E-JOURNAL (2020)
9. JAHRGANG / 1

zfl

FORUM INTERDISZIPLINÄRE BEGRIFFSGESCHICHTE (FIB)

LEIBNIZ-ZENTRUM
FÜR LITERATUR- UND
KULTURFORSCHUNG

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IMPRESSUM

Herausgeber dieser Ausgabe
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Direktorin
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Redaktion
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Gestaltung	KRAUT & KONFETTI GbR, Berlin
Layout/Satz	Constantin Sinn
Titelbild	D. M. Nagu

ISSN 2195-0598

INHALT

THE ENERGETIC LEGACY OF ANTHROPOCENE THOUGHT

Anna Simon-Stickley

"In thousands of years, when, seen from the distance, only the broad lines of the present age will still be visible, our wars and our revolutions will count for little, even supposing they are remembered at all; but the steam engine, and the procession of inventions of every kind that accompanied it, will perhaps be spoken of as we speak of the bronze or of the chipped stone of pre-historic times: it will serve to define an age." (Henri Bergson, *Creative Evolution*)[1]

In May 2019, the Anthropocene Working Group, after ten years of scientific research and debate, voted 97% in favor of defining the contemporary geological era as the Anthropocene – the age of the human as geological force.[2] The term Anthropocene has, in the recent years, experienced a steep career – one that has sprawled outside of its geological birthplace and into virtually all natural sciences and all humanities disciplines. To illustrate, Google Ngram's graph for the term Anthropocene plods along the twentieth century before skyrocketing in the year 2000 – mirroring the trajectory of 'hockey stick' graph of global temperature increase that has become so iconic of the 'Anthropocene' itself.[3] Both images visualize what many scientists and scholars have been asserting ever since the atmospheric chemist Paul Crutzen, frustrated by a conference discussion of human impacts in the Holocene era, proclaimed that the Holocene had ended. Grasping for words, he declared we were actually living through the 'Anthropocene' – the geological age in which human influence has inscribed itself onto and into the Earth, the oceans, and the atmosphere. Hence, it is not a term that merely *describes* human influence on Earth but points its *extent*. Humans, the Anthropocene term implies, have broken onto new spatiotemporal scales. Whereas for millennia humans scampered across the surface of planet Earth barely making a scratch, today, Anthropocene scholars agree, humans leave traces, often irreversible traces, on a global scale. But how did this shift in perspective – counterintuitive at least from a Western modernist worldview – come about? Though there are no doubt many intellectual avenues[4] this conceptual history has taken, I intend to shed light on its historical entanglement with the discourse of energy and entropy.

At first glance, this sounds plausible. After all, all major contenders for the starting date of the Anthropocene describe a shift in energy use. For example, the original proposal by Crutzen and Stoermer was the massive increase of fossil fuel extraction and use around 1800.[5] From this point on, humankind embarked on a trajectory that liberated it from the energy

1 Henri Bergson: *Creative Evolution* (1907), translated by Arthur Mitchell, London 1911, p. 146.

2 Anthropocene Working Group: "Results of Binding Vote by AWG," International Commission of Stratigraphy, Subcommission on Quartenary Stratigraphy, press release from the 21st May 2019, http://quaternary.stratigraphy.org/working-groups/anthropocene/ (accessed 28th June 2020).

3 This is GoogleBook's tool for mining specific words and phrases within their text corpus, which spans many European languages and reaches back to 1800, making it extremely valuable for a digitally supported *Begriffsgeschichte*. The "Anthropocene" graph is available at: https://books.google.com/ngrams/graph?content=Anthropocene&case_insensitive=on&year_start=1800&year_end=2008&corpus=15&smoothing=3&share=&direct_url=t4%3B%2CAnthropocene%3B%2Cc0%3B%2Cs0%3B%3BAnthropocene%3B%2Cc0%3B%3Banthropocene%3B%2Cc0 (accessed 27th June 2020).

4 Thus, I neglect the no doubt important aspect of time as discussed in environmental history, in favor for energy historiography. I also side-line the problem of scale, save for a few remarks on how the logic of energy enables up-scaling. Furthermore, I discuss the worldview of modernity from which the 'Anthropocene' attempts to depart only implicitly. These issues are discussed in length in Eva Horn/Hannes Bergthaller: *The Anthropocene. Key Issues for the Humanities*, London 2020.

5 Paul Crutzen/Eugene Stoermer: "The 'Anthropocene,'" in *Global Change Newsletter* 41 (2000), pp. 17–18 and Paul Crutzen: "The Geology of Mankind," in: *Nature* 415 (2002), issue 6867, p. 23.

regime of agriculture, propelling its reach across the globe and deep into its crust. This proposal appears especially plausible from the perspective of the humanities as it coincides with other designated periods of human history: the beginning of modernity, colonialism, the Industrial Revolution, and consumer culture.[6] Other suggestions have been the Agricultural Revolution, as the inception of humankind's terraforming activity, and the Columbian Exchange, which significantly changed global ecology by trafficking flora and fauna across the globe, liberating Europeans from the famines that had haunted them for centuries.[7] Here, a change in the nutritional resources is defined as hailing the anthropocentric age. And lastly, the detonation of the first atomic bomb in 1945 has been proposed, as it displays the so-called 'golden spike' of nuclear radiation spread over the far corners of the globe – and conveniently coincides with the so-called Great Acceleration from the 1950s onwards. Here, too, the energetic legacy is evident. The 'golden spike' is the entropic trace left by the exertion of the largest amount of energy ever released.

However, this paper does not intend to write a history of the Anthropocene as an earthly break meriting a new geological epoch but a history of the concept. The contemporary Anthropocene concept is characterized by an astute awareness of the co-dependence of human civilization and its energetic resources, by the conviction that the human animal is entangled on all levels with its living and non-living environment, and by the perceived need for recalibrating the worldviews and epistemologies that, throughout modernity, served us to understand the world. All of these conceptual implications have a history that is intertwined with but not determined by the energetic changes. The discourse on which the Anthropocene concept builds developed alongside and in reaction to the changed material reality. Thus, for instance, the experience of colonialism and industrialization in the eighteenth and nineteenth centuries engendered the beginnings of ecological awareness,[8] and in the twentieth century the threat of nuclear warfare, resource scarcity, and unfettered economic growth lead to the environmental movement. Taking into account the specific historico-epistemological contexts, I ask how the concept of energy shaped the knowledges, epistemological attitudes, and worldviews that are integrated in the Anthropocene concept today. From this an image emerges in which the concept of energy generated both the justification of the large-scale extortion of nature but also the very worldview that purports to subvert it: the Anthropocene.

I. THE EPISTEMIC BREAK OF THE ANTHROPOCENE

One may rightly maintain that the Anthropocene concept has only just broken onto the historical stage and has turned fundamental epistemological distinctions upside down. Can one really do it justice by scraping together shreds of historical thought into a straw man of a concept? This contention has, in fact, been voiced by some Anthropocene scholars. For instance, the philosopher Clive Hamilton has argued that the Anthropocene, as the paradigm of the Earth system sciences, represents a Kuhnian 'paradigm shift,' or a 'scientific revolution' that, when historicized, "depraves it of its profound significance."[9] Any references to historical precursors are vain attempts at bolstering "the credibility of the new concept by locating it within a respected tradition."[10]

Indeed, Georges Canguilhem has warned us that historiography often falls victim to the all to "starry-eyed,"[11] uncritical narratives that, as Bachelard said, made "every vague shimmering of the past seem like bright lights" of rationality.[12] By making the faint glints of the past into glaring headlights announcing the arrival of modern concepts (think, for example, of the

6 Though this Eurocentric perspective has been heavily criticized. After all, not all humans have participated in these events. See Horn/Bergthaller: *The Anthropocene* (note 4), p. 29 and the concluding chapter entitled "Conclusion: How Western is the Anthropocene?" on pages 170–176.

7 Simon Lewis/Mark Andrew Maslin: "Defining the Anthropocene," in: *Nature* 519 (2015), issue 7548.

8 Bonneuil and Fressoz have termed such notions as 'ecological reflexivity.' See Christophe Bonneuil/Jean-Baptiste Fressoz: *The Shock of the Anthropocene: The Earth, History and Us*, London 2016.

9 Clive Hamilton: "The Anthropocene as rupture," in: *The Anthropocene Review* 3 (2016), issue 2, pp. 93–106, here p. 94. Such genealogies were often uncritically prefixed in early introductions to the new concept. For examples see Crutzen: "The Geology of Mankind" (note 5), p. 23; Will Steffen/Jacques Grinevald/Paul Crutzen et al.: "The Anthropocene: conceptual and historical perspectives," in: *Transactions of the Royal Society* 369 (2011), pp. 842–867.

10 Clive Hamilton/Jacques Grinevald: "Was the Anthropocene anticipated?," in: *The Anthropocene Review* 2 (2015), issue 1, pp. 59–72, here p. 60.

11 Georges Canguilhem: *Wissenschaftsgeschichte und Epistemologie. Gesammelte Aufsätze*, translated by Michael Bischoff and Walter Seittner, ed. by Wolf Lepenies, Frankfurt a. M. 1979, p. 12.

12 Ibid., quoted from Gaston Bachelard: *Le rationalisme appliqué*, Paris 1949.

topos of the forgotten genius) historians had, according to Canguilhem, created an army of precursors that in reality were none. One must, then, pay attention to the semantic discontinuities of concepts (*Begriffe*), even those manifested in the very same terms.

With this caution in mind, notions describing the entanglement of humans, economies, resources, and prehistoric carbon energy as well as the proclamation of 'human ages' must be viewed with critical distance – and seen as critically distant. The notion of the Anthropocene represents a radically new concept, one that departs from earlier notions on one key point: All invocations of human ages and of the role of mankind within the web of nature were concepts meaningful to the *human* realm. They were relevant either to human history or as diagnosis of human societies. Today, however, the geological force of humankind is discussed within the sciences themselves. Human impact is being treated as one earthly factor in line with geological and ecological forces. When scientists uttered proto-Anthropocene thoughts before the 2000 conference, their claims were directed at society and at politics, aiming to show the extent of human destruction by likening homo sapiens to geological factors. Today, however, we no longer say humans are *like* geological forces to make a point. Today, scientists understand human impact to *be* a geological force. We have moved from an analogy to a totalizing metaphor backed by the authority of the natural sciences.

