# About Non-living Things and Living Systems as Cultural Determinants

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**Abstract.** For the future development of cultural technology, access to the cultural foundations of these culture carriers is necessary. One relevant aspect of this cultural foundation is the distinction between non-living things and living systems. Culture can be preserved, transported, and adapted by non-living things and living systems. Cultural development is only possible through living systems (e.g., humans). Non-living things (e.g., books, fossils, paintings, sculptures) are for preserving, archiving, and displaying the past. First, I present and discuss the theoretical and practical implications of the mechanistic worldview. Second, I give an overview of the ways to define non-living things and life forms. Third, I argue that our mechanistic worldview and the way we grasp the truth is limited by our way of thinking to deal with non-living things only. To resolve the main challenges, we must change our thinking and our acting in the world. Finally, I provide two primary sources of inspiration for this new way of thinking: the Asian way and the way of Indigenous people.

**Keywords:** Context · Culture · Development · Environment · Indigenous knowledge · Life · Mechanistic world view · Non-living things · Ontology · Sustainability · Traditional ecological knowledge · Transformative power

## 1 Prolog

Now, close to the end of my academic life, I started to reflect on how I was trained in scientific research and design. Several books and discussions with colleagues helped me to sort out some relevant aspects. In this paper, I will address how we as Western academics think and act, in contrast to how we *should* think and act. Our cultural embedding enables us to achieve astonishing things but also constrains us from seeing and thinking beyond. The following books (among many others) helped me better understand why we as humanity run into problems like climate crisis, pandemics, etc.: “The mechanization of the world picture” from Dijksterhuis [1], “Steps to an ecology of mind” from Bateson [2], and “The science delusion” from Sheldrake [3]. In particular, Sheldrake is a very courageous colleague, traveling along the edges of our worldview to make us aware of our limits. In a nutshell, I am trained to think and rationalize in a mechanistic manner (in particular the ‘mechanization of qualities’ [1, p. 431f]), although this way of reasoning is probably only applicable for non-living things consisting of ‘dead’ matter. This way of


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reasoning is what I mean when saying: "Quality and quantity are different qualities." So, how can we overcome this to be fair and correct in addressing living systems adequately to harmonize with nature? (see [4]).

## 2 Introduction

We can distinguish our environment in many ways; however, the following distinction appears to be fundamental: (1) non-living things (NLT) versus (2) living systems (LS). The prime discipline to investigate this distinction is biology [5]. We had different worldviews over the last centuries (see Table 1). Our most recent one is the materialistic one which treats nature as a complex 'machine'; Freudenthal [6] carefully worked out how the mechanistic world view has emerged over the last centuries.

**Table 1.** Worldviews over the last centuries; time goes from top to bottom (from [3, p. 39]).

| Worldview | God | Nature |
|---|---|---|
| Traditional christian | Interactive | Living organism |
| Early mechanistic | Interactive | Machine |
| Enlightenment deism | Creator only | Machine |
| Romantic deism | Creator only | Living organism |
| Romantic atheism | No god | Living organism |
| Materialism | No god | Machine |

Today academia (but not only academia) is operating mainly under the worldview of *materialism* where we don't need a God anymore [7] and can think of "nature as a complex machinery" [8]. Sheldrake [3] argues to strive for an *organic* worldview to capture and nurture nature as a living organism. Why is this relevant or even important to overcome materialism? As Merchant [9, p. xvii] describes it: "The machine image that has dominated Western culture for the past three hundred years seems to be giving way to something new. Some call the transformation a 'new paradigm'; others call it 'deep ecology'; still others call for a postmodern ecological world view." It seems to be obvious that the way we think and act today (at least in Western cultures) has lead us into severe problems (e.g., climate crisis [10] and many others). Most people see the solution to such problems in *more* science and technology. But listing to the warning of Einstein, "we cannot solve our problems with the same thinking we used when we created them," let me doubt that this is the right way. Taking Einstein's warning seriously, we must change our way of thinking and acting. How should we do this cultural transformation?

First, I will explain what the mechanistic worldview is all about. Second, I will elaborate on what we know already about life in contrast to 'dead' machines. Finally, I will sketch how we should think and act.

## 3 The Mechanistic Worldview

By far, the most important single factor in world history has been the process of a technological revolution whereby small-scale agricultural societies have been transformed into massive industrialized and urbanized communities. This development has occurred over a long period of time, but its most significant thrust has been concentrated over the last two centuries, beginning in the West, in Europe, and North America, and then spreading through the rest of the world. Buchanan [11] systematically analyzed this process, showing how increasing mastery over sources of power provided increased industrial and agricultural productivity, and created radically new methods of transport and communication. He then examines the impact of these technical achievements on society, paying particular attention to the political and ecological consequences of a vastly increased world population, the facilities for rapid transport and instantaneous communication, and the possession of weapons of immense destructive force.

Hornborg [12, p. 2] argues that three possible meanings of 'machine power' exist and can be distinguished as follows: (1) power to conduct work (i.e., automation), (2) power over other people (i.e., weapons), and (3) power over our minds. These three meanings are aspects of a single cultural phenomenon and historical development [13]. Today, the third meaning can be described as the 'mechanization of our mind' and summarized as the *mechanistic worldview* (MWV). MWV is dominant today, not only in academia [14] but also in public and political debates [13]. Hence it is essential to understand its nature and characteristics. According to Merchant [9, p. 228], "the following assumptions about the structure of being, knowledge, and method make possible the human manipulation and control of nature:

1. Matter is composed of particles (the ontological assumption).
2. The universe is a natural order (the principle of identity).
3. Knowledge and information can be abstracted from the natural world (the assumption of context independence).
4. Problems can be analyzed into parts that can be manipulated by mathematics (the methodological assumption).
5. Sense data are discrete (the epistemological assumption)."

Based on these five assumptions about the nature of reality, science has been widely considered to provide objective, value-free, and context-free knowledge of the external world. Following Sheldrake [3, pp. 7–8], "here are the ten core beliefs that most scientists take for granted:

1. *Everything is essentially mechanical*[1]. Dogs, for example, are complex mechanisms rather than living organisms with goals of their own. Even people are machines, 'lumbering robots,' in Richard Dawkins's vivid phrase, with brains that are like genetically programmed computers.
2. *All matter is unconscious*. It has no inner life or subjectivity, or point of view. Even human consciousness is an illusion produced by the material activities of brains.

[1] *Italic* formatting added by author.

