The New Atlantis
A Journal of Technology & Society

The Time of Our Lives

Raymond Tallis

When I wake up each morning, I am less likely to reflect that a new day has arrived than that yet another day has departed. What we unthinkingly call "the passage of time" tinges the first few minutes with apprehension. I am reaching the end of my sixties and, although the end is as invisible as it ever was, my probability of dying in a given year is many times greater than when, as a teenager, I first tried to imagine the extinction of my life, my world, and all those who had shared it with me. My human being is more begoing than becoming. I am somewhere between suppertime and midnight in my life's day.

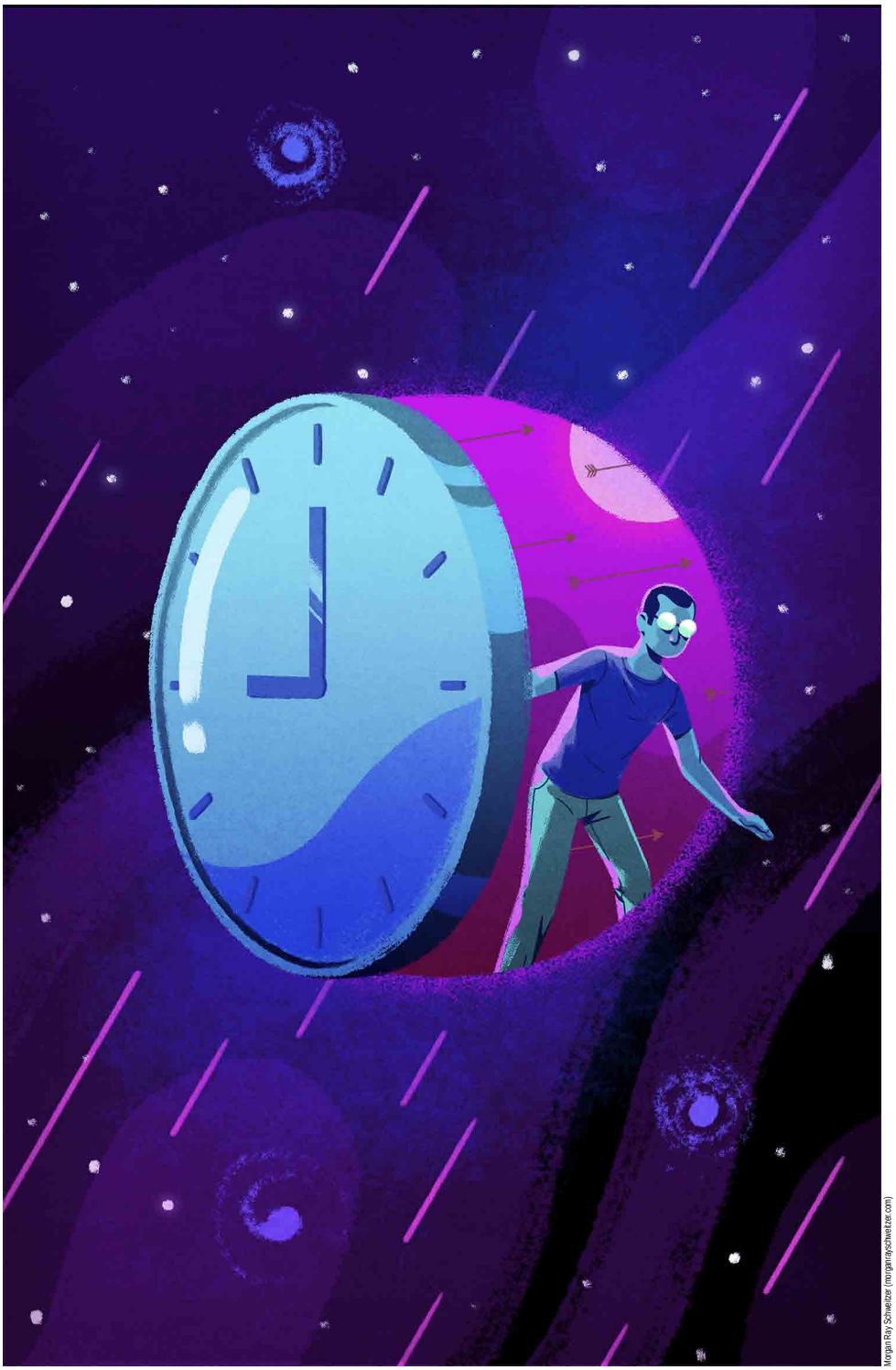
What's more, the pace seems to be quickening. On each January 1 the number designating the year just past looks less used up than its predecessor. By the time 1960 had arrived, my 1959 was worn out and its replacement overdue. When 2011 was announced, I was still not used to 2010 and even 2009 and 2008 looked scarcely touched. It is hardly surprising that I sometimes feel—as I imagine you, reader, do when yet another day, another week, another summer, another year has melted away—as if I were being swept, log-like, towards a cataract dropping into oblivion.