The Anthropocene can therefore be characterized as what Bachelard termed an "epistemic break."[13] Writing during the turbulent beginnings of the twentieth century, Bachelard witnessed the actual refutation of presumably universal and eternal natural laws as Einstein's theory of relativity toppled Newtonian cosmology and quantum mechanics threatened the very existence of objectivity.[14] These profoundly counterintuitive leaps of rationality lead Bachelard to conclude that science imposes on reality a layer of abstraction simply inaccessible to human experience – a process of realizing (*Verwirklichung*[15]) through experiment, discourse, and representation. Scientific knowledge, in his view, cannot be gained by inferring from immediate human experience. This contrast between experience and its abstraction through science is conceived of as an 'epistemic break.'

The contemporary notion of the Anthropocene represents such an 'epistemic break.' The scientific subject of the human has shifted from the context of the humanities to that of the sciences. And contexts are vital. Concepts only unfold their meaning within specific historical or epistemic contexts. The phenomenon of metaphor, for instance, vividly displays how, when a concept is transferred to a new linguistic context, new meaning is created through interaction with the new frame.[16] Furthermore, how humans metaphorically come to terms with the world changes throughout different historical contexts, as Hans Blumenberg said (and showed in his works): "[D]er historische Wandel einer Metapher bringt die Metakinetik geschichtlicher Sinnhorizonte und Sichtweisen selbst zum Vorschein."[17] If concepts become meaningful only within specific contexts, it is clear that the concept of the Anthropocene can have no precursors. The concept must be understood as specific to the twenty-first century and its historical-epistemological situation – a conceptual history demands we take this break into account.

Even though, as I show in this paper, the epistemologies and worldviews that have congregated in the contemporary concept of Anthropocene cannot be said to be precursors, they do have a history. Today, they have been relocated in the realm of science. Even though the Anthropocene has become a major topic of debate in the humanities, it is debated as a scientific concept, one that, for the first time, understands the human in terms of the Earth system sciences. Human agency, human culture, and human systems are now understood, literally, as geological forces. Force, here, is an important hint at the semi-hidden assumptions that have shaped Anthropocene thought. What was discussed as 'force' in the nineteenth century and what we now call 'energy' was projected into natural processes and entities to grasp their function and value.

13 Gaston Bachelard: *Der neue wissenschaftliche Geist* (1934), translated by Michael Bischoff, Frankfurt a. M. 1988, p. 11.

14 Hans-Jörg Rheinberger: *Historische Epistemologie zur Einführung*, Hamburg 2007, p. 36.

15 "Es geht also weniger um die Wirklichkeit und ihre Erkenntnis – um das was *ist* – als vielmehr um einen Prozess der 'Verwirklichung,' um das was sein *kann*." Ibid., p. 11.

16 This is the basis of Max Black's interaction theory, see Max Black: *Models and Metaphors. Studies in Language and Philosophy*, Ithaca 1962.

17 Hans Blumenberg: *Paradigmen zu einer Metaphorologie*, Frankfurt a. M. 1960, p. 13.

II. ENERGY, ECONOMY, AND THE MAKING OF A RESOURCE

'Energy' is defined as the ability to do work. Formalized as a concept in physics in the mid-nineteenth century, it was henceforth projected into all other kinds of 'abilities to do work.' As the essays by Ernst Müller and Christian Hoekema in this volume show, energy and its nemesis entropy rationalized not only machine labor but human labor, too. Here, I add the natural world and its ability to do 'work.' Backed by the scientific credibility of thermodynamics, economists projected 'energy' into nature's animate and mineral stocks, thereby 'making' it into a resource – one that could be used but also, significantly, one that could run dry and should, therefore, be used 'economically.'[18] As philosopher Ivan Illich has said: "[The] universe itself [was] placed under the regime of scarcity," humans were "no longer born under the stars but under the axioms of economics."[19]

Serhii Podolinsky, an ardent supporter of Marx, was one of the first to calculate the energetic value of agriculture. Building on the principles of thermodynamics, he explained that if humans spent their energy by creating more energy through farming, less would be lost. By adding more fields to the Earth's surface, it was possible to maximize the energy efficiency of the sun.[20] He says:

"Man kann nämlich als unzweifelhaft annehmen, daß die Existenz der Pflanzen in höherem Grade als diejenige der Tiere die Eigenschaft besitzt, eine Anhäufung der Energie auf der Erdoberfläche zu bewerkstelligen. […] Gewiß ist […], daß der Mensch durch gewisse, von seinem Willen abhängige Handlungen die Menge der angehäuften Energie des Pflanzenlebens vergrößern und die Menge der von den Tieren zerstreuten verkleinern kann."[21]

Increasing the Earth's energy was also a concern for the chemist Justus Liebig, who studied the mineral uptake of plants.[22] Before chemical fertilizers, guano, the excrement of certain birds from South America, was shipped to Europe in bulk to recharge soils that had been depleted. It is estimated that in 1900 around ten kilograms of guano were imported for every German. As one of Liebig's fellow chemists pointed out:

"[F]rom the calculations of M. de Humboldt, the excrements of these birds in the course of three centuries, would form a layer of guano of no more than a third of an inch in thickness; – imagination stops short, startled in the presence of the vast lapse of time which must have been necessary to accumulate such beds of the substance as now exists, or rather, as lately existed in many places; for it is rapidly disappearing since it has become subject of the commercial enterprise of mankind."[23]

For Liebig, however, guano itself was not the problem so much as the fact it was not native to Europe. Chemical fertilizers should do the trick, he thought.

The newly tapped resource of coal naturally was not exempt from this discourse of scarcity. Rudolf Clausius, who formulated the second law of thermodynamics, reflected these societal concerns:

"Science will not be able, however advanced, to originate a new source of energy once that resource, coal, is exhausted […] In the interest of mankind, it is highly desirable that the natural forces, which are being wasted at present, should be utilized expediently and the coal reserves, which do not spoil beneath the ground, be protected against depletion. […] The next centuries will have the task of introducing a wise economy."[24]

18 Though, of course, natural products had always been understood as resourceful, thermodynamics endowed the notion of energy with scientific authority.

19 Ivan Illich: "The Social Construction of Energy," in: Rania Ghosn (ed.): *Landscapes of Energy*, Cambridge 2010, pp. 11–22, as quoted in Thomas Turnbull: *From Paradox to Policy: The Problem of Energy Resource Conservation in Britain and America, 1865-1981*, Oxford 2017. Unpublished dissertation, Oxford University Research Archives, https://ora.ox.ac.uk/objects/uuid:5cd441cd-a809-48bc-b82a-61842975e7d6, p. 42, (accessed 16th June 2020).

20 He calculated, using data from France's bureau of statistics, that French forests accumulated 900 kilograms of biomass per hectare, amounting to a mere 2 295 000 kilocalories, while French pastures yielded only insignificantly more with 6 375 000 kilocalories. See Serhii Podolinsky: "Menschliche Arbeit und die Einheit der Kraft," in: *Die neue Zeit. Revue des geistigen und öffentlichen Lebens* 1 (1883), issue 9, pp. 413–424, here p. 421.

21 Hence, comparing pastures to wheat fields, he computed an increase of 22 kilocalories for every kilocalorie of human labor. Farming land could thus be seen as the accumulation of wealth in the soil. See ibid., p. 420 and Juan Martinez-Allier: *Ecological Economics. Energy, Environment, Society*, Oxford 1987, p. 49.

22 Martinez-Allier: *Ecological Economics* (note 21), pp. 38–42.

23 Jean Baptiste Boussingault: *Rural Economy, in Its Relations with Chemistry, Physics, and Meteorology*, London 1845, p. 381.

24 Rudolf Clausius: *Über die Energievorräthe der Natur und ihre Verwerthung zum Nutze der Menschheit*, Bonn 1885, pp. 24–26.

The question of what constituted a "wise" economy was, however, subject to debate. William Stanley Jevons, who had worked as a metallurgical assayer and later held a post as professor of political economy, observed an odd development. With ever more efficient machines being developed constantly, one would assume that the rate of resource extraction would diminish. However, exactly the opposite occurred. As the historian of energy Thomas Turnbull explains, in the 200 years since industrialization, "the efficiency of energy use doubled, […] [but] the economy grew fifty times larger, and energy consumption had increased twenty-five fold."[25] By the 1820s, the energy derived from coal in Britain was equivalent to the biomass production of the entire island.[26] Jevons concluded that increased efficiency did nothing to save fuel, on the contrary: because it lowered the cost of fuel consumption, it actually incentivized consumption.[27] If energy came at less financial and physical cost, humans would only flock to consume it.

This, again, was explained by thermodynamics. The law of the conservation of energy suggested that humans would always strive to minimize the loss of their energy – physical as well as financial. The economic actor thus sought to maximize the efficiency of his or her 'work,' as Jevons said, to retain "purchasing pleasure […] at the lowest cost of pain."[28] Therefore, Jevons concluded that it made little sense to impede civilization's progress. Rather, nations should ramp up their use, thereby increasing wealth and power, which could be invested in technology in order to escape this paradox. Jevons' paradox became orthodoxy, subsumed in the central tenet of classical economics that the market regulates itself and no amount of saving would yield any increase in efficiency.

In these examples we see clearly that projecting energy into earthly reserves both raised awareness of impeding scarcity and 'rationalized' its extraction. Jevons, for instance, was only able to logically link economy, human labor, and mineral resources by equating them to one single measure: energy. Likewise, only in the energetic view did pouring fertilizer over depleted fields make 'sense.' In the energetic view, fertilizer and minerals are the same. In reality, they are clearly not. Through the rise of the concept of energy, nature was rendered both exploitable and rechargeable at will.