3. *The total amount of matter and energy is always the same* (with the exception of the Big Bang, when all the matter and energy of the universe suddenly appeared).
4. *The laws of nature are fixed*. They are the same today as they were at the beginning, and they will stay the same forever.
5. *Nature is purposeless*, and evolution has no goal or direction.
6. *All biological inheritance is material*, carried in the genetic material, DNA, and in other material structures.
7. *Minds are inside heads* and are nothing but the activities of brains. When you look at a tree, the image of the tree you are seeing is not 'out there,' where it seems to be, but inside your brain.
8. *Memories are stored as material traces in brains* and are wiped out at death.
9. *Unexplained phenomena like telepathy are illusory.*
10. *Mechanistic medicine is the only kind that really works.*"

In this paper, I will concentrate on points (1), (2), and (6). Like Sheldrake, is Radin convinced that there is more 'out there' than what he calls the "materialistic monism." Radin's quest to search for limitations and anomalies in our state of the art knowledge describes eight scientific doctrines that constrain our way of thinking as follows [15, chap. 16]:

1. "**Realism**[2]: The physical world consists of objects that are completely independent of observation. This means, with a little exaggeration for the sake of illustration, that the moon is still there when you're not looking at it. …
2. **Localism**: Objects are completely separate. There is no such thing as 'action at a distance.' …
3. **Causality**: The arrow of time points exclusively from past to future, with no exceptions. …
4. **Mechanism**: Everything can be understood in the form of causal networks, like the gears of a clock that operate in a strictly local, causal fashion. …
5. **Physicalism**: Everything can be described with real properties that exist in space and time, and all meaningful statements are either analytically provable, as in logic and mathematics or can be reduced to experimentally verifiable facts. …
6. **Materialism**: Everything, including the mind, is made of matter or energy; anything else thought to be "immaterial" doesn't exist. …
7. **Determinism**: There is no free will, and all events are fully caused by preceding states. …
8. **Reductionism**: Objects are made up of a hierarchy of ever-smaller objects, with subatomic particles at the bottom. All causation is strictly 'upward,' from the microscopic to the macroscopic world. …"

Radin consequently provides very strong arguments against each of those doctrines (i.e., the consequences of quantum physics regarding space-time, locality, etc. [16]) to create space for scientific investigations beyond the materialistic monism into the realm of supernormality [15]. "That is, we know that every single one of the eightfold doctrines

[2] **Bold** formatting added by author.

has been falsified by advancements in physics. For example, the doctrine of *realism*[3] is falsified by quantum mechanics. That is, we know through theory and experiments that quantum objects do not have fully determined properties before they are observed. *Causality* is falsified by general relativity, where a fixed arrow of time is known to be an illusion. *Locality* is falsified by quantum mechanics, in which quantum-entangled objects display 'spooky action' at a distance and display instant correlations that are not located 'inside' ordinary space-time. *Physicalism*, like realism, is falsified by quantum mechanics, partially because quantum events are not fully localized with real properties until they are observed, but more speculatively because of the possibility that 'observation' may require consciousness, which in turn may or may not be a purely physical phenomenon. Experiments on mind-matter interaction, as discussed in earlier chapters, support this speculation. *Materialism*, at least a simple physicalist form of materialism, looks like it may be headed for falsification if it turns out that psi phenomena cannot be accommodated by any known form of matter or energy. This is by no means certain yet, but the possibility remains. It may also fail because of quantum-inspired theories proposing that the physical world is better described in terms of mindlike *information* instead of material 'stuff'. … Finally, *determinism* fails because of the collapse of causality, and *reductionism* breaks down because mind-body effects demonstrate 'downward' causation from mind to body, and because psychokinesis demonstrates a more far-reaching form of downward causation, directly from mind to matter." [15, chap. 16].

In physics,[4] all irreversible processes based on energy transformation will - in the long term - end in a state of minimal order, called 'heat death' [17, 18]. So, how is it then possible that we experience an ordered nature? In the context of the second law of thermodynamics, it is difficult to explain any process contributing to enhancing order [19, p. 653ff]. We can consider *culture* as an ordering process, but then we have to explain how this is possible. In my paper [20], I introduced an attempt to overcome and combine these contrary views. Based on the theoretical concept of Swenson's *autocatakinesis* I explore the possibilities of developing cultural technology beneficial to society. Autocatakinetic systems [21] attempt to characterize self-organizing systems at the level of macroscopic thermodynamic forces and flows.

Following Swenson, we can envision how to overcome materialistic monism [22, pp. 1f]. "Ecological science addresses the relations between living things and their environments, and the study of human ecology is the particular case of humans. However, there is an opposing tradition built into the foundations of modern science which *separates* living things and particularly humans, from their environments. Beginning in modern times with Descartes' radical separation of psychology and physics (or 'mind' from 'matter'), this dualistic tradition was extended into biology with Kant's biology versus physics (or living thing versus environment) dualism, and into evolutionary theory with the rise of Darwinism and its grounding in Boltzmannian thermodynamics. If ecological science is to be about what it purports to be about, about living thing-environment relations, it must provide a principled basis for dissolving Cartesian incommensurability. A deeper understanding of thermodynamic law and the principles of self-organizing ('autocatakinetic') systems provides the nomological basis for doing just this, for putting

[3] *Italic* formatting added by author.

[4] See the Second Law of Thermodynamics.

evolution back in its universal context, and showing the reciprocal relation between living things and their environments, thereby providing a principled foundation for ecological science in general and human ecology in particular."

Modern science and technology are incredibly successful [11], among others based on the MWV [23]. I do not deny this success, but the price we all have to pay is that we have severe difficulties handling adequately dynamic, non-linear systems [24] and, in particular, living systems in relation to their environment [25]. Any living system can only be understood together with its specific niche, habitat, and ecotope [26]. Humanity is obliged to overcome this dangerous and unsustainable situation. But how can we achieve this?

Twenty-three hundred years ago, Aristotle wrote in his Nicomachean Ethics that there are five different ways to grasp the truth as they are [27, p. 105f]: (1) Science ('episteme'), (2) art or producing ('techne'), (3) practical wisdom ('phronesis'), (4) theoretical wisdom ('sophia'), and (5) intuition or the capacity to grasp first principles or sources ('nous'). Only one of them is science (episteme), and this science is limited to things that cannot be otherwise than they are. The other four ways and capacities of grasping the truth apply to all the different contexts of reality and life. Now we need to broaden our view of science to include the other capacities [28].