This feeling of suppressed panic has prompted me to think systematically about time, perhaps in the hope that, by cultivating a special kind of attention to it, I might slow it down or (if the expectation of having such an impact on the universe was unrealistic) slow my own passage to oblivion. Of course, most thinking about time, especially in the last century or so, has been done by physicists. But if thinking about time is an indirect way of meditating on our mortality, then we need to focus on time as it is lived. This means rescuing time from the jaws of physics—challenging the increasingly prevalent assumption that physics has the last word on the nature of time.

To do so, however, is to risk being classified with the kind of individual who, writing to Professor Einstein from a park bench (with a crayon in one hand and a methylated spirits spritzer in the other), points out the errors

***Raymond Tallis**, a* New Atlantis *contributing editor, is emeritus professor of geriatric medicine at the University of Manchester, United Kingdom, and the author of the forthcoming* Of Time and Lamentation: Reflections on Transience *(Agenda, 2017), from which this essay has been adapted.*

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.



Morgan Ray Schweitzer (morganraygschweitzer.com)

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

in his Theory of Relativity. So it is important to make clear that my aim is not to correct the physics of time but only to say why and how physics has little or nothing to say about much that truly matters about time. In an important sense it "loses" time—something that some physicists might welcome, given that aspects of it seem to have no place in a physical world whose laws seem to be time-reversible, or invariant with respect to temporal reversal, and hence indifferent to the unfolding of time.

But it is the unfolding of time, and its apparent "unidirectionality"—always moving (or so we are inclined to say) from earlier to later—that matters most in our experience of time. The attempts of physicists to explain this feature of time have on the whole been thoroughly inadequate, including the attempt, which we will discuss later in this essay, to define the direction of time in terms of an accumulation of information. The idea of time as an "arrow of information," as it is sometimes called, shows the general inability of physics to accommodate the conscious observer that makes physical science possible—the inability, that is, to connect an objective explanation of time, understood as a feature of material events, with a person's subjective experience of time. It is the role of philosophy to try to make this connection, to examine the relationship between what the philosopher Wilfrid Sellars characterized as the "scientific image" and the "manifest image," and to seek something that encompasses them both.

The Physicists and the Philosophers

Several prominent physicists have attacked philosophy as a waste of breath. Notable among them is the Nobel laureate Steven Weinberg, who devotes an entire chapter of his *Dreams of a Final Theory* to this topic. Even where "the insights of philosophers have occasionally benefited physicists," he says, this has been "generally in a negative fashion—by protecting them from the preconceptions of other philosophers." Ouch! And he reports that

> I know of *no one* who has participated actively in the advance of physics in the postwar period whose research has been significantly helped by the work of philosophers.

It is tempting to respond by inviting him to get out more, or at least to note that in the early part of twentieth century many of the great physicists (Einstein, Bohr, Schrödinger, and Heisenberg) *were* preoccupied with philosophy and acknowledged the influence of philosophers. Some physicists and philosophers of physics—most notably Lee Smolin—have even

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

argued that the stagnation in particle physics of the past few decades since the Standard Model was completed might have something to do with the rejection of the kind of radical reflection on the conceptual framework of science that philosophers indulge in. The science writer George Musser notes that, while certain physicists think that being seen talking to a philosopher is "like being caught coming out of a pornographic cinema," others do have different views. Musser quotes Carlo Rovelli, a leading figure in the endeavor to reconcile quantum mechanics with the General Theory of Relativity, who has argued that "the contributions of philosophers to the new understanding of space and time in quantum gravity will be very important."