Jevons had already argued in his theory of utility that the value of a resource, and what could be seen as 'efficient' use, was not simply an "object" or a "thing"[29] but a human concept. Whether something was a resource, thus, depends on whether the amount of energy (and/or money) *gained* was more than that *expended*. The question of what counts as a resource has returned full force in Anthropocene thought. As the contemporary philosophers and Anthropocene scholars Bernard Stiegler and Maël Montévil point out in their critique of capitalism:

"Entropy describes configurations and is directly related to our ability to use such resources. For example, ore deposits are at an improbably high concentration – generated by geological and atmospheric far from equilibrium processes – and human activities concentrate them further by the use of free energy. For these resources, the critical concepts are the dispersion and, on the opposite, the concentration of matter; that is, the entropy of their distribution on Earth."[30]

Here, the Anthropocene thinkers build on the thermodynamic reconceptualization of the resource economy by Nicolas Georgescu-Roegen. Capitalism, he says, is caught in the paradoxical process of reducing entropy by, for example, condensing copper ore into a pure copper sheet (at concentrations far higher than found in nature) but at the same time increasing entropy with every material and financial exchange:

"When a piece of coal is burned, its chemical energy is neither decreased nor increased. But the initial free energy has become so dissipated in the form of heat, smoke, and ashes that man can no longer use

25 Thomas Turnbull: *From Paradox to Policy* (note 19), p. 14, especially footnote 9.

26 Rolf Peter Sieferle: *The Subterranean Forest* (1982), translated by Michael Osmann, Cambridge 2001, pp. 103–104.

27 "Whatever, therefore, conduces to increase the efficiency of coal, and to diminish the cost of its use, directly tends to augment the value of the steam engine, and to enlarge the field of its operation." William Jevons: *The Coal Question; An Inquiry Concerning the Progress of the Nation, and the Probable Exhaustion of Our Coal Mines*, London 1865, p. 78.

28 William Jevons: *Theory of Political Economy*, London 1871, p. 23.

29 Ibid., p. 77.

30 Maël Montévil/Bernard Stiegler/Giuseppe Longo et al.: "Anthropocene, exosomatization and negentropy," in: idem: *Pour fournir des éléments de réponse à António Guterres et Greta Thunberg: International, internation, nations, transitions: penser les localités dans la mondialisation*, to be published 2020, quoted from the author's manuscript: https://montevil.theobio.org/en/system/files/articlepdf/ch1_anthropocene_exosomatization_and_negentropy-web_3.pdf (accessed 28th June 2020), p. 4.

it. […] Free energy implies some ordered structure, comparable with that of a store in which all meat is on one counter, vegetables on another, and so on. Bound energy is energy dissipated in disorder, like the same store after being struck by a tornado. This is why entropy is also defined as a measure of disorder. It fits the fact that a copper sheet represents a lower entropy than the copper ore from which is was produced."[31]

Thus, as the resource economist Erich Zimmermann said, "resources are not, they become."[32]

They become, I would argue, through human intervention with nature – both on the material level through extraction and on the conceptual level through the scientific practices of measurement, experiment, and conceptualization. For instance, in assigning a certain numerical value to certain materials, based on the fact that its energy is quantifiable, natural resources are enqueued into a defined scale, one which is translatable into other forms of energy. Nature is 'made' into a resource through projecting energy *into* phenomena and reading it *out again* in the act of measurement.

It is the notion of nature as a resource that has found entry in the Anthropocene concept. It makes no 'sense,' after all, to exploit nature, leaving it bare and barren if it is, at the same time, the energetic basis of life. And, as I have argued, it is context that makes 'sense,' or meaning. In the context of an energetic world, depletion is 'senseless.' As Alfred North Whitehead said: "Any physical object which by its influence deteriorates its environment, commits suicide."[33] Thus, the symptoms of the Anthropocene era are said to be due to either one of two things: the depletion of a resource or the accumulation of entropic waste in places it does not belong – and too dispersed to recycle economically. This describes issues such as carbon dioxide accumulation, microplastic accumulation, accumulation of pollutants in the atmosphere, biosphere, and oceans, nitrogen accumulation, as well as freshwater depletion – and, of course, the depletion of oil reserves.

As oil levels drop, humans have gone farther and farther to drill it from see beds and even suck it out of rock layers – at the expense of its 'efficiency.' As Richard Manning has shown, reflecting Anthropocene sensibilities, every calorie of fossil fuel energy produced 2,3 calories in food energy in the 1940s. In 1974, the ratio was 1:1 and today, he says, we use roughly ten times that for equal yield. "And this," he points out, "understates the problem, because at the same time that there is more oil in our food there is less oil in our oil."[34] The realization that loading up the Earth system with energy from deep time (oil) could not, in the long term, ameliorate impending energetic scarcity emerged in parallel with its upscaling in the second half of the twentieth century, which saw, for example, the so-called Green Revolution. Whereas Howard Odum, one of the founders of ecosystem science, remarked, at the time, that the idea that modern farming techniques could increase the 'carrying capacity' of Earth was a "sad hoax, […] industrial man no longer eats potatoes made from solar energy; now he eats potatoes partly made from oil."[35]

This mid-century anxiety over the world's dwindling resources gave rise to neo-Malthusian thought captured, for instance, in the Club of Rome's well-known study of terrestrial resources, *The Limits of Growth*.[36] Using mathematical modelling, its authors calculate and predict that human civilization will perish, having outstripped the Earth's ability to support it.[37] Fairfield Osborn's *Our Plundered Planet* and William Vogt's *Road to Survival* also represent this resource-energetic view in proto-Anthropocene thought. Employing the ecological concept of carrying capacity on human populations (which had started to explode at the time), they claimed that mankind was "overtaxing

31 Elsewhere he says, "[f]rom the viewpoint of thermodynamics, matter-energy enters the economic process in a state of low entropy and comes out of it in a state of high entropy." Nicolas Georgescu-Roegen: "The Entropy Law and the Economic Problem," in: Herman Daly/Kenneth Townsend: *Valuing the Earth. Economics, Ecology, Ethics* (1992), second edition, Cambridge MA 1993, pp. 77–88, here p. 77.

32 Stephen McDonald: "Erich W. Zimmermann, the Dynamics of Resourceship," in: Rennie Philips (ed.): *Economic Mavericks: the Texas Institutionalists*, Bingley 1995, p. 782, as quoted in Thomas Turnbull: "Toward histories of saving energy: Erich Walter Zimmermann and the struggle against one-sided materialistic determinism," in: *Journal of Energy Histories* 4, 2020, pp. 1–20.

33 Alfred North Whitehead: *Science and the Modern World*, London 1925, p. 109.

34 Richard Manning: "The Oil We Eat. Following the Food Chain back to Iraq," in: *Harper's Magazine* (February 2004), archived at https://harpers.org/archive/2004/02/the-oil-we-eat/.

35 Howard Odum: *Environment, Power, and Society*, New York 1971, p. 116.

36 Donella Meadows/Dennis Meadows/Jørgen Randers et al.: *The Limits to Growth. A report for The Club of Rome's project on the predicament of mankind*, New York 1972.

37 Horn/Bergthaller: *The Anthropocene* (note 4), p. 44.

its environment"[38] and was doomed to "rush down a war-torn slope to a barbarian existence in the blackened rubble."[39] Resources would be depleted, leaving behind an entropic wasteland. Thus, humans were, Osborn wrote, "for the first time a large-scale geological force."[40]

It is important to note at this point, however, that when Osborn refers to man as a "large-scale geological force" he does so as a rhetorical means to mobilize politics and public awareness. Though both Vogt and Osborn were biologists, they wrote for a popular audience. Though this does not denigrate the value of the statement, it does point to the fact that the Anthropocene concept is epistemologically distinct from such rousing rhetoric.

Furthermore, while Anthropocene scholars assume this scrambling for the last remnants of prehistoric energy sources to be symptomatic of the present, many believe we must rethink this perspective completely. In modernity, nature "is reduced to a 'raw material' or 'resource' to be used, processed, traded, and exploited,"[41] as Eva Horn has said. "The Anthropocene," she continues, "requires that we abandon this belief."[42]

III. THE HISTORIOGRAPHY OF ENERGY IN THE ANTHROPOCENE

The historical implications of this new energy regime did not pass people by. The energeticist and chemist Wilhelm Ostwald, for instance, had conceived of a "transformation coefficient" that determined the ratio with which society transformed energy into work, a ratio that increased throughout humankind's evolution.[43] He believed that "every machine, every process, in fact every intelligent person who improves this coefficient of transformation is valuable, and the greater the improvement and the more important for mankind the kind of energy upon which the improvement is devoted, the more valuable he is."[44] Ostwald was not alone in this conviction. Using nature's resources, Europeans agreed, was imperative to civilization's progress.

Though, of course, this notion is far removed from contemporary discourse, which conversely derides such naïve, imperialist, and racist notions as the very *causes* of the contemporary situation, it does point to an emerging awareness of how energy use structures society. This notion has become fundamental to assessing the role and predicament of humankind in Anthropocene thought. It was the experience of industrialization, colonial expansion, technological prowess, the mushrooming industrial factories and sprawling expansion of agriculture – all of which rode on the back of the new fossil fuel regime and the worldviews it engendered – that brought forth the first intuitions of anthropocentric ages.