## 4 From Non-living Things to Living Systems

Before discussing what we know about life and living systems, I have to talk about non-living things (NLT). This distinction between NLTs and living systems (LS) is so crucial that it is sometimes already part of the kindergarten curriculum [29] and primary school [30]. Obviously, almost everyone agrees that a stone is not a living thing, and any chemical element [31] is a 'dead' matter. NLT's are inanimate objects or forces that can influence, shape, alter a habitat, etc. Examples of NLT's include climate, rocks, water, weather, and natural events such as earthquakes or rockfalls. In biology, an NLT means any form of a thing that does not possess life. NLT's do not have cells and show no growth or movement. NLT's are lifeless and do not possess any life span. NLT's do not respire or require food for energy ('input') and hence do not excrete ('output'). Many distinct features make an NLT different from a living thing [32]. NLT's do not fall into the cycle of birth, growth, and death [33]. Non-living things are different in a way such as the fundamental unit of life is a living cell that grows, metabolizes, responds to external stimuli, adapts, and reproduces. Only a living thing has a live cell; an NLT doesn't. An NLT, on the other hand, is made up of elements or compounds formed out of chemical reactions. NLT's can be divided into two categories, and they are (1) natural NLTs (i.e., nature) and (2) man-made NLTs (i.e., artifacts). All things from both categories can be archived and/or displayed to the public in archives, libraries, and museums to calibrate culture through narrating history [34]. Most important characteristics of NLTs are listed below (taken from [35] and sorted alphabetically):

- Non-living things do not respond to the environment.
- Non-living things don't have protoplasm; thus, no life.
- There are no processes of reproduction, nutrition, excretion in them.

- These things are not sensitive.
- These things cannot die.
- These things do not obtain or use energy.
- They are lifeless and do not have cells.
- They cannot grow and develop.
- They do not adapt to their environment.
- They do not breathe.
- They do not possess any metabolic activities.
- They do not respond to stimuli.
- They don't move.
- They have no lifespan.

It seems to be challenging to define NLTs without referring to LSs. It is also unclear whether all these attributes have to be met or just a couple of them (see also [32]). E.g., a computer can be seen as an NLT but still needs electrical energy to operate and can be responsive to stimuli. Robots are also NLTs, but some of them can move (see, e.g. [36]). Most daily-life consumer products are NLTs, but they have a 'lifespan' (i.e., 'expiry date').

Schrödinger tried to clarify the relations between physics/chemistry on one side and biology on the other by asking the question [37, p. 3f]: "How can the events in space and time which take place within the spatial boundary of a *living organism* be accounted for by physics and chemistry? The preliminary answer … can be summarized as follows: The obvious inability of present-day physics and chemistry to account for such events is no reason at all for doubting that they can be accounted for by those sciences." Schrödinger elaborates in his book [37] how biological systems (i.e., living organisms) must rely on the physical and chemical laws. For example, he proposed that the exchange of energy and matter with the environment could reduce thermodynamic entropy by living systems and the local accumulation of Gibbs free energy [38].

The main challenge is to explain how from 'dead' matter (i.e., NLT), something emerges that we experience as a life form (i.e., LS). How is it possible that complex organic molecules arise in non-living environments? Let us assume that an adequate prebiotic soup or paste was available on earth a very long time ago. How did the transition from chemical chaos to biological order come about? So far, we assume "that complex organic compounds - including amino acids, the primary constituents of proteins and an essential component of living systems - could have been produced from inorganic chemicals and lightning energy in the primitive environment of the earth" [39, p. 390]. Then, Darwinian selection must have emerged early as a source of complexity, but what was the first system to appear on the primitive earth capable of Darwinian selection? Was it a ribonucleic acid (RNA), some simpler covalent polymer of perhaps some non-covalent aggregate? Are there complex evolvable metabolisms that do not depend on a genetic material? We will not find definitive answers to these crucial questions in any book on the 'Origin of Life' [40, 41]; we don't even know how far away we are to unravel this mystery and whether our way of academic thinking is appropriate.

According to Phelan, life originated on earth probably in several distinct phases [39, p. 388ff]: (1) Phase 1: The formation of small molecules containing carbon and hydrogen; (2) phase 2: the formation of self-replicating, information-containing molecules; and (3) phase 3: the development of a membrane, enabling metabolism and creating the first cells. Phelan gives a basic definition of what he means by “life.” *Life* is defined by the ability (1) to *replicate* and (2) by the presence of some sort of *metabolic activity*[5]. Remarkable is that this definition of life is grounded in the biological substrate, i.e., molecules. This view is incompatible with all approaches to creating ‘artificial life’ [42], where the authors are using the term ‘life’ very likely in a metaphorical sense [43].

What are the criteria for any LS, so we can call them alive? Most modern definitions avoid the noun ‘life’ and instead use the adjective ‘living,’ meaning that life is more of a *transient state* affecting some matter [44]. An LS is said to be transient or in a transient state when a process variable or parameter has been changed, and the LS has not yet reached a *steady state.* An LS or its process is in a steady state if the parameters called state parameters, which define the system’s behavior, or the process are unchanging in time. Homeostasis is the property of an LS that regulates its internal environment and tends to maintain a stable, constant condition. The concept came from that of *milieu interieur* that was defined by Bernard [45]. Multiple dynamic equilibrium adjustment and regulation mechanisms make *homeostasis* possible. “However, the controversies surrounding the definition of life are probably just symptoms of a deeper problem, and unfortunately, these have led to the larger issue of the classical divide on the approaches to the origin of life. Each definition of life has put its emphasis on a trait(s) expressed by living entities, such as their replicative capabilities, their far-from-equilibrium state, their compartmentalization, or their evolutionary potential” [44, p. 3 of 53].

Most biologists agree that the basic unit of any LS is the cell, the smallest unit of life that can function independently and perform all the necessary functions of life, including reproducing itself. “The facts that (1) all living organisms are made up of one or more cells and (2) all cells arise from other, preexisting cells are the foundations of *cell theory*, one of the unifying theories in biology, and one that is universally accepted by all biologists” [39, p. 84]. Cells are the building blocks of any LS. “All organisms, from ants to plants to people, are composed of cells—the structural and functional units of life. The phenomenon we call life emerges at the level of a cell: A cell can regulate its internal environment, take in and use energy, and respond to its environment. The ability of cells to give rise to new cells is the basis for all reproduction and the growth and repair of multicellular organisms. A cell may be part of a complex plant or animal or an organism in its own right. Indeed, single-celled bacteria and other unicellular organisms far outnumber multicellular organisms on Earth” [5, p. 44]. We cannot separate any life form from its biological substrate – the wetware [46]. We cannot create life directly, but we can modulate already existing life forms (e.g., breeding).

## 5 How We Should Think and Act

Before I can discuss our way of thinking in more detail, I have to clarify the metaphysical foundation of such a discussion [47]. Any ontology is embedded in the actual world view of a particular community. But what is an ontology? Following Guarino, Oberle, and Staab [48], the word *ontology* is used with a different meaning in different contexts.