Rovelli—who believes that time at the fundamental level is unreal—and Smolin are probably in a minority in their belief that physicists need philosophy. The quantitative epidemiology of opinions is an uncertain science; it is possible to mistake loudness for quantity. What is beyond question is the prominence of those for whom mathematical physics is the only way to advance our understanding of time. Foremost among them in the popular mind is Steven Hawking. He has famously argued that questions such as "How can we understand the world in which we find ourselves? How does the universe behave? What is the nature of reality? Where did all this come from? Did the universe need a creator?"—traditionally questions for philosophy—are this no longer. His assertion that "philosophy is dead. Philosophy has not kept up with modern developments in science, particularly physics" attracted wide public attention and a good deal of uncritical agreement. The absurdity of his one-time (but now withdrawn) claim that astrophysics can even answer questions that philosophers usually leave to theologians does not seem to have discredited him in the eyes of many people. M-theory, which unifies (or, we are promised, will one day unify) quantum mechanics and the General Theory of Relativity, is apparently able to explain how the universe came into being; why there is something rather than nothing.

The dismissal of philosophy by physicists has been made easier by the fact that many philosophers have colluded in the capitulation of metaphysics to physics. The heirs of the Vienna Circle who gave birth to logical positivism and the most scientistic strands of analytical philosophy would have agreed with Weinberg:

> The insights of the philosophers I studied seemed murky and inconsequential compared with the dazzling successes of physics and mathematics.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

The deferential attitude to physics among philosophers has outlived logical positivism and the discrediting of its critique of metaphysics. The philosopher Hilary Putnam was speaking for many when he stated quite baldly that philosophy has little to contribute to our understanding of time:

> I do not believe that there are any longer any *philosophical* problems about Time; there is only the physical problem of determining the exact physical geometry of the four-dimensional continuum that we inhabit.

The conviction that the last word on the ultimate nature of the universe, and even of items in the universe such as you and me, belongs to (mathematical) physics, which is approaching by successive approximations to a God's-eye view, is tenacious. The contrary notion that time is inseparable from human consciousness—which would seem to challenge the assumption that physics has the last word on time—does not cut much ice with some. After all, physicalist accounts of consciousness were, until recently, ascendant in philosophy, though there are signs that they are now in retreat.

The philosopher Hugh Mellor deplores the fact that "so many philosophers are absurdly credulous of the wildest speculations of physicists about time." Not all philosophers are so prone to cringe before the authority of science or believe that their role is merely to act as cheerleaders for physical science because the immensely powerful, complex, and largely unintelligible discourses of science are not only the latest, but will generate the last, word on metaphysical issues. Numerous writers have assimilated the findings of physicists but have nonetheless continued with their own inquiries, confident that the nature of time is not entirely to be revealed in the world of mathematical physics. They have examined the logic of tenses, puzzled over the nature of becoming, tried to grasp what we mean, or should mean, by the "passage of time" and the idea of the "direction of time," endeavored to make sense of past and future events, and wondered whether time is inseparable from change, whether it is punctuate or continuous, and whether tensed time, or even time itself, are real—without deferring to physics.

Even so, those who hunger to make other than mathematical sense of physical theories such as those of quantum mechanics are often rebuffed by physicists. The truth is in the mathematics: this is all ye know and ye need to know. This attitude is encapsulated in David Mermin's famous "Shut up and calculate!" This is unsatisfactory—not the least to those

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

such as myself who are not particularly brilliant at calculation. But that's not the only reason that I, for one, am not going to shut up. The more important reason for opening my mouth—or at least thinking for myself—is that I, too, live in time and inhabit space, and so I am entitled to talk about both. And I am inclined to retort to the physicists: "Shut up and get on with your calculations." For I have no problem with those who simply get on with their calculations, so long as they don't think their calculations are metaphysics, or that they render philosophical metaphysics redundant, like a cognitive ox cart in an age of sports cars and jumbo jets.

In short, there are many reasons for not turning to physics for the last word on time. First, physics is itself in something of an impasse, with its two most powerful theories in conflict. As Barry Dainton has put it:

> We know that our current fundamental physical theories are imperfect: quantum theory and general relativity have yet to be fully reconciled. It may well be that the theory that emerges from this eventual marriage will have very different implications for the nature of space and time than those of currently accepted theories, so it would be very short-sighted to take *current* scientific theories to be the last word on space and time *in our universe.*

Since general relativity treats physical quantities such as velocity and position as having determinate values, which quantum mechanics cannot accommodate, and quantum mechanics allows interaction between particles at faster-than-light speeds not permitted by general relativity, this is not only shortsighted but also contrary to the spirit of science.