Georges-Louis Leclerc, Comte de Buffon, for instance, whose study of Earth's temporality culminated in his landmark work of 1778, *Les Époques de la Nature*, defined the last *époque* as that in which "the power of Man assisted the operation of nature."[45] He assumed a constantly cooling Earth and thus welcomed the warming of the climate through deforestation and draining marshes. In the face of the rapid and all-encompassing changes brought about by the use of steam power, various terms were put forward to conceptualize human ages, such as the 'Anthropozoic'[46] or the 'Psychozoic.' The latter "Age of Reason," for instance, as the geologist Charles Schuchert said,[47] was "dignified by the appearance of man as the dominant agent of change" able to "modify the whole fauna and flora of the earth."[48] Across the Atlantic, George Perkins Marsh, an American

38 Ibid, p. 119.
39 William Vogt: *The Road to Survival*, New York 1948, p. 288.
40 Fairfield Osborn: *Our Plundered Planet*, Boston 1948, p. 29, as quoted in Steffen/Grinevald/Crutzen et al.: "The Anthropocene" (note 9), p. 844.
41 Horn/Bergthaller: *The Anthropocene* (note 4), p. 27.
42 Ibid, p. 91.
43 Thomas Turnbull: "Toward histories of saving energy" (note 32), here p. 3.
44 Wilhelm Ostwald: "The Modern Theory of Energetics," in: *Monist* 17(1907), issue 4, pp. 480–515, here p. 514.
45 Georges-Louis Leclerc Comte du Buffon: *Les Époques de la Nature. Édition critique* (1778), ed. by Jacques Roger, Paris 1962, as quoted in Jan Zalasiewicz/Colin Waters/Mark Williams (eds.): *The Anthropocene as a Geological Time Unit. A Guide to the Scientific Evidence and Current Debate*, Cambridge 2019, p. 5.
46 This was also introduced, though independently, by the Italian geologist and theologian Stoppani. See Zalasiewicz/Waters/Williams (eds.): *The Anthropocene* (note 45), p. 5.
47 Charles Schuchert: "Outlines of Historical Geology," in: Louis V. Pirsson/Charles Schuchert: *Introductory Geology: For Use in Universities, Colleges, Schools of Science, etc. and for the General Reader*, New York 1924, p. 480.
48 Joseph LeConte: "On critical periods in the history of the Earth and their relation to evolution; and on the Quarternary as such a period," in: *American Journal of Science* 14 (1877), p. 99–114, here p. 114, as quoted in: Robert Davis: "Inventing the Present: Historical Roots of the Anthropocene," in: *Earth Sciences History* 30 (2011), issue 1, pp. 63–84, here p. 67.

congressman and amateur naturalist, revived the term Anthropozoic in his book tellingly named *The Earth as Modified by Human Action*. It states: "It is certain that man has reacted upon and organized inorganic nature, and thereby modified, if not determined, the material structure of his earthly home."[49] And in 1867, Ernst Haeckel, who coined the term ecology, referred to his own age as "the era of Man, the anthropolithic or anthropozoic period" in his lectures.[50] At the turn of the century, two Parisian professors, Pierre Teilhard de Chardin (geology) and Édouard Le Roy (mathematics and philosophy), were promoting the terms biosphere and noosphere. While 'biosphere' referred to the complex system of living entities, minerals, water masses, the atmosphere and energy from the sun,[51] 'noösphere', in contrast, represented the sphere of human influence and humankind's increasingly transformative activity on the face of the Earth. Indeed, the image of nature as entirely transformed by mankind was a common topic in popular scientific literature.

What catalyzed this proliferation of purported human ages was the experience of a profound break. A new energy regime was instated, one that radically changed the ways of life for Westerners and that, it soon became clear, structured the entire course of history. This was most prominently voiced by Karl Marx, when he made the material exchanges of energy (again, physical or financial) the basis of his units of work. To do so, he drew, like so many of his contemporaries, on the notion of energy to fathom the manifold exchanges of 'valuable' material in anything from engines, to economies, to the human mind itself.[52] It thus served, as Vaclav Smil has observed, as a conceptual bridge between social theory and the natural sciences.[53]

Herbert Spencer, never shy of abducting science for supporting his sociological ideas, proposed in his treatise *First Principles* (1862) that the increase of available energy was a feature common to both to the evolution of species and social systems. In evolution, more energy leads to more complex organisms. The same, by analogy, held for the "social organism": Only the excess of available food resources could unburden certain members of society from agricultural labor, thus enabling them to perform managerial duties or craftsmanship. Like this, more energy lead to more complex societies lead to progress.[54] If fossil energy ran out, Wilhelm Ostwald suggested, future civilizations might be powered by "photoelectric apparatus,"[55] while the American anthropologist Leslie White thought they would rely on "sub-atomic energy."[56]

The notion that more efficient use of resources marked significant steps in human history also influenced the field of philosophical anthropology, which emerged in the 1920s. Drawing on Jakob von Uexküll's concept of *Umwelt* (environment) as a space relative to the perceptual and behavioral capacities of a species, humans were considered unique in radically expanding their physical and cognitive horizon of experience. Because homo sapiens, according to one of philosophical anthropology's protagonists, Arnold Gehlen, were "physically and instinctually feeble,"[57] they were not optimally adapted to their natural environment, they were, in his words, "Mängelwesen" (deficient beings).[58] Therefore, humans needed technologies, especially energy excavating and converting technologies but also social institutions, to fashion environments stable and habitable enough to thrive. Theories like these sought to explain the apparent discrepancy between man's frailty and his increasing modification of the face of the Earth. But what also becomes apparent is the fact that such ideas diagnosing the role of humans in modernity were relevant to history and not to the natural sciences."

49 This was the second edition to his book *Man and Nature* from 1864. George Perkins Marsh: *The Earth as Modified by Human Action*, New York 1874, p. 8.

50 Ernst Haeckel: *The history of creation: On the development of the Earth and its inhabitants by the action of natural causes. A popular exposition of the doctrine of evolution in general, and of that of Darwin, Goethe, and Lamarck in particular* (1870), translated by Edwin Ray Lankester, London 1876, p. 17, quoted from Horn/Bergthaller: *The Anthropocene* (note 4), pp. 39–40.

51 See Zalasiewicz/Waters/Williams (eds.): *The Anthropocene* (note 45), p. 7.

52 See Ernst Müller's article "Energy" in this issue, pp. 29–38.

53 Vaclav Smil: *Energy and Civilization. A History*, Cambridge 2017, p. 1.

54 Herbert Spencer: *First Principles*, London 1862, pp. 159–162.

55 Wilhelm Ostwald: *Energetische Grundlagen der Kulturwissenschaft*, Leipzig 1909, p. 96.

56 Leslie White: "Energy and the Evolution of Culture," in: *The American Anthropologist* 45 (1943), issue 3, pp. 335–356, here p. 351.

57 Horn/Bergthaller: *The Anthropocene* (note 4), p. 86.

58 Arnold Gehlen: *Man. His Nature and Place in the World* (1940), translated by Clare McMillan and Karl Pillemer, New York 1988, especially chapter 4.

This growing awareness that energy structured history, however, is a perspective that has become crucial to Anthropocene historiography. The nexus of energy, colonial power, and economic growth is seen as a defining feature of the Anthropocene age: "Since the development of the steam engine in the eighteenth century, it [fossil fuels] had been a primary driver of modernization and a symbol of the geopolitical ascendancy of the West."[59] Or, more abstractly, "If the Anthropocene is the geological epoch in which human activities begin to transform the Earth system in its entirety, then this must be linked to an increase in society's use of energy," as Hannes Bergthaller says.[60]

Narratives that rewrite human history through their ever more efficient uses of energy are experiencing a renaissance in the discursive surrounding of the 'Anthropocene.' Jared Diamond has, for example, recounted the histories of various past civilizations that overshot their ecological limits and perished, predicting that contemporary societies were heading a similar way – though many historians cide his recycling of old deterministic tropes from 19th century.[61] And Smil, in his recent book *Harvesting the Biosphere*, makes a quantitative argument by summing up the entire biomass production of past societies and tracing how the advancement of civilization displays a mutually reinforcing relationship with energy use. This line of thought, revitalized in the 1970s by Smil and Georgescu-Roegen,[62] is taken up by Richard Wrangham, when singling out cooking as an evolutionarily critical event. Using heat to make food more digestible released energy that could be used for other purposes, such as growing a brain that is irresponsibly large from an evolutionary-energetics perspective.[63] Invoking Spencerian thought, scholars like Wrangham draw attention to the development of more complex social organization in terms of population size, hierarchies, but also professions and viable habitats. Agriculture, especially, has recently been the subject of much critique. Here, for the first time, humans dug up the Earth for their energetic needs. James Scott, for example, has come out against one particular crop – wheat – arguing that its introduction legitimated and secured power for the earliest states. Wheat was easily transportable, quantifiable, and storable, and made the new city state's subjects 'legible.'[64] This, in effect, is the same logic that informed the projection of energy into all corners of nature: It converted a messy panorama of diverse materialities and visualities into a common 'currency': energy.