[5] Metabolic activity is the sum of all chemical processes by which molecules are acquired and used and energy is transformed in controlled reactions.

Perhaps the most radical difference is between the philosophical meaning, which has a well-established tradition, and the computational meaning, which emerged in recent years in the knowledge engineering domain, starting from an early informal definition of computational ontologies as explicit specifications of conceptualizations. However, in the context of this paper, I will refer to a philosophical discipline, namely the branch of philosophy that deals with the nature and structure of *reality* [49]. Unfortunately, philosophers sometimes treat *metaphysics* and *ontology* as synonyms. Already Aristotle dealt with this subject in his Metaphysics and defined *ontology* as the science of *being qua being*, i.e., the study of attributes that belong to things because of their very nature [50, p. 68]. In other words, metaphysics addresses the foundation of our world view.

As Levinas puts it [51, p. 122]: "From now on, the comprehension of being does not presuppose a merely theoretical attitude, but the whole of human comportment. The whole of humanity is ontology. An individual's scientific work, his or her affective life, the satisfaction of his or her needs and labour, his or her social life and death - all these moments articulate, with a rigour which reserves to each a determinate function, the comprehension of being or truth. Our entire civilization follows from this comprehension, be it only in forgetfulness of being. It is not because there is humanity that there is truth. It is because there is truth, because being is found to be inseparable from its appearing [aperite], or if one likes, because being is intelligible, that there is humanity".

Before I discuss 'how we should think,' I will describe 'how we think' according to state of the art in cognitive science. Holyoak and Morrison define *thinking* as follows [52, p. 1]: "Thinking is the systematic transformation of mental representations of knowledge to characterize actual or possible states of the world, often in service of goals."

For our reasoning capacity, we can use *deduction*, *induction*, and *abduction* (see part 2 in [53]). Deductive reasoning is an inference rule in which the conclusion is of greater generality than the premises. Inductive reasoning is an inference rule that we infer from particular cases to the general case. Abduction is an inference rule, requiring premises encompassing explanatory considerations and yielding a conclusion that makes some statement about the truth of a hypothesis (see also the distinction in abduction-1 and -2 [54]). Of course, we have different modes of thinking [53]: (1) reasoning, (2) quantitative thinking, (3) visuospatial thinking, (4) gesture in thought, (5) musical thought, and probably many more [55]. In general, we can distinguish between implicit and explicit modes of thinking [56]. While mainstream psychology and economics focused a long time on the concept of 'full rationality' [57], Neisser already tried to overcome this bias by concentrating in his research on ecological valid real-world behavior [58].

Today Griffin et al. discuss the limitations of *full* rationality for humans: "Herbert Simon [59], early in his Nobel Prize-winning research on economic models, argued that 'full' rationality was an unrealistic assumption because of processing limitations in living systems (and, incidentally, in virtually all computers currently available). He proposed a limited form of rationality, termed 'bounded rationality,' that accepted the limited search and computational ability of human brains but nonetheless assumed that after a truncated search and after considering a limited subset of alternatives, people did act and reason rationally, at least in terms of achieving their goals" [60, p. 324]. Bounded rationality revises perfect or full rationality notions to account for the fact that perfectly rational decisions are often not feasible in practice because of the intractability of natural decision problems and the finite computational resources available for making them. Elster argued "that failure to recognize the indeterminacy of rational-choice theory can lead to irrational behaviour" [61, p. 2]. The concept of bounded rationality significantly influenced different disciplines, i.e., cognitive science, economics, law, political science, and psychology [62]. However, while in daily life this is reasonable, academia as such still operates under the assumption of unbounded rationality! [63].

"[T]he picture of non-scientists drawn by scientists be-comes bleak: a few minds discover what reality is, while the vast majority of people have irrational ideas or at least are prisoners of many social, cultural and psychological factors that make them stick obstinately to obsolete prejudices. The only redeeming aspect of this picture is that if it were only possible to eliminate all these factors that hold people, prisoners of their prejudices, they would all, immediately and at no cost, become as sound-minded as the scientists, grasping the phenomena without further ado. In every one of us, there is a scientist who is asleep, and who will not wake up until social and cultural conditions are pushed aside" [64, pp. 184–185].

From around 1960 to 2000, the psychology of reasoning was – according to Evans [65] – strongly focused on the *deduction* paradigm, in which test subjects are assessed for their ability to judge the logical validity of arguments without any prior training or instruction. However, since the 1980s, experimental evidence has accumulated indicating that ordinary people were poor at logical reasoning because of being strongly influenced by irrelevant features of the content and subject to several other cognitive biases. As a result, the deduction paradigm has shifted in the past 20–25 years; there is also a lot more interest in human reasoning as a probabilistic and pragmatic rather than deductive process (see [62]).

**Table 2.** Dual-process theories of reasoning and higher cognition (from [65, p. 116]).

| Type-1 processes | Type-2 processes |
|---|---|
| Unconscious, preconscious | Conscious |
| Rapid | Slow |
| Automatic | Controlled |
| Low effort | High effort |
| High capacity | Low capacity |
| Associative | Rule-based |
| Intuitive | Deliberative |
| Contextualized | Abstract |
| Cognitive biases | Normative reasoning |
| Independent of cognitive capacity (IQ, WMC)[a] | Correlated with individual differences in cognitive capacity |
| System-1 | System-2 |

[a]IQ = intelligence quotient; WMC = working memory capacity.

Dual-Process Theories (DPT) are the focus of much research in cognitive and social psychology and have several independent origins. The main characteristics are summarized in Table 2. I already discussed the relationship between system-1 and -2 regarding time travel in [66]. Evans [65] has shown how dual-process accounts were developed from the 1970s onward within the study of deductive reasoning, primarily as an attempt to explain why cognitive biases coexisted and competed with attempts at effortful logical reasoning on these tasks. More recently, reasoning researchers have examined individual differences in cognitive capacity linked with type-2 *analytic* reasoning. They have also introduced a range of experimental and neuroscientific methods to identify dual processes. However, Evans has also shown how several fallacies have arisen in the received view of DPT, both within the psychology of reasoning and more generally.

Evans has identified five fallacies associated with DPT of *thinking* and *reasoning* [65, p. 117]: (1) All dual-process theories are essentially the same; (2) there are just two systems underlying type-1 and -2 processing; (3) type-1 processes are responsible for cognitive biases; type-2 processes for normatively correct responding; (4) type-1 processing is contextualized, whereas type-2 processing is abstract; and (5) fast processing indicates the use of a type-1 rather than type-2 process. All those five assumptions seem to be wrong. The next generation of DPTs provides a comprehensive overview of the new directions in which dual-process research is heading [67]. Human thinking is often characterized as an interplay between intuition and deliberation. This two-headed, dual-process view of human thinking has been very influential in the cognitive sciences and popular media. However, despite the popularity of DPTs, they face multiple challenges [65]. Recent advances indicate a strong need to re-think some of the fundamental assumptions of the original dual process model [68]. One challenge is to answer why and for what *emotions* are essential.