Furthermore, it is not only unscientific but also unphilosophical to assume that *any* findings and theories from objective, quantitative science will settle the nature of time once and for all or that what is lost in physics of our experience and of what makes our world intelligible was well lost because illusory. To say this is not to reject science—how could any sane person deny that it is the greatest collective cognitive achievement of humanity?—but to assign it to its proper place and to rescue time from the jaws of physics and from the dropped jaws of philosophers so awed by physics as to hand over metaphysical inquiry to physicists.

Let us not forget that there are also many physicists, most notably Einstein, who are unhappy with the impoverished (though immensely powerful) conception of time he had had such a crucial role in developing. At points in his career, he would have sympathized with this question from Paul Davies, physicist and brilliant popularizer of science:

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

> Should we simply shrug the human experience of time aside as a matter solely for psychology? . . . Does our impression of the flow of time, or the division of time into past, present and future tell us nothing about how time *is* as opposed to how it merely appears to us muddle-headed humans? . . . It seems to me there is an aspect of time of great significance that we have so far overlooked in our description of the physical universe.

The Physics of Time's Direction

Physicists and philosophers of time feel that the unidirectionality of time is not simply a matter of definition but is connected with something fundamental about the universe in which we live.

The hunt has therefore been on for a universal property of objects and events that will give time a direction, at least in the very restricted sense of its moving "forward" but not "backward," the other possibilities (up and down or side to side) not being on the table. This something will account for the difference between the temporal dimension and the three spatial ones; namely, that we can wander at will in space but not in time. The multiplicity of the dimensions of space makes movement independent of those dimensions. While I can move in the up-down, side-to-side, or back-to-front axes, I can (as I do for the most part) move in directions intermediate between these axes, or directions created out of different contributions from these axes. Time, however, appears to have a built-in trajectory: it *is* a trajectory.

It is awareness of this difference that motivates the all-too-familiar metaphor of "the arrow" of time, introduced by the astronomer and physicist Arthur Eddington, and tied by him to the principle of entropy. The idea goes like this. If we are looking for a characteristic of the material world that will give time a direction, it, too, should have something that can be construed as a direction—at least to the extent of being one-way—and it should be a ubiquitous feature. The Second Law of Thermodynamics seems to meet both of these criteria. According to this law, a closed system will tend towards increasing entropy or disorder. This is illustrated throughout nature. Concentrations of heat, of diffusible substances, of gases, and so forth will spread to fill any space made available to them, and in that space there will be an ever more homogeneous distribution of the relevant variable or substance. If you deposit a drop of ink into a jar of water, it will spread throughout the water. The reverse process does not happen—or very rarely happens—spontaneously. For example, we do not see the drop of ink gathering itself up from the water.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

The direction of the unfolding of events with time towards increasing homogeneity, or disorder, is that of increasing entropy. "Later" means in a state of higher entropy compared with "earlier."

This connection was expressed by Eddington as follows:

> Let us draw an arrow arbitrarily. If as we follow the arrow we find more and more of the random element in the state of the world, then the arrow is pointing towards the future; if the random element decreases the arrow points towards the past. That is the only distinction known to physics. This follows at once if our fundamental contention is admitted that the introduction of randomness is the only thing which cannot be undone.
>
> I shall use the phrase "time's arrow" to express this one-way property of time which has no analogue in space.

The spontaneous trend towards "thermodynamic equilibrium" is essentially a mixing up and evening out of the material contents in the world, one manifestation of which is the degradation of complex items, a loss of order or structure, within closed systems. The one-way passage of events towards de-differentiation is associated in physics and engineering with loss of energy available for use (as when heat dissipates into the surroundings of the heated object), and in homely everyday life with upsets such as the breaking of a cup, which can be brought about by a simple event such as its being dropped and cannot be as easily or entirely reversed. The irresistible passage from an earlier, comparatively lower entropy state (whole cup) to a later, higher entropy state (the broken cup) and the barriers to the opposite ordering of these states—returning the higher-entropy broken cup to its lower-entropy state of wholeness—suggests that there is a natural tendency in the material world to a state in which earlier states of the universe as a whole are tagged by higher order and later states by lower order, or increased entropy.