A whole school of thought has gathered around investigating the energetic regimes of historical humans. The Vienna School of social ecology distinguishes three distinct phases in human history: (1) a hunter and gatherer regime which is based on the passive utilization of solar energy, (2) the agrarian regime which harnesses solar energy actively, and (3) the fossil energy regime.[65] Our hunter-gatherer forefathers and -mothers were forced to roam about in search of nutrition, because the energy density of wild food is low. Agrarian societies, in contrast, make "controlled use of solar energy flows [...], where people employ primarily biological converters (plants, animals) that are genetically modified for this purpose and whose habitats are actively transformed."[66] Though, over the course of human history, more and more wilderness was transformed into energetically dense farmland, in the end, agriculture was still bound to the "law of diminishing returns: after a certain point, higher investments of labor no longer generate a commensurate increase in yields."[67] Thus, the advent of the fossil fuel regime represents a profound break in Anthropocene historiography. As the philosopher Peter Sloterdijk has described, fossil fuels meant a profound "reprogramming of existential moods" induced by the experience of "de-scarcification."[68]

59 Horn/Bergthaller: *The Anthropocene* (note 4), p. 40.
60 Ibid., p. 128.
61 Jared Diamond: *Collapse. How Societies Choose to Fail or Succeed*, New York 2005.
62 Nicolas Georgescu-Roegen: *The Entropy Law and the Economic Process*, Cambridge MA 1971, p. 308.
63 Richard Wrangham: *Catching Fire. How Cooking Made Us Human*, New York 2009.
64 James C. Scott: *Against the Grain. A Deep History of the Earliest States,* New Haven 2017.
65 Marina Fischer-Kowalski/Fridolin Krausmann/Heinz Schandl et al.: "The Global Sociometabolic Transition: Past and Present Metabolic Profiles and Their Future Trajectories," in: *Journal of Industrial Ecology* 12 (2008), issue 5/6, pp. 637–656, especially p. 639 and Marina Fischer-Kowalski/Fridolin Krausmann/Irene Pallua: "A Sociometabolic Reading of the Anthropocene: Modes of Subsistence, Population Size and Human Impact on Earth," in: *The Anthropocene Review* 1 (2014), issue 1, pp. 8–33, here p. 20.
66 Rolf Peter Sieferle: "Lehren aus der Vergangenheit. Expertise für das WBGU-Hauptgutachten 'Welt im Wandel: Gesellschaftsvertrag für eine Große Transformation,'" (Wissenschaftlicher Beirat der Bundesregierung 'Globale Umweltveränderungen': Materialien), Berlin 2010, p. 5, online: https://www.wbgu.de/fileadmin/user_upload/wbgu/publikationen/hauptgutachten/hg2011/pdf/wbgu_jg2011_Expertise_Sieferle.pdf (accessed 14th February 2019), as quoted in Horn/Bergthaller: *The Anthropocene* (note 4), p. 133.
67 Horn/Bergthaller: *The Anthropocene* (note 4), p. 134.
68 Peter Sloterdijk: *In the World Interior of Capital: Towards a*

Industrialization caused the collapse of time and space: Human beings could be propelled across the globe faster and at less cost, their thoughts communicated across vast distances even faster and at even less cost, while sites of production moved to the city, amassing crowds of homo sapiens in urban structures. And just like agriculture had liberated a certain privileged class from retrieving food, so too did fossil fuels create new forms of work in which humans read, wrote, organized and calculated while less and less worked the land.[69] Shifting the source of wealth creation away from the countryside loosened the ties between landed interests and political power, while the often abysmal social conditions associated with urban factories influenced the first comprehensive social reforms. Oil gave humans an unprecedented degree of personal freedom of movement.[70] Sloterdijk has articulated this mass psychological phenomenon: "We can no longer imagine a freedom that does not automatically include the freedom to risky accelerations, the freedom to move to the remotest of destinations, the freedom to exaggerate and to be extravagant, indeed the freedom to explode and self-destruct."[71] In fact, as Dipesh Chakrabarty has put it: "The mansion of modern freedoms stands on an ever-expanding base of fossil-fuel use."[72]

Having detected the etiology of the Anthropocene in energy, many Anthropocene scholars have put forward new terms for the present state of affairs. Nearly all of these suggested terms refer to a certain energetic feature of modernity, be it Samways' "Homogenocene"[73] or Haraway's "Plantationocene"[74] (both emphasizing the homogenizing effect of agriculture that condenses vegetational kilocalories), Haraway's currently preferred "Chthulhucene,"[75] Norgaard's "Econocene"[76] (pointing to the energetic degradation of the ecosphere), or the most popular contender for diagnosing the present: Malm's and Moore's "Capitalocene."[77] It says that the logic of capitalism, more than the universalizing concept of humanity, caused the Anthropocene by making nature into a commodity. Thus, much of Anthropocene thought also fosters degrowth sentiments. This line of thought holds that on a planet with finite fossil resources, the economic growth initiated by the Industrial Revolution cannot be maintained.

However, there are also Anthropocene scholars who take a less pessimistic attitude towards the technological reorganization of energetic infrastructure. Under banners like "ecological modernization"[78] or the 'good Anthropocene,' thinkers such as the environmental scientist Erle Ellis paint a utopian picture in which humans cluster in energy-efficient cities while increasing agricultural productivity makes it possible to release swathes of land from domestication and return it to its wild state. Here, again, energy serves as the explanatory foil: Just as human history is an upward spiral of ever more efficient energy use, so too will the future be marked by more efficiency. Ellis explains: "As we did at the end of the Paleolithic, most of humanity is defecting from the older ways, which will soon become hobbies for the elite and nostalgic memories for the rest of humanity. Just as wild forests, wild game, and soon, wild fish disappear, so do the human systems associated with them."[79] Advocates of the

Philosophical Theory of Globalization (2005), London 2013, p. 227.

69 Helga Weisz: "The probability of the improbable: Society-nature coevolution," in: *Geografiska Annaler: Series B, Human Geography* 93 (2011), issue 4, p. 325–336, here p. 332. See Horn/Bergthaller: *The Anthropocene* (note 4), p. 135.

70 Stefanie Le Menager even uses the term "pertomodernity" instead of modernity. See Stefanie LeMenager: "The Aesthetics of Petroleum, after Oil!" in: *American Literary History* 24 (2012), issue 1, pp. 59–86, here p. 60.

71 Peter Sloterdijk: "How Big is 'Big'?" in: *Collegium International* [online], February 2010, http://www.collegium-international.org/index.php/en/contributions/127-how-big-is-big (accessed 17th July 2020).

72 Dipesh Chakrabarty: "The Climate of History: Four Theses," in: *Critical Inquiry* 35 (2009), issue 2, pp. 197–222, here p. 208.

73 Michael Samways: "Translocating fauna to foreign lands: Here comes the Homogenocene," in: *Journal of Insect Conservation* 3 (1999), issue 2, pp. 65–66.

74 Donna Haraway: "Anthropocene, Capitalocene, Plantationocene, Chthulucene: Making Kin," in: *Environmental Humanities* 6 (2015), issue 1, p. 159–165 as well as Nils Bubandt/Scott Gilbert/Noburo Ishikawa et al.: "Anthropologists Are Talking – About the Anthropocene," in: *Ethnos* 81 (2016), issue 3, pp. 535–564.

75 Donna Haraway: *Staying with the Trouble. Making Kin in the Chthulucene*. Durham 2016 and Haraway: "Anthropocene, Chthulhucene" (note 74). 'Chthulhucene' refers to the Greek word for 'Earth' and is taken by Haraway to imply compostation instead of posthuman-ness. In her view, in order to survive, humanity must look to the composting powers of subterranean beings in order to tackle the waste of the Anthropocene. This view can easily be retraced to the ecological idea of microbial beings converting energy that is treated as waste (entropy) by other beings.

76 Richard Norgaard: "The Church of Economism and Its Discontents," Great Transition Initiative, December 2015, https://greattransition.org/publication/the-church-of-economism-and-its-discontents, (accessed 17th July 2020).

77 Jason Moore: *Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism,* Oakland 2016.

78 Maarten Hajer: *The Politics of Environmental Discourse. Ecological Modernization and the Policy Process*, Oxford 1995.

79 Erle Ellis: "The Planet of No Return. Human Resilience on an Artificial Earth," in: *Breakthrough Journal* 2 (2011),

'good Anthropocene' thus frequently refer to the role of humanity in the Anthropocene as 'stewardship.' Though most Anthropocene scholars deride such views as naïve and vain fantasies, as remnants of the very 'modern' techno-optimism that got us into this mess, they are another example of how Anthropocene thought explains the present and mankind's role within it though material energy shifts.

Despite these historiographic perspectives on the Anthropocene, it must be pointed out that the Anthropocene is a concept that originated in the natural sciences, specifically Earth system science. The Anthropocene concept describes a proposed geological age and was conceived to describe the state of mankind at the end of modernity. Nevertheless, the historiography of the Anthropocene draws on the tradition of writing history through the transformations of human energy regimes, histories that inherently depict the entanglement of humans with their material, energetic environment. Such narratives are possible because the concept of energy brands all material exchanges between humans and their environment as energetic. Synchronously, the concept of energy makes history into an enmeshed web of relations between human bodies, human minds, resources, money, and the actors of what we call nature. The same capacity makes the diachronic perspective comparable throughout history: Not only can we compare the first wheat fields in Mesopotamia to the wheat fields stretching from coast to coast over the North American continent, the energetic perspective compares a handful of prehistoric berries with the oil in our cars, the coins in our pockets, and the buttons we press while partaking in data capitalism.

IV. ECOLOGICAL ENERGETICS

Until now, the energetic legacy of both the Anthropocene era and of the Anthropocene worldview (that naturally co-evolved) has been relatively intuitive: Projecting energy into nature reinterpreted its 'ability to do work' as something that could be harnessed by industrial capitalism, naturalized by the notion that increasing use of energy was indicative of evolving civilization. Here, Anthropocene scholarship is usually opposed to the energetic view. However, the concept of energy also shaped the very views in whose tradition Anthropocene scholarship sees itself: the ecological perspective in which humans, animals, microbes, and minerals are all actors within an interconnected and mutually dependent whole. Connecting this whole was, again, the homogenizing yet holistic concept of energy.

In direct opposition to the nineteenth century materialist conception of nature in the Helmholtzian school of energetic physiology, holistic conceptions of nature returned towards the turn of the twentieth century. Many biologists felt much of the holism of Darwinian natural history had unfairly been superseded by the experimental ideal of physiology.[80] It was in this context that the geologist Eduard Suess, in his 1875 book *The Origin of the Alps*,[81] introduced the term biosphere to describe the entirety of living beings and their interactions. Vladimir Vernadsky took up Suess' concept and developed it further in his essays *Geochemistry* and *Biosphere*,[82] and also integrated the term Anthropozoic, which, as we have seen, had been percolating in public consciousness at the close of the nineteenth century.[83] Vernadsky was one of the first to integrate the inanimate chemical processes into the biological realm and conceived "Earth as a chemical system where the elements cycled between the various parts."[84] Importantly, and in contrast to Suess, he drew on Lamarck's conception of a global sphere of organisms to explain how life *alters* the face of the Earth, a terraforming practice that Vernadsky observed in mankind:

"Man has introduced into the planet's structure a new form of effect upon the exchange of atoms between living matter and inert matter. Formerly, organisms affected the history only of those atoms that were necessary for their respiration, nutrition and proliferation. Man has widened this circle, exerting influence upon elements necessary for technology and for the creation of civilized forms of life. Man acts here not as homo sapiens, but as homo sapiens faber."[85]

pp. 39–44.