As I wrote already [69], if we assume *emotions* are perceived as essential aspects in relation with other cognitive functions, then we could go so far as to conceptualize emotions as the appearance of these implicit cognitive processes to our explicit conscious. This process is an internal perception loop about our own mental and bodily states (see Fig. 2 in [70]). Suppose we assume further that the information processing capacity of the unconscious (i.e., system-1) is several magnitudes higher than the conscious (i.e., system-2), and both systems are somehow separate. In that case, we have to answer how these two systems 'communicate.' My idea is that *emotions* can play this role as the 'voice of the unconscious' in telling the conscious the solutions found in a high-dimensional space. These emotions are not only to inform the conscious but also to the social context around us. Our body language is also part of the emotional expression space for adjusting social relations in a specific context [71].

So far, I have discussed that our cognitive architecture exists at least out of two different systems, which can be described with two different types of thinking processes. I have also argued that both systems can communicate via emotions. We know that rational thinking is limited and must be extended [72]. But where can we learn from to enhance our new way of thinking? First, I will introduce cultural differences between the West and East, and then I will discuss what we can learn from indigenous cultures.

There is a fundamentally different way of thinking between western and eastern cultures. Westerners and East Asians perceive the world and act in it in very different ways [73, 74]. *Westerners* pay primary attention to some focal object, analyzing its attributes and categorizing it to determine its behavior. The way to determine is mainly based on formal logic. Causal attributions are prime and tend to focus exclusively on the object; therefore, they are often mistaken. On the other side, *East Asians* pay immediate attention to a broad perceptual and conceptual field, noticing relationships and changes and grouping objects based on familiarities rather than categories. East Asians relate causal attributions to the context/environment instead of objects. Mainly social factors are directing the East Asians' attention because they live in complex social networks with determined role relations. Attention to the context is more important than to objects for effective functioning [75].

In contrast, Westerners live independently in less constraining social worlds and attend to the object and their goals with respect to it. Physical 'affordances' of the environment can also influence perception but is assumed less critical. For example, the built environments of the West are less complex and contain fewer objects than do those of the East. In addition, artistic products of the East emphasize the field and deemphasize objects. In contrast, Western art renders less of the field and highlights individual objects and people (see at [74, p. 11163]).

The western way of thinking – the MWV – underestimates the influential power of the context, environment resp., and focuses too much on the objects and their relationships with each other. While we know already that we can only understand an LS together with its ecotrope, we must enhance our Western way of thinking towards the Eastern way. Additionally, another invaluable source to consider for our future way of thinking is knowledge from indigenous cultures [76].

Nelson "believes we are at a crossroads in time. Within one instant, monumental changes can be made. Since the world is now globally connected, there is no excuse anymore. We are very aware of the fragility of the disbalance between humans and nature, and now is the time to act. Let us learn from the wisdom and way of life of indigenous peoples. They are rich because they feel. They are wise because they let nature be their guide. They are loving because they take care of each other. They are enlightened because they live life to the fullest. Let us be inspired and let them lead us into the future. We need it for the survival of humanity" [77, p. 8].

*Traditional Ecological Knowledge* (TEK) has emerged growing recognition that indigenous people worldwide developed sustainable *Indigenous Knowledge* (IK) that can be used to address problems we are facing on a global scale. Suzuki wrote, "my experiences with aboriginal peoples convinced me… of the power and relevance of their knowledge and world view in a time of imminent global eco-catastrophe" [78, p. xliv]. Following Mistry, it is helpful to have five commonly accepted characteristics of IK [79, pp. 371f]:

1. *Local* – IK is context-specific in that it has roots in a particular place and in the experiences of the people that live in that location. Transferring that knowledge to another location quite literally makes it meaningless.
2. *Oral transmission* or through imitation and demonstration – whether it be through stories, myths, songs, or through accompanying other people and observing and learning, IK is rarely written down. Yet, writing it down can change some of the fundamental properties of knowledge.

3. *Adaptive capacity* – over time and through everyday life experiences, IK is adapted through repetition, learning, experimentation, and the adoption of novel solutions. It is therefore not static but constantly changing.
4. *Social memory* – IK is shared to a much greater extent than other forms of knowledge. This shared understanding and knowledge are vital as it helps to establish a long-term communal understanding of people's environment and the transmission of pertinent experience. However, the distribution of this knowledge can still be socially differentiated, for example, by age and gender, and preserved in the memories of particular individuals by virtue of their spiritual or political status.
5. *Holistic* – IK is situated within numerous interlinked facets of people's lives. Therefore, it is difficult and impractical to separate, for example, the cultural from the ecological or the rational from the non-rational.

Shilling summarizes some crucial characteristics from North America's IK as follows: (1) *Reciprocity and respect* define the bond between all members of the land family. (2) *Reverence toward nature* plays a critical role in religious ceremonies, hunting rituals, arts and crafts, agricultural techniques, and other day-to-day activities. (3) One's *relationship to the land* is shaped by something other than economic profit. (4) To speak of an individual *owning land is anathema*, not unlike owning another person, akin to slavery. (5) Each generation is *responsible for leaving a healthy world* to future generations [80, p. 12].

How do IK and TEK relate to each other? Johnson describes TEK as "a body of knowledge built up by a group of people through generations of living in close contact with nature. It includes a system of classification, a set of empirical observations about the local environment, and a system of self-management that governs resource use. The quantity and quality of traditional environmental knowledge vary among community members, depending upon gender, age, social status, intellectual capability, and profession (hunter, spiritual leader, healer, etc.). With its roots firmly in the past, traditional environmental knowledge is both cumulative and dynamic, building upon the experience of earlier generations and adapting to the new technological and socioeconomic changes of the present" [81, p. 4].

However, according to McGregor, "there is a major dichotomy in the realm of TEK that needs to be understood: (1) there is the Aboriginal view of TEK, which reflects an Indigenous understanding of relationships to Creation[6], and (2) there is the dominant Eurocentric view of TEK, which reflects colonial attitudes toward Aboriginal people and their knowledge" [82, p. 386]. Because each local IK base contains this particular culture's whole ontology and epistemology, we can conclude that TEK is a derivative of IK. TEK can be regarded as a subset of all available IKs.