Such a net change in the universe over time will seem to be puzzling given that the laws of classical physics are time-reversible. For example, the laws of motion do not dictate that the passage from whole cup to broken cup should be privileged over the passage from broken cup to whole cup. A film of the broken cup reassembling itself would not show the laws of physics being broken. So, it would seem, there should be no overall trend towards increased entropy over time; there should be to-ing and fro-ing here and there without a net change. However, the apparent clash between the reversibility of Newtonian mechanics and the irreversibility of thermodynamics can be resolved. It is, as Ludwig Boltzmann pointed

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

out, a consequence of the fact that there are more (many more) possible disordered states than there are ordered ones. The passage from non-equilibrium to equilibrium states (as when local heat is dissipated into the world at large) is in accordance with statistical probability. This dictates that random change—as is seen at the molecular level—will overwhelmingly result in a macroscopic passage from lower to higher entropy rather than the other way round.

But at the heart of the thermodynamic arrow and the notion that times can be defined by the comparative levels of disorder in the universe there is a deep confusion. We are still left with the fact that we have to determine, independently of any of their characteristics, which of two events, or even which of two states of the universe, is "earlier" and which "later." The very idea that we *progress from* "less probable" (low entropy) states *to* "more probable" states seems to *presuppose* a temporal order, not to *create* it. Time, and the direction of time, is built into the very idea of change, of an entity moving from one (a prior) state to another (posterior) state, irrespective of what form the change takes. Without an independent sense of time order and the ordering of times, we could not have arrived at the Second Law.

An adjacent point is argued with great clarity by the philosopher Huw Price in his incomparable book *Time's Arrow and Archimedes' Point*:

> We are inclined simply to help ourselves to the principle that the past explains the future, but what could possibly justify that inclination here, where the temporal asymmetry of the universe is what we are seeking to explain?

And he develops this as follows:

> *Unless one temporal direction is already privileged, the statistical reasoning involved is as good in one direction as the other.*

A particular trend in the state of the universe over time (for example towards increasing untidiness) does not give time an externally definable directionality; on the contrary, directionality in time is required to make this trend the basis of temporal asymmetry. A trend can be seen as the basis of "forward in time" as opposed to "backward in time" only if we establish in advance the order of events or states, so that we can see that State 2 *follows* State 1. To put this another way,

> No theory of the evolution of a physical system over time can produce different results for the two temporal directions, unless it treats them differently in the first place.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

Elaborating this point, Price writes,

> It has not been properly appreciated that we have no right to assume that it is an objective matter that entropy *increases* rather than *decreases*. . . . What is objective is that there is an entropy gradient over time, not that the universe "moves" on this gradient in one direction rather than the other.

It is, in short, our asymmetry of gaze—which is neither omnitemporal nor atemporal—rather than the entropy gradient that delivers the asymmetry in time.

It should by now be evident that the relationship earlier-to-later cannot be defined, even less created, *post hoc* by trends in the physical world, if only because those trends, being time trends, presuppose that "earlier" and "later" have already been established. Even so, philosophers and physicists have looked to even broader one-way or irreversible trends in the universe to account for the apparent unidirectionality of time, such as the cosmological arrow, to be found in the totality of the universe's irreversible processes, or the arrow of radiation, which is illustrated by dropping a stone into a pool, resulting in concentric waves spreading across the surface of the water—clearly a process that could not go into reverse. But these arrows, too, fail to generate the requisite temporal asymmetry, the difference between the tip and the tail of the arrow, for the same reason as does the appeal to increasing entropy; namely, that we have already to identify that certain states are temporally prior to other states in order to register that there are trends which are irreversible.

Direction in our Minds

While every event in the universe is in theory temporally related to every other event, without an observer to experience the events and to connect them, they are neither "earlier" nor "later," "before" or "after." For example, an unobserved event on a distant planet does not have this ordering in relation to the events that I am aware of as going on around me now or indeed other unobserved events on that planet. This is why some have argued that, if there is an arrow of time, it must be built not out of the intrinsic properties of material events but out of the linkage of events through the succession of the experiences of them. Without this linkage, two happenings would not as it were reach beyond their own boundaries to relate to each other. Thus the basic argument for time's arrow being a "psychological arrow."

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

Locating the arrow of time in the human psyche, however, raises as many questions as it answers. If we reduce the directionality of time to the *experience* of the succession of events, within our minds, our bodies, or the observed material world, we run into trouble accounting for those aspects of succession that are more objective, or less observer-dependent, than others.

