sustainable activity rather than the depletion of natural resources. A massive deployment of adequate technology is continuously needed to achieve the quality objectives of an ecologically sound industry (e.g., cradle-to-cradle sustainable products).
3. The capital needed to achieve the turn to ecologically sound production is often in the wrong hands. A central problem in modern economics is to turn speculative capital into (ecologically sound) productive capital. Adequate measures for this must be developed by economists, and implemented by legislators, banks, companies (driven by consumers), etc., leading to necessary *hard measures for sustainability* that reward healthy behavior and prevent ecological damage.
4. "Semantic alignment" or mutual understanding between the many players on the world scene is the key factor to achieve a consensus on the path to be followed to achieve sustainability and QoL. Semantic alignment requires *soft measures for sustainability*, i.e., conditioning measures in education, social media, politics, research, and development.
5. To focus its actions in the right direction, humanity needs to create "tipping points" that generate massive change in the public understanding of ecological necessity, following the example of Greta Thunberg and leading to a new world order (a new *social contract*) in which only ecologically sound activities are tolerated and QoL of the Earth's symbiosis is the prime focus.

7 Glossary

Agent	An independent entity capable of interpreting observations and influencing a system;
Chaos	Extreme sensitivity of the evolution of a system to variations in initial (or earlier) state conditions;
Cradle-to-cradle	In each and every stage of production, from origin to disposal;
Control	action by an agent on the dynamics of a system;
Dynamics	How data that characterize a system change with time;
Emergence	A novel order generated by a complex dynamic system, obeying new laws not covered by the basic laws, but observable by external agents;
Ethics	Behavioral goals and intentions (whether conscious or not); *ecological ethics*: the collective behavioral goals and intentions of humanity with respect to the Earth's ecology;
Measures	Institutionalized control; *hard measures:* enforced societal constraints; *soft measures:* measures that aim at shared cognition;
Resilience	Adaptivity of a system's structure and dynamics to external disturbances;
Semantics	The meaning of a phenomenon as interpreted by an emergent agent; *semantic alignment*: agreeing on meaning and significance;
State	Time-evolving data characterizing a dynamical system;
System	A set of entities that have constitutive structural relations; *dynamical system*: a system whose structural relationships evolve coherently in time; *distributed system*: a system consisting of many independent but interacting agents;
Tipping point	The start of a fast growing emergence.

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