As McGregor puts it: "TEK is *not merely* descriptive knowledge about the natural environment, knowledge gained by experience in a place, but also prescriptive – that is, it provides an account of how people *ought* to act in relationship to nature. TEK is then a blend of science, spirituality, and ethics. In this way (and in many others),

[6] Many indigenous religions regard *creation* as an on-going process in which they are morally and religiously obligated to participate [see: Lyng v. Northwest Cemetery Ass'n, 485 U.S. 439, 460 (1988), Brennan, J. dissenting].

it differs from traditional Western scientific accounts of nature that merely describe nature (Mendelian genetics, for example) but says nothing about how we morally ought to treat nature" [83, pp. 109f]. What TEK in the context of IK characterizes is the normative aspect; while scientific knowledge framed by MWV avoids being normative, TEK cannot be understood without nature-oriented values. Fortunately, this normative approach is already reflected in the United Nations resolution from 2015 [84]. The seventeen 'Sustainable Development Goals' are specified as follows:

"Goal 1. End poverty in all its forms everywhere.
Goal 2. End hunger, achieve food security and improve nutrition and promote sustainable agriculture.
Goal 3. Ensure healthy lives and promote well-being for all at all ages.
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
Goal 5. Achieve gender equality and empower all women and girls.
Goal 6. Ensure availability and sustainable management of water and sanitation for all.
Goal 7 Ensure access to affordable, reliable, sustainable, and modern energy for all.
Goal 8. Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
Goal 10. Reduce inequality within and among countries.
Goal 11. Make cities and human settlements inclusive, safe, resilient, and sustainable.
Goal 12. Ensure sustainable consumption and production patterns.
Goal 13. Take urgent action to combat climate change and its impacts.
Goal 14. Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation and halt biodiversity loss.
Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development" [84, p. 14].

Since 2015, the United Nations Secretary-General has regularly appointed a group of independent *scientists* to monitor the progress worldwide [85]. Already in the first report from 2015, IK has been mentioned: "Consideration of a broader range of knowledge and in particular indigenous knowledge is critical to the credibility and legitimacy of science-policy interface mechanisms" [85, p. 34]. Indigenous people are only considered as a 'vulnerable group'; this seems to be a clear case for McGregor's Eurocentric critique. Unfortunately, IK is not considered a source of inspiration to fundamentally change our way of thinking and acting in the world. IK should be mainly addressed to 'enhance credibility and legitimacy.' Monitoring the progress in achieving the sustainable development goals is still dominated by the MWV way of thinking and reasoning. So, we still have to go a long way to become wise, humble, responsible, and accountable!

Beauregard and colleagues wrote a manifesto for a post-materialist science. They conclude that "the shift from materialist science to post-materialist science may be of vital importance to the evolution of the human civilization" [86, p. 274]. "When we decide that the purpose of science is to generate wonder about nature, rather than to control nature, we will not be far from a relationship with nature that can flourish for all time and generations" [87, p. 129]. As academics and as responsible citizens, we have to put *spirituality* back on our agenda [88].

## 6 Conclusions

To overcome our mechanistic worldview (MWV), I introduced and discussed the fundamental difference between non-living things (NLT) and living systems (LS). The way of thinking in the MWV the Western academics follow these eight doctrines: (1) causality, (2) determinism, (3) localism, (4) materialism, (5) mechanism, (6) physicalism, (7) realism, and (8) reductionism. History has proven that this way of thinking is compelling to master NLTs and enables technological developments of tremendous power. But unfortunately, MWV cannot deal with LSs adequately and responsibly. Consequently, humanity is facing dramatic global challenges, of which today nobody knows how to overcome to avoid catastrophes. I argue that the way of thinking that produced these challenges is probably insufficient to overcome them. So, we need a *new* way of thinking and acting. I sketched two primary sources of inspiration for this new way of thinking: (a) the Eastern, Asian way of focusing on the context and environment first (i.e., a holistic dimension), and (b) the humble attitude of Indigenous thinking toward nature (i.e., value-driven reasoning). I sincerely hope this paper contributes to the *transformational power* in our way of thinking and acting in the world we all desperately need. This transformation will last long, but I am afraid it has to be done.

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## References

1. Dijksterhuis, E.J.: The Mechanization of the World Picture. Clarendon Press, Oxford (1961)
2. Bateson, G.: Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology, 7th edn. Ballantine Books, New York (1978)
3. Sheldrake, R.: The Science Delusion: Freeing the Spirit of Enquiry. Coronet, London (2012)
4. Labadi, S.: UNESCO, Cultural Heritage, and Outstanding Universal Value: Value-Based Analyses of the World Heritage and Intangible Cultural Heritage Conventions. AltaMira Press, Lanham, New York, Toronto, Plymouth (2013)
5. Taylor, M.R., et al.: Campbell biology: Concepts and connections. 10th (edn.) Essex: Pearson Higher Education (2022)