80 Robert Kohler: *Landscapes and Labscapes. Exploring the Lab-Field Border in Biology*, Chicago 2002.

81 Eduard Suess: *Die Entstehung der Alpen,* Vienna 1875.

82 Both are reprinted in: Vladimir Vernadsky: *Essays on Geochemistry and the Biosphere* (1924, 1929), translated by Olga Barash, Sante Fe 2006.

83 Also, in Russia, the term Anthropogene (sometimes mistranslated to Anthropocene from Cirillic) was used interchangingly with the Quartenary Period. See Zalasiewicz/Waters/Williams (eds.): *The Anthropocene* (note 45), p. 6.

84 Golley is talking of Vernadsky, here. See Frank Benjamin Golley: *A History of the Ecosystem Concept in Ecology*, New Haven 1993, p. 57.

85 Vladimir Vernadsky: *La géochimie*, Paris 1924, p. 342, as quoted in: Steffen/Grinevald/Crutzen et al.: "The Anthro-

Vernadsky's words are indicative of a wider cultural discourse on nature conceived as a whole. Whitehead, who has been called the "greatest philosopher of the twentieth century" by Anthropocene scholar Bruno Latour,[86] emphasized connections and the role of change in nature: "All things flow."[87] And Zimmermann, the economist whom we have encountered in the section on resources, like many of his contemporaries, saw the world as an organism, as "a living growing complex of matter and energy."[88] His studies into the use and conservation of resources had revealed the "altogetherness of things," an "inextricable mesh of forces and conditions."[89]

This "inextricable mesh of forces and conditions" was likened to the organism and its metabolism – both of which drew on thermodynamics. The biologist Lawrence Henderson noted, for instance, that metabolism "is the proof that the principle of the conservation of energy applies to the living organism."[90] And John Scott Haldane dismisses Hans Driesch's vitalistic notion of entelechy as it "implies a definite breach in the fundamental law of conservation of energy […], a principle, which has been verified again and again under all sorts of conditions."[91] Energy, in short, was what made animals animate.

But it might also be what animated communities, as ecologist John Phillips said: "A biotic community in many respects behaves as a complex organism […]; it possesses a special identity – it is indeed a mass-entity with a destiny peculiar to itself."[92] For some, however, the metaphor of the organismic world did not go far enough. Apart from the questionable liberal extension of ecological terms beyond their designated reference,[93] the ecologist Arthur Tansley insisted that the organism metaphor failed to account for inanimate matter. According to him, it implied an inanimate stage on which animals acted out the drama of life.[94]

In his famous paper *The Use and Abuse of Vegetational Concepts and Terms*, Tansley introduced the concept of ecosystem to overcome these conceptual shortcomings. In the place of 'complex organism' he offered the term "system (in the sense of physics), including not only the organism complex, but also the whole complex of physical factors forming what we call the environment."[95] It was not necessary to avail oneself of a 'mere' metaphor when the laws of physics had already provided the actual facts of the universe – facts that surely held for life also: "These ecosystems, as we may call them, are the most various kinds and sizes. They form one category of the multitudinous physical systems of the universe, which range from the universe as a whole down to the atom."[96] Humans and non-humans as well as inanimate matter, in this reinterpretation of energy, were inextricably bound through energy.

Henceforth, ecologists calculated the efficiency of trophic transfers, the length and composition of food chains, energy storage, productivity rates, the role of bacteria in decomposing dead organic matter – in short, an energy budget of nature.[97] Measuring such energy flows in nature soon revealed that human cities were entirely out of scale; as the ecologist Eugene Odum put it, "in terms of energy metabolism, cities are pinpoint 'hot spots' in the biosphere's surface."[98] While human energy consumption, as well

pocene" (note 9), here p. 845.

86 See Bruno Latour: "Foreword: What Is Given in Experience?" in: Isabelle Stengers: *Thinking with Whitehead: A Free and Wild Creation of Concepts*, translated by Michael Chase, Cambridge MA 2011, p. x.

87 Alfred North Whitehead: *Process and Reality*, New York 1978, p. 208.

88 Thomas Turnbull: "Toward histories of saving energy" (note 32), p. 5.

89 Erich Walter Zimmermann: *World Resources and Industry. A Functional Appraisal of the Availability of Agricultural and Industrial Resources,* New York 1933, p. 818, as quoted in Turnbull: "Toward histories of saving energy" (note 32).

90 Lawrence Henderson: *The Fitness of the Environment; an Inquiry into the Biological Significance of the Properties of Matter,* New York 1913, pp. 24–25.

91 John Scott Haldane: *Mechanism, Life and Personality*, London 1914, p. 28.

92 John Phillips: "The biotic community," in: *Journal of Ecology* 19 (1931), pp. 1–24, here p. 20.

93 "Here we are back again at the question of the meanings of words […]. The word organism can be applied very widely indeed. Thus, we have Professor Whitehead's 'Philosophy of Organism' and a whole school of 'organicist' philosophers: many have not hesitated to call the universe an organism." Arthur Tansley: "The Use and Abuse of Vegetational Concepts and Terms," in: *Ecology* 16 (1935), issue 3, pp. 284–307, here p. 299.

94 Golley: *A History of the Ecosystem* (note 84), p. 24.

95 Tansley: "Concepts and Terms" (note 93), p. 299.

96 Ibid.

97 Golley: *A History of the Ecosystem* (note 84), p. 54.

98 Eugene Odum: *Ecology. The Link Between the Natural and Social Sciences* (1963), New York a. o. 1975, p. 42. Odum explicitly remarks in the introduction to his influential and tellingly named textbook that in the book "man is considered to be a dependent part of ecological systems. The impact of man's fuel-powered systems on the natural sun-powered environment is viewed as an internal, rather than an external, problem. Therefore, there is no separate chapter or appendix called 'man and nature'; the whole book is as much an introduction to human ecology as to general ecology." Ibid., p. vi.

as population, was growing (think Great Acceleration), it was at the same time becoming increasingly problematic, culminating in the oil crisis of the 1970s. Systems ecology had translated older notions of a balance of nature (obeying the first law of thermodynamics) into notions of dynamic equilibrium where elements regulated each other into homeostasis. These developments lead James Lovelock and Lynn Margulis to develop their Gaia hypothesis, on which many Anthropocene scholars draw today.[99] Starting from the observation that the sun's intensity had continuously increased over Earth's lifetime while Earth's climate had not warmed as a result, Lovelock gathered evidence to support the idea that Earth, and the living creatures inhabiting it, kept atmospheric temperature within a viable range. Through respiration and decay, prehistoric microbes and plants had built up the atmosphere. This event, called the Great Oxygenation event, implied that Earth was actually punctuated by catastrophic discontinuities.

In this view, Earth is regulated by cybernetic feedback mechanisms where animate beings as well as inanimate chemicals are all part of the same self-organized system. Margulis, who was also instrumental in the translation and publication of Vernadsky's books,[100] emphasized the importance for symbiotic cohabitation within the world conceived as Gaia. She maintained, for instance, that mitochondria had originally been free floating microorganisms that, for reasons of evolutionary advantage, had formed symbiotic relationships with larger organisms ultimately leading to their assimilation into cells.

It is important to remember, however, that the energetic perspective not only engendered holistic philosophies of merry symbiosis. Though the systems perspective of ecology was interpreted by the environmental movement as a philosophy of democratic entanglement, thermodynamics, at the same time, made ecology into a "machine theory applied to nature."[101] Indeed, Tansley himself claimed that "all living organisms may be regarded as machines transforming energy from one form to another."[102] Importing thermodynamics to the study of the environment also imported its focus on efficiency, production, and waste – notions that had since the nineteenth century legitimated the 'rational' exploitation of labor and the 'rational' management of natural resources. As Benjamin Golley has pointed out, "[t]he manager and industrialist found the ecosystem equally attractive. It promised a way to manage complex natural systems."[103] Thus, "[w]ith adequate understanding of the ecosystem we might use salt marshes to process sewage and industrial wastes," or "use forest management practices that would yield an optimum product with minimal damage to streams and soils." Though the idea of running the economy with minimal damage to the environment is, of course, eminently desirable, it shows at the same time how nature, understood through ecological energetics, was enlisted in the logic of capitalism.

Indeed, this avenue of thought was decisively established by Howard Odum who, together with his brother Eugene, advocated so-called 'ecological economics,' which sought to quantify the value of nature in dollars. Today, this field of research is termed 'ecosystem services' and integrates both resources and natures only indirectly 'useful,' for example habitats and parks. Scientists such as Gretchen Daily and Paul and Anna Ehrlich explicitly use economic terms to appeal to politics.[104] In order to spark change, they believe, nature must be made legible to human systems of governance. Indeed, the discipline presents itself as combating the environmental malaises of the Anthropocene. Nevertheless, in translating and subjecting nature to the logic of capitalism (through the concept of energy), nature is rendered (as if it hadn't been already) understandable, exploitable, and also discardable by economics. This translation into energetic terms enables economic decisions to be taken, because what nature 'means' is 'known' – at least in economic terms. Anything that cannot be converted conceptually to financial energy cannot be read, in effect, it is written in a different language and can be ignored to be piled onto the refuse of Anthropocene history.

99 James Lovelock/Lynn Margulis: "Atmospheric Homeostasis by and for the Biosphere: The Gaia Hypothesis," in: *Tellus* 26 (1974), issue 1–2, pp. 2–9.