Consider a simple example. Suppose I am looking at a group of smiling people. I will see the smile on the face of Mr. A before I see the smile on the face of Mrs. B if I pan round in one direction and the reverse if I pan round in the other direction. This does not, however, determine the temporal order of the smiles. If Mr. A started smiling before Mrs. B, this fact is not altered by the other fact that I perceive Mrs. B's smile first. The psychologizing of time's arrow, in other words, does not accommodate the objective reality of temporal order or those features of it that cannot be relativized, as, for example, where the salient events are causally related; where, let's say, Mr. A's smile triggered off Mrs. B's. We acknowledge that the sequence of events and the sequence of our experience of events are distinct—something that is more obvious when we consider the order in which we become aware of something as a matter of general knowledge. The Big Bang may have been the first event, but it has only recently become an object of knowledge.

The psychological theory of the arrow sits ill with the fact that something outside of consciousness, or a conscious individual, is the final determinant of the succession of events. What's more, implicit in the notion that time's arrow is based on our perception of the succession of events is the assumption that there is a succession of events to be perceived—that temporal order and direction is intrinsic to the events we perceive—that gives rise to the experience of succession. There is a confounder arising out of the fact that the order in which we perceive things also to some extent depends on us (just as what we perceive depends to some extent on where I choose to look from and the direction of my gaze). But this is not sufficient to determine the order of events, though it does determine the order of my perceptions.

The psychological reduction of the directionality of time—and of what makes "before" before and "after" after—is open, therefore, to a variety of objections. And so we have reached an impasse. The endeavor to find the directionality of time in the asymmetry of physical processes, such as is reflected in the Second Law of Thermodynamics, may be doomed because it overlooks the necessity for a conscious observer to translate the states of the universe or of local systems within them into a *succession* that has

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

been picked out and connected. However, the radical conclusion that the directionality of time is entirely internal to our psyche—and to our sense of the past and the future—makes it difficult to see the connection between the succession of our experiences and the ordering of events that appears to be independent of anyone's experiences.

The Arrow of Information

The complementary deficiencies of physical and psychological bases for the direction of time may in part explain why the notion of time's arrow being an "arrow of information" has had such a good run for its money. "Information" in common (sloppy) usage is something that can be seen as having a *recto* of psychological contents and a *verso* of physical events.

Notwithstanding the selling point of this arrow—its combining physical processes and psychological events—the focus is often on the latter. We look back at the past in knowledge of what has taken place and we look forward to the future in ignorance of what may come to pass—and it is this that provides respectively the tail and head of the arrow. To put this another way, the forward movement of time is an *accumulation of information*, reflected in a difference between what we have known and what we will know; or between a remembered past of irreversible, determinate events, and an unknown, indeterminate future.

This is expressed most clearly by Paul Davies: "The fact that we remember the past, rather than the future," he says, "is an observation not of the passage of time but of the asymmetry of time." Given that (as he and many others believe) memory is a matter of "information," so the difference between the determinate past and the indeterminate future is also a matter of information. We obviously have more information about the past than we do about the future. Indeed, in one sense we have *no* information about the future, except at a probabilistic level. So, as the indeterminate future becomes a determinate past, information accumulates.

Now it is of course obvious that the difference between past and future, or between "before time *t*" and "after time *t*" cannot be the difference between what I know and what I don't know; cannot be reduced to the difference between my knowledge and my ignorance. No "Arrovian" would wish to advance a hypothesis so vulnerable. It might have all sorts of undesirable consequences, such as for example that an event would pass from the future to the past only when I (or someone) got to know of it; and, even, that it would be returned to the future when I (and everyone else) had forgotten it. It is not about information understood as personally

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

held knowledge but about what, for reasons that lie outside of me, I or anyone else could possibly know. No, the contrast is that what is in the past, irrespective of whether anyone knows it or not, is knowable because it has happened, whereas the future is not knowable because it has not happened yet.

This reminder of the contrast between the relatively information-poor future and the relatively information-rich past explains why it is insufficient to deliver time's arrow. The arrow of information seems to merge two processes that should not be confused, never mind identified with one another; namely, states of the universe passing into *knowledge* (increasing information in the narrow sense, which is an epistemic difference) with passing into *existence*, from possibility to actuality (which is an ontological difference). The confusion is the result of the way that, in this context as in many others, the idea of "information" is widened to include the passage from indeterminacy to determinacy in the case of *material* events in the absence as well the presence of consciousness. Some explanation is needed.