6. Freudenthal, G.: Atom and individual in the age of Newton: on the genesis of the mechanistic world view. In: Cohen, R.S., Wartofsky, M.W. (eds.) Boston Studies in the Philosophy of Science, vol. 88. Dordrecht: D. Reidel Publishing Company (1986)
7. Hawking, S., Mlodinow, L.: The Grand Design. Bantam Books, New York (2010)
8. Leydeckers, S.: Hello nanomaterials – Towards cultural (r)evolution. In: Hørmann, M. (ed.) Hello Materials Blog, Danish Design Center: Copenhagen (2012)
9. Merchant, C.: The Death of Nature. Women, Ecology and the Scientific Revolution. Harper & Row, San Francisco (1983)
10. Archer, D., Rahmstorf, S.: The Climate Crisis: an Introductory Guide to Climate Change. Cambridge University Press, Cambridge (2010)
11. Buchanan, R.A.: The power of the machine: the impact of technology from 1700 to the present day. Viking-Penguin Books, London, New York (1992)
12. Hornborg, A.: The Power of the Machine: Global Inequalities of Economy, Technology, and Environment. AltaMira Press, Walnut Creek, Lanham, New York, Oxford (2001)
13. Husbands, P., Holland, O., Wheeler, M. (eds.) The mechanical mind in history. MIT Press, Cambridge, London (2008)
14. Zhang, L.-F.: Thinking styles: their relationships with modes of thinking and academic performance. Educ. Psychol. **22**(3), 331–348 (2002)
15. Radin, D.: Supernormal: Science, Yoga, and the Evidence for Extraordinary Psychic Abilities. Deepak Chopra, New York (2013)
16. Radin, D.: Entangled Minds: Extrasensory Experiences in a Quantum Reality. Sydney: Paraview Pocket Books, New York, London, Toronto (2009)
17. Kutrovátz, G.: Heat death in ancient and modern thermodynamics. Open. Syst. Inf. Dyn. **8**(4), 349–359 (2001)
18. Ulanowicz, R.E.: Increasing entropy: Heat death or perpetual harmonies? Int. J. Des. Nat. Ecodyn. **4**(2), 83–96 (2009)
19. Serway, R.A., Jewett, J.W.: Physics for Scientists and Engineers with Modern Physics, 9th edn. Brooks/Cole, Boston (2014)
20. Rauterberg, M.: How is culture and cultural development possible? In: Hachimura, K., Ishida, T., Tosa, N. (eds.) International Conference on Culture and Computing, pp. 177–178. IEEE, Kyoto (2013)
21. Swenson, R., Turvey, M.T.: Thermodynamic reasons for perception-action cycles. Ecol. Psychol. **3**(4), 317–348 (1991)
22. Swenson, R.: Autocatakinetics, evolution, and the law of maximum entropy production: a principled foundation towards the study of human ecology. Adv. Hum. Ecol. **6**, 1–48 (1997)
23. Verbeek, P.-P.: What Things do: Philosophical Reflections on Technology, Agency, And Design. University Park: Pennsylvania State University Press (2005)
24. Meadows, D., Randers, J., Meadows, D.: Limits to Growth: the 30-Year Update. Sterling: Earthscan, London (2004)
25. Yanofsky, N.S.: The Outer Limits of Reason: What Science, Mathematics, and Logic Cannot Tell us. MIT Press, Cambridge, London (2013)
26. Whittaker, R.H., Levin, S.A., Root, R.B.: Niche, habitat, and ecotope. Am. Nat. **107**(955), 321–338 (1973)
27. Ameriks, K., Clarke, D.M. (eds.) Aristotle, Nicomachean Ethics. Cambridge Texts in the History of Philosophy. Cambridge University Press, Cambridge, New York, Melbourne, Madrid (2014)
28. Hennig, B., Rauterberg, M.: The Significance of Aristotle's four Causes for Design. Design Issues. **Manuscript** (under review), pp. 1–19 (2022)
29. Gasparatou, R., Ergazaki, M., Kosmopoulou, N.: Using philosophy for children to introduce the living/non-living distinction in kindergarten. Int. J. Early Years Educ. 1–16 (2020). (in press)

30. Petr, J.: The use of living and non-living things during school practice in primary science education. New Educ. Rev. **32**(2), 255–263 (2013)
31. Scerri, E.R.: The evolution of the periodic system. Sci. Am. **279**(3), 78–83 (1998)
32. Ablondi, F.: Automata, living and non-living: descartes' mechanical biology and his criteria for life. Biol. Philos. **13**(2), 179–186 (1998)
33. Rauterberg, M.: The three phases of life: An inter-cultural perspective. In: Hachimura, K., Ishida, T., Tosa, N. (eds.) Culture and Computing 2011, pp. 80–85. IEEE Computer Society, Los Alamitos (2011)
34. Hooper-Greenhill, E.: Museums and Education: Purpose, Pedagogy, Performance. Routledge, London, New York (2007)
35. Varsha, R.: Non-living things: properties, detailed classification and differences. In: Embibe, B., Avasthi, A. (eds.). Indiavidual Pvt. Ltd: Bengaluru (2022)
36. Naremore, J.: Love and death in A.I. artificial intelligence. Mich. Q. Rev. **44**(2), 256–284 (2005)
37. Schrödinger, E.: What is life? The Physical Aspect of the Living Cell. Cambridge University Press, Cambridge (1944)
38. Gibbs, J.W.: A method of geometrical representation of the thermodynamic properties by means of surfaces. Trans. Conn. Acad. Arts Sci. **2**, 382–404 (1873)
39. Phelan, J.: what is Life? A Guide to Biology, 2nd (edn.). W.H. Freeman, New York (2013)
40. Oparin, A.I.: The Origin of Life on the Earth, 3rd edn. Academic Press, New York (1957)
41. Seckbach, J. (ed.) Origins: genesis, evolution and diversity of life. In: Seckbach, J. (ed.) Cellular Origin and Life in Extreme Habitats and Astrobiology, vol. 6. Kluwer Academic Publishers, Dordrecht (2004)
42. Langton, C.G. (ed.) Artificial Life: an Overview. MIT Press, Cambridge, London (1996)
43. Boudry, M., Pigliucci, M.: The mismeasure of machine: Synthetic biology and the trouble with engineering metaphors. Stud. Hist. Philos. Sci. Part C: Stud. Hist. Philos. Biol. Biomed. Sci. **44**(4, Part B), 660–668 (2013)
44. Camprubí, E., et al.: The emergence of life. Space Sci. Rev. **215**(8), 1–53 (2019)
45. Bernard, C.: Lectures on the phenomena of life common to animals and plants. In: Thomas, C.C. (ed.) 1875 American Lecture Series, vol. 900. Charles C Thomas Publisher, Springfield (1974)
46. Bray, D.: Wetware: A Computer in Every Living Cell. Yale University Press, New Haven (2009)
47. Saariluoma, P.: Foundational Analysis: Presuppositions in Experimental Psychology. Routledge, London, New York (1997)
48. Guarino, N., Oberle, D., Staab, S.: What is an ontology? In: Staab, S., Studer, R. (eds.) Handbook on ontologies. IHIS, pp. 1–17. Springer, Heidelberg (2009). https://doi.org/10.1007/978-3-540-92673-3_0
49. Hacking, I.: Historical ontology. In: Gärdenfors, P., Wolenski, J., Kijania-Placek, K. (eds.) In the Scope of Logic, Methodology and Philosophy of Science, pp. 583–600. Springer Science+Business Media, Dordrecht (2002). https://doi.org/10.1007/978-94-017-0475-5_13
50. Reeve, C.D.C.: Substantial Knowledge: Aristotle's Metaphysics. Hackett Publishing, Indianapolis, Cambridge (2000)
51. Levinas, E.: Is ontology fundamental? Philos. Today **33**(2), 121–129 (1989)
52. Holyoak, K.J., Morrison, R.G.: Thinking and reasoning: a reader's guide. In: Holyoak, K.J., Morrison, R.G. (eds.) The Oxford Handbook of Thinking and Reasoning, pp. 1–7. Oxford University Press, Oxford, New York (2012)
53. Holyoak, K.J., Morrison, R.G.: The oxford handbook of thinking and reasoning. In: Nathan, P.E. (ed.) Oxford Library of Psychology. Oxford University Press, Oxford, New York (2012)
54. Dorst, K.: The core of 'design thinking' and its application. Des. Stud. **32**(6), 521–532 (2011)