100 Indeed, Lynn Margulis was instrumental in re-publishing Vernadsky's work *The Biosphere*. See Zalasiewicz/Waters/Williams (eds.): *The Anthropocene* (note 45), p. 8.

101 Golley: *A History of the Ecosystem* (note 84), p. 2.

102 Arthur Tansley: *Elements of Plant Biology,* London 1922, p. 25.

103 Golley: *A History of the Ecosystem* (note 84), p. 3.

104 Gretchen Daily: *Nature's Services: Societal Dependence on Natural Ecosystems*, Washington 1997, and Paul Ehrlich/Anne Ehrlich: *Extinction: The Causes and Consequences of the Disappearance of Species*, New York 1981.

V. THE ENTANGLEMENT OF NATURE AND ANTHROPOCENE EPISTEMOLOGY

It is this reconceptualization of Earth as a symbiotic, self-regulating, complex system where human influence is one of the geological forces that is characteristic of Anthropocene thought. As we have seen, this worldview was decisively influenced and legitimated by translating the kaleidoscope of natural processes to the single common currency of energy. Though the legacy of the energy concept is hardly ever acknowledged, apart from as an explanatory foil for human evolution, it is what holds notions of a symbiotic, global system together. This conviction has entered the semantics of the Anthropocene: its epistemology, its ethics, and its historiography.

If human activity is a geological force, this radically calls into question the very distinction between nature and culture. Thus, the Anthropocene concept, shaped by the discourse of energies from oil fields to ecosystems, sees humans and nature and, depending on who you ask, technology as well, as inextricably intertwined. The Anthropocene condition, in this view, has been caused by the disregard of non-human life and inanimate matter – rationalized by 'making' them into energetic resources, into 'others,' instead of sentient beings. Paul Edwards[105] and Jürgen Renn[106] have focused on the technological aspect and have pointed to the embeddedness, interconnectedness, and mutually reinforcing dynamics between humans and technology. This coincides with Donna Haraway's position that "we are all chimeras, theorized and fabricated hybrids of machine and organism; in short we are cyborgs."[107] Or as Bruno Latour has put it, "[w]hat characterizes our era is thus not simply the disappearance of nature, but rather the proliferation of 'hybrids' which subvert the categorical distinction between nature and culture."[108]

This statement has found its most radical elaboration in the proponents of posthumanism. While in Western thought, the defining (and ennobling) feature of human beings was their capacity for consciousness and agency, posthumanists maintain that animals have cognitive abilities that differ from ours only in degree.[109] This has been taken by some to imply the fundamental constructedness of the concept of species itself – in turn supporting the notion that the concept of biological sex is a human construction.[110] Furthermore, taking cue from the perspective proposed by Margulis and Lovelock, they emphasize the, not least evolutionary, importance of symbiosis. This has found reception in multispecies ethnography, which studies all societies as 'multi-species' communities.[111] Some also reject the distinction between humans and machines, building on developments in machine learning where cognition is seen as any process that digests information. What had been viewed as inanimate backdrop to human agency is now imbued with faculties hitherto clearly assigned to human minds and cultures. The concept of agency is projected into inanimate matter, thereby blurring the distinction between "intentional action and causal efficacy."[112] Though avoiding some of the more extreme implications, Bruno Latour has been an important advocate of earthly agency. Nature and culture, in his view, form a "seamless fabric where human and non-human actors are tightly interwoven."[113] "[T]he task," he says, "the crucial political task, is […] to distribute agency as far and in as differentiated a way as possible."[114] Here, the legacy of 'energy' emerges again. What enables inanimate matter to have 'agency' is the fact that is has the 'ability to do work' – and in turn, has the 'power' to shape, enable, or hinder human existence. Contemporary Anthropocene metaphysics directly trace back to the projection of energy as a universal link between nature's idiosyncratic actors.

105 Paul Edwards: *A Vast Machine. Computer Models, Climate Data, and the Politics of Global Warming*, Cambridge MA 2007.

106 Christoph Rosol, with Sara Nelson and Jürgen Renn: "In the Machine Room of the Anthropocene," in: *The Anthropocene Review,* special issue Perspectives on the Technosphere 4 (2017), issue 1, pp. 2–8 as well as Jürgen Renn: "Was wir von Kuschim über die Evolution des Wissens und die Ursprünge des Anthropozäns lernen können, " in: Bernd Scherer/Jürgen Renn: *Das Anthropozän. Zum Stand der Dinge*, Berlin 2015, pp. 184–209.

107 Donna Haraway: "A Cyborg Manifesto," in: *The Socialist Review,* 1985, pp. 456–475, here p. 457.

108 Bruno Latour: We Have Never Been Modern (1991), translated by Catherine Porter, Cambridge MA 1993, pp. 3–5.

109 Some philosophers advocating 'panpsychism' even go so far as to claim all matter in endowed with consciousness, ranging from very complex to virtually non-existent.

110 Rick Dolphijn/Iris van der Tuin: *New Materialism: Interviews & Cartographies*, Ann Arbor 2012, especially the chapters 6, 7, and 8.

111 Eben Kirksey/Stefan Helmreich: "The Emergence of Multispecies Ethnography," in: *Cultural Anthropology* 25 (2010), issue 4, pp. 545–576 and Anna Tsing: *The Mushroom at the End of the World. On the Possibility of Life in the Capitalist Ruins,* Princeton 2015.

112 Horn/Bergthaller: *The Anthropocene* (note 4), p. 53.

113 Bruno Latour: We Have Never Been Modern (note 108), p. 7.

114 Bruno Latour: "Agency in the Time of the Anthropocene," in: *New Literary History: A Journal of Theory and Interpretation* 45 (2014), issue 1, pp. 1–18, here p. 15.

While nature is charged with anthropomorphic agency, humans, in turn, are frequently naturalized. Thus, as Latour points out, drawing on Lovelock, many species mould their environment so as to render them "more favourable" to their evolutionary success.[115] Terraforming is no longer a uniquely human attribute. Indeed, early energy biologists had already interpreted the growing human energy consumption as Darwinian evolution, a move that situated human history within biology. Reformulating evolution in thermodynamic terms, Alfred Lotka reinterpreted all evolutionary adaptations as enhancing an organism's energy efficiency, i.e. how well it uses the available natural resources. The advance of civilization, then, was nothing other than human evolution. In a similar vein, Latour casts terraforming as a "general property of living things."[116] This notion has recently been substantiated by ecologists who have put forward the concept of niche construction. Biologists such as Kevin Laland and John Odling-Smee[117] assert that animals reshape their environment in ways that influence the selection pressures that determine genetic evolution. In human evolution, then, what we do to our immaterial and material environment (culture) has the power to "facilitate, constrain, and structure the cognitive work that we do."[118] Jürgen Renn has recently developed this notion for a sweeping view of human cultural evolution in which human environmental intervention is understood as the externalisation of internal cognitive structures – or more simply: knowledge. Thus, both drilling oil and writing are expressions of the cultural evolution of knowledge.[119] To overcome the Anthropocene condition, he says, we must develop new ways of externalizing, or representing, the present.[120]

How we represent the world is always already intertwined with how we think of the world. The Anthropocene worldview implies several things for ethics and epistemology. Ethically, philosophers involved in the debate around the Anthropocene emphasize the responsibility implied by being a geological force. Donna Haraway has advocated that we should develop a sense of kinship with individuals not bound to us though common ancestry, even to those individuals beyond our own species.[121] She calls this "multispecies flourishing,"[122] while Anna Tsing has spoken of collective survival within the ruins of modernism.[123] Latour, lastly, has urged us to accept the technological hybridity of Anthropocene nature and to 'love our monsters.'[124]

Interconnectedness also has implications for epistemology. The embeddedness and interconnectedness of humans with their material environment has, in recent years, influenced theories of knowledge in sociology, the history of science, and media studies – termed the *material* or *practical turn*.[125] This is what provoked Bruno Latour's well-known thought that "the laboratory has extended its walls to the whole planet."[126] But what kind of experiment are we performing? Bachelard, whose writings have seen a recent revival in the material turn, proposed that science does not merely *find* its phenomena pre-given in nature. The practices of science, rather, *constitute* their phenomena in what he termed 'phénoménotechnique.'[127] In a similar vein, Karen Barad has based the entanglement diagnosed by the Anthropocene in the fundamental principles of quantum mechanics. Subatomic particles, when measured, behave *either* like a wave *or* like a particle. We can either measure its *momentum* (wave) or its *position* (particle), because the

115 Bruno Latour: *Facing Gaia. Eight Lectures on the New Climate Regime,* translated by Catherine Porter, London 2017, p. 99.

116 Ibid.

117 John Odling-Smee/Kevin Laland/Markus Feldman: *Niche Construction. The Neglected Process in Evolution*, Princeton 2003.

118 Edward Baggs/Vincente Raja/Michael L. Anderson: "Culture in the world shapes culture in the head (and vice versa)," open peer commentary to Cecilia Heyes: "Précis of Cognitive Gadgets: The Cultural Evolution of Thinking," both in: *Behavioral and Brain Sciences* 42 (2019), pp. 1–58, here p. 17.

119 He elaborates on this in his recent book: Jürgen Renn: *The Evolution of Knowledge. Rethinking Science for the Anthropocene,* Princeton 2020.

120 "Aus diesem Grund war die neolithische Revolution nicht nur eine wirtschaftliche Umwälzung oder Nischenkonstruktion im Sinne der Biologie, sondern auch ein Stadium in der Evolution des Wissens. […] Aus demselben Grund kann schließlich das Überleben der Menschheit im Zeitalter des Anthropozäns nicht einfach nur eine Frage wirtschaftlicher und technologischer Anpassungen sein. Es wird auch davon abhängen, wie wir uns den Herausforderungen stellen, die das Anthropozän unserem Wissen stellt." Quoted from Jürgen Renn: "Was wir von Kuschim" (note 106), p. 206.

121 Donna Haraway: "Anthropocene, Chthulhucene" (note 74), p.161.

122 Donna Haraway: *Staying with the Trouble* (note 75), p. 3.

123 Anna Tsing: *The Mushroom at the End of the World. On the Possibility of Life in the Capitalist Ruins*, Princeton 2015, pp. 17–19.

124 Bruno Latour: "Love Your Monsters. Why We Must Care for Our Technologies as We Do for Our Children," in: *Breakthrough Journal* 2 (2011), pp. 21–28.

125 Though I believe there has been no direct link established, the coinciding of both epistemic shifts is striking, at least.

126 Bruno Latour: "Atmosphère, atmosphère," in: Susan May (ed.): *Olafur Eliasson. The Weather Project*, London 2004, p. 2.

127 Gaston Bachelard: *Le nouvel esprit scientifique*, Paris 1934.

measurement techniques interfere with the subatomic particles, as Barad puts it: "the nature of the observed phenomenon changes with corresponding changes in the apparatus."[128] Thus, at the most fundamental level of reality, we observe the interference of scientific measurement with its object. It follows, Barad purports, that we should reject the "epistemological assumption that experiments reveal the pre-existing determinate nature of the entity being measured."[129] There are, she holds, no differences between fact and artefact, between nature and culture, between matter and meaning.

VI. THE EPISTEMOLOGY OF ENERGY

In the Anthropocene era, scales of time and space clash. This is a central implication of the thesis that mankind is shaping Earth history – now and for centuries to come. While for most of human history the reach of our agency barely extended to the next village and no longer than an individual's lifespan or perhaps a dynasty, scholars acknowledging the Anthropocene are grappling with a vastly exploded range and entanglement of humanity. Some, as I have touched upon, are starting to rethink historiography with deep history and environmental history. And both Eva Horn and Bruno Latour advocate a 'planetary' view that, unlike the 'global' view with its 'modern,' totalizing, 'view from nowhere,' epitomized by the iconic Earthrise image, situates the Anthropocene subject *inside* the sphere of Earth, couched in the sheer complexity of entanglement. But thinking complexly is, to put it bluntly, complex. How do we wrap our heads around what the philosopher Timothy Morton has termed "hyperobjects"[130] – objects that are so massively distributed in time and space as to transcend spatiotemporal specificity. How do we cognitively come to terms with this exploded reality?

The phrase "coming to terms" may hold some hints. Throughout this essay we have seen how the concept of energy was projected into anything that displayed the 'ability to do work.' Concepts, encapsulated in terms, order the world by reducing its complexity – framing phenomena with a certain concept necessarily obscures other ways of knowing.[131] Because of our limited "human perceptual mesocosm,"[132] the worldview of the Anthropocene and its exploded scales rely (and have relied) heavily on simplification, standardization, and a mutual language. This universal language was, to a large extent, the concept of energy – a radical simplification strategy reducing the plethora of materialities, temporalities, and visualities of natural phenomena to a single quantifiable force. What qualified the mapping of the energy concept into virtually all walks of life (and death) was its ontology, teetering on the edge of metaphoricity.

Although, of course, geologists, economists, and ecological energetics would insist that 'energy' was no 'mere' analogy but ontology, it is incontrovertible that the concept of energy was trafficked across disciplinary borders where it relieved ecologists' minds of the messiness and overburdening abundance of natural phenomena. And this, as Hans Blumenberg said, is just what metaphoric concepts do:

"Der Begriff, das Instrument der Entlastung, der entspannten Vergegenwärtigung des Nicht-Anwesenden, ist zugleich das Instrument einer Anwartschaft auf neue Gegenwärtigkeit, neue Anschauung […]. Sie [die Metapher] befreit künftige Situationen davon, in der Irritation durch Reize zu ersticken oder zu zerflattern. Sie tut es, indem sie das Mögliche vorweg verarbeitet. […] [Z]ur bloßen Entlastung [tritt] hier der Sachverhalt, daß das Weniger-wahrnehmen-Müssen ganz im Dienst des Mehr-wahrnehmen-Könnens [steht]."[133]

'Energy' became a kind of Leibnizian *characteristica universalis*, a common language with which natural processes could (be said to) communicate.[134] Such

128 Karen Barad: *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*, Durham NC 2007, p. 106.
129 Ibid.
130 Timothy Morton: *The Ecological Thought*, Cambridge MA 2010.
131 This point was made prominent by Foucault: terms and concepts, he said, "reduce[…] the whole area of the visible to a system of variables all of whose values can be designated, if not by a quantity, at least by a perfectly clear and always finite description." Michel Foucault: *The Order of Things: An Archaeology of the Human Sciences* (1966), New York 1994, p. 137, as quoted in: Robert Davis: "Inventing the Present: Historical Roots of the Anthropocene," in: *Earth Sciences History* 30 (2011), issue 1, pp. 63–84, here p. 63.
132 Derek Woods: "Scale Critique for the Anthropocene," in: Michael Tavel Clarke/David Wittenberg: *Scale in Literature and Culture*, Cham 2017, pp. 133–142, here p. 87.
133 Hans Blumenberg: *Theorie der Unbegrifflichkeit*, edited from the estate by Anselm Haverkamp, Frankfurt a. M. 2007, p. 27.
134 For instance, Jevons spoke of "engines in which the motive power is excited by the communication of heat to fluids," while the industrialist William Armstrong remarked that Watt's steam engine enabled engineers "communicate

legibility, however, translated directly to governance, either on scientific terms or in political terms – the results of which are captured in the Anthropocene concept. Indeed, energy allowed human agency and natural agency to be measured and quantified with a single concept.

In its abstractness, the concept of energy also served as a bridge to the humanities – with the result that it fostered the erosion of the nature/culture dichotomy cemented in modernity. In Anthropocene thought and indeed in its conceptual legacy reaching back to the nineteenth century, terms and concepts from the sciences were taken to hold for the realm of the human. We observe this, for example, in the realm of human economy, when energy begins serving as a scientifically sanctified measure of wealth. We observe it when humans are rebranded first as laborers and increasingly as consumers, rendering them digestible in the belly of capitalism. We observe it when evolution serves as an explanatory foil for the progress of civilization and of knowledge. We observe it when ecologists, heavily invested in energetic holism, begin including human activity in their discipline. We observe it every time when, in the last two centuries, man has been recast as a geological force to diagnose various presents. And we observe it in contemporary Anthropocene epistemology. The notions of entanglement, of hybridity, and of holism arose from the systems worldview from ecology – one enabled by 'energy.'

This strategy of drawing on science to explain the sphere of human activity and thought is indicative of a wider cultural dynamic. The twentieth century, conceptual historians have pointed out, saw a 'scientification' (*Verwissenschaftlichung*) of concepts, most prominently exhibited in Social Darwinism and psychoanalysis.[135] This practice of conceptual trafficking has become characteristic of Anthropocene epistemology. One of its central premises is, after all, that the nature/culture dichotomy, and therefore the science/humanities dichotomy, is artificial and must be rejected. Karen Barad, building on this notion, projects facts from the subatomic realm to the level of reality accessible to human senses – assuming them to remain valid here. In philosophy, this move is derided as a naturalistic fallacy.[136] Canguilhem diagnosed it as a symptom of a scientific ideology.[137] But whether or not it is 'correct' to assume that the logic of the quantum world holds for *our* life-worlds, or whether the myriad of natural phenomena with their idiosyncratic materialities can be reduced to energy without loss, conceptual transfer does indicate an uneasy oscillation between 'mere' analogy and ontology.

This remarkable continuity at the same time betrays the radical break of the Anthropocene. Throughout the nineteenth and twentieth centuries the scientific concept of energy, in multiple different guises, was imported to illuminate mankind – it was this projection, as I have tried to show, that paved the way for the emergence of the Anthropocene concept. However, whenever energy was drawn upon to explain the actions of human beings – to illuminate their economic behavior, their progression throughout history, and lastly their interfering and managing role in the Earth's ecosystems – it was unfailingly as an argument embedded within a human context. It said more about how humans should think of themselves and act politically and ethically than it did about the material world. Though ecology realized the role of human activity as relevant to its discipline early on, it was only with the advent of genuinely Anthropocene thought that this notion flourished into a research paradigm that takes the entirety of Earth systems into account. Where Darwin had proven man was an animal, ecology described his part in the system of nature. In the Anthropocene concept, however, humankind and all its actions are treated as relevant beyond its role as an animal and beyond local ecosystems. Human beings, in this view, have advanced onto the scale of a geological force, spatially and temporally. The Anthropocene thus imposes on reality a layer of abstraction inaccessible to human experience. Mankind has sprawled beyond the conventional disciplinary reaches of history, politics, sociology, and cultural studies. The 'human' has surpassed the humanities and social sciences and entered the sciences. It is this that constitutes the epistemic break of the Anthropocene.

equable circular motion directly from a steam-engine to a machine." See William Jevons: *The Coal Question* (note 28), p. 176 and William Armstrong: *Report of the Thirty-Third Meeting of the BAAS*, London 1863, p. 5, as quoted in Thomas Turnbull: *From Paradox to Policy* (note 19), p. 80.

135 Ernst Müller/Falko Schmieder: *Begriffsgeschichte und historische Semantik. Ein kritisches Kompendium*. Frankfurt a. M. 2016, p. 384. In this diagnosis they refer to Christian Geulen: "Plädoyer für eine Geschichte der Grundbegriffe des 20. Jahrhunderts, " in: *Zeithistorische Forschungen* 7 (2010), issue 1, pp. 79–97, here p. 81; online: https://doi.org/10.14765/zzf.dok-1790.

136 Lorraine Daston has recently elaborated the metaethical question of why humans persist in reading societal values into nature and, legitimated by science, out again. Lorraine Daston: *Against Nature*, Chicago 2019.

137 Georges Canguilhem: *Ideology and Rationality in the History of the Life Sciences* (1977), Cambridge MA 1988.