55. Freeman, M.: Modes of Thinking for Qualitative Data Analysis. Routledge, New York, London (2017)
56. Reber, A.S.: Implicit learning and tacit knowledge: an essay on the cognitive unconscious. In: Schacter, D. (ed.) Oxford Psychology Series. Oxford University Press, Oxford (1993)
57. Hunt, E.K., Lautzenheiser, M.: History of Economic Thought: a Critical Perspective. 3rd (edn.). M.E. Sharpe, Inc., New York, London (2011)
58. Neisser, U.: Memory observed: Remembering in Natural Contexts. W.H. Freeman, San Francisco (1982)
59. Simon, H.A.: Models of man: Social and rational. Mathematical Essays on Rational Human Behavior in a Social Setting. Wiley, New York (1957)
60. Griffin, D.W., et al.: Judgmental heuristics: a historical overview. In: Holyoak, K.J., Morrison, R.G. (eds.) The Oxford Handbook of Thinking and Reasoning, pp. 322–343. Oxford University Press, Oxford, New York (2012)
61. Elster, J., *Solomonic judgements: Studies in the limitation of rationality*. 1989, Cambridge • New York • Melbourne • Paris: Cambridge University Press
62. Gigerenzer, G., Selten, R. (eds.) Bounded Rationality: The Adaptive Toolbox. MIT Press, Cambridge, London (2001)
63. Dunbar, K., Fugelsang, J.: Scientific Thinking and Reasoning. In: Holyoak, K.J., Morrison, R.G. (eds.) The Cambridge Handbook of Thinking and Reasoning, pp. 705–725. Cambridge University Press, Cambridge, New York (2005)
64. Latour, B.: Science in Action: How to Follow Scientists and Engineers Through Society. Harvard University Press, Cambridge (1987)
65. Evans, J.S.B.T.: Dual-process theories of deductive reasoning: facts and fallacies. In: Holyoak, K.J., Morrison, R.G. (eds.) The Oxford Handbook of Thinking and Reasoning, pp. 115–133. Oxford University Press, Oxford, New York (2012)
66. Wang, X., Rauterberg, M.: Time travel in our mind based on system 2. In: Atmanspacher, H., Hameroff, S. (eds.) Book of Abstracts of the 13th Conference of the Science of Consciousness, pp. 130–131. Collegium Helveticum Zurich, Zurich (2019)
67. De Neys, W. (ed.) Dual Process Theory 2.0. In: Ball, L. (ed.) Current Issues in Thinking and Reasoning. Routledge, London, New York (2018)
68. Kahneman, D.: Thinking, Fast and Slow, 1st pbk. Farrar, Straus and Giroux, New York (2013)
69. Rauterberg, M.: Emotions as a communication medium between the unconscious and the conscious. In: Nakatsu, R., et al. (eds.) Cultural Computing - Second IFIP TC 14 Entertainment Computing Symposium, pp. 198–207. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-15214-6_20
70. Rauterberg, M.: About a framework for information and information processing of learning systems. In: Falkenberg, E.D., Hesse, W., Olivé, A. (eds.) Information System Concepts - Towards a Consolidation of View, pp. 54–69. Chapman & Hall, London, New York, Tokyo, Melbourne. (1995)
71. Patterson, M.L.: Nonverbal behavior: a functional perspective. In: Social Psychology. Springer Verlag, New York, Berlin, Heidelberg, Tokyo (1983)
72. Cook, K.S., Levi, M. (eds.) The Limits of Rationality. The University of Chicago, Chicago, London (1990)
73. Nisbett, R.E., et al.: Culture and systems of thought: holistic versus analytic cognition. Psychol. Rev. **108**(2), 291–310 (2001)
74. Nisbett, R.E., Masuda, T.: Culture and point of view. Proc. Natl. Acad. Sci. **100**(19), 11163–11170 (2003)
75. Libert, S., Pletcher, S.D.: Modulation of longevity by environmental sensing. Cell **131**(7), 1231–1234 (2007)
76. De La Cadena, M., Starn, O.: Introduction. In: De La Cadena, M., Starn, O. (eds.) Indigenous Experience Today, pp. 1–30. Berg, Oxford, New York (2007)

77. Nelson, J.: Before they Pass Away, 2nd edn. JN Publishing, Haelen (2020)
78. Suzuki, D., Knudtson, P.: Wisdom of the Elders: Sacred Native Stories of Nature. Bantam Books, New York, Toronto, London, Sydney (1992)
79. Mistry, J.: Indigenous knowledges. In: Kitchin, R., Thrift, N. (eds.) International Encyclopedia of Human Geography, pp. 371–376. Elsevier, Amsterdam, Boston, Heidelberg, London, New York (2009)
80. Shilling, D.: Introduction: the soul of sustainability. In: Nelson, M.K., Shilling, D. (eds.) Traditional Ecological Knowledge: Learning from Indigenous Practices for Environmental Sustainability, pp. 3–14. Cambridge University Press, Cambridge, New York, Melbourne, New Delhi, Singapore (2018)
81. Johnson, M.: Lore: Capturing Traditional Environmental Knowledge. Diane Publishing, Pennsylvania (1998)
82. McGregor, D.: Coming full circle: Indigenous knowledge, environment, and our future. Am. Indian Q. **28**(3/4), 385–410 (2004)
83. McGregor, J.: Toward a philosophical understanding of TEK and ecofeminism. In: Nelson, M.K., Shilling, D. (eds.) Traditional Ecological Knowledge: Learning from Indigenous Practices for Environmental Sustainability, pp. 109–128. Cambridge University Press, Cambridge, New York, Melbourne, New Delhi, Singapore (2018)
84. United-Nations, resolution 70/1-transforming our world: the 2030 agenda for sustainable development. In: Seventieth United Nations General Assembly, Secretary-General. United Nations, New York (2015)
85. Le Blanc, D., et al.: Global sustainable development report. Advanced unedited ed, ed. U.N. Secretary General. United Nations, New York (2015)
86. Beauregard, M., et al.: Manifesto for a post-materialist science. Explore J. Sci. Healing **10**(5), 272–274 (2014)
87. Nelson, M.P., Vucetich, J.A.: Wolves and ravens, science and ethics: traditional ecological knowledge meets long-term ecological research, in traditional ecological knowledge: learning from Indigenous practices for environmental sustainability. In: Nelson, M.K., Shilling, D. (eds.). Cambridge University Press, Cambridge, New York, Melbourne, New Delhi, Singapore. pp. 129–136 (2018)
88. Kheirandish, S., et al.: A comprehensive value framework for design. Technol. Soc. **62**(art. 101302), 1–12 (2020)

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