The massive expansion of the catchment area of the word "information" is one of the most striking trends in recent philosophical and scientific discourse. I won't go into this in any detail here, as I have discussed it at length elsewhere (see the essay on "Information" in my 2004 book *Why the Mind Is Not a Computer*). Suffice it to note that a term that originally designated intelligence, news, gossip, facts exchanged between people—between an informant and one who is informed—is now being used to designate any kind of transaction in the material world. The flimsy rationale for this is set out by David Chalmers, who speaks for many:

> Wherever there is a causal interaction, there is information, and wherever there is information, there is experience. One can find information states in a rock—when it expands and contracts, for example—or even in the different states of an electron.

This greatly expanded notion of information has been particularly attractive to some philosophically inclined physicists. According to John Wheeler's famous phrase "it from bit," the universe is a massive information-processing machine. There is, of course, more to be known about a universe that has a history of 2 billion years compared with one that has a history of 4 billion years—namely 2 billion years' worth of happening. It does not, however, follow from this that more *is* known. The "more" of the first 4 billion years compared with the first 2 billion years (long before conscious life emerged) is not more information.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

The vision of the History of Everything as a progressive accumulation of information makes it easy to merge the fact that the past is known while the future isn't with the fact that the past is determinate while the future is not; to conflate *knowledge* and *knowability*. This confusion is sometimes compounded by another that brings the thermodynamic arrow back into the frame: the identification of information with, on the one hand, entropy (something intrinsically remote from consciousness) and, on the other, memory (which, in my case at least, is inseparable from consciousness). Paul Davies again:

> As physicists have realized over the past few decades, the concept of entropy is closely related to the information content of a system. For this reason, the formation of memory is a unidirectional process—new memories add information and raise the entropy of the brain. We might perceive this unidirectionality as the flow of time.

Exposure to events creates memories; memory is the accumulation of information; information is increased entropy; the increased entropy of our brains gives us a sense of the passage of time but underpins the reality of the directionality of time. Let us deal with each of these assumptions in turn.

The first two are easily dealt with. To reduce memory to information in the sense of factual knowledge is to traduce it. It is much wider than that: it includes much that is *not* accessible as information (such as changes in unconscious presuppositions and the acquisition of skills); and much that, though accessible to recall, is not information in anything other than a strained sense—such as the sad recollection of a day that has passed. This would not be a problem for Davies and others. Their notion of information is, as we have seen, very broad. Which brings us to the next association of terms: information is identified with entropy. It is worth tracing the argument that leads to this conclusion.

When you are sending me a signal, the quantity of information (according to the engineering definition) that you transmit depends on how much uncertainty you resolve. If there are only two possibilities, and the signal tells me which one, then the delivery of the signal has given me one binary digit (one "bit") of information. If I were sending randomly determined letters, then each letter would resolve a greater uncertainty: the probability of any given letter being sent is 1 in 26 and the arrival of a signal bearing a letter delivers 4.7 bits of information. There seems to be a correlation between the amount of uncertainty resolved and the quantity of information transmitted. A more chaotic system simply contains more

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

information—or potential information; it is richer in uncertainty. There would be more facts to know about it. It would be less susceptible to summary or algorithmic compression.

The slither between potential and actual information—or between a system and what there is to be known about it—is a symptom of another invalid conflation: of "information" in the engineer's sense with "information" in the conventional sense. In fact, the engineer's quantification of information in terms of uncertainty reduction presupposes the prior existence of the uncertainty that has to be generated or entertained in order for an event to count as something that resolves it. Uncertainty will be very context- and, indeed, interest-dependent. If I am expecting a message consisting of one out of the 26 letters of the alphabet, then the single-letter message that turns up will deliver 4.7 bits of information. If the options, however, are framed as "letter" versus "number," then the receipt of any letter will count as one bit of information. If I am wondering whether the transmission system is working, then the arrival of *anything at all* would count as an additional bit of information. Other information may be carried by the transmission of the letter; for example, whether you, the sender, are cooperating with me, are competent, are still there at the other end. In sum, there is no measurable information, even in the engineer's sense, without an uncertainty being proposed or felt that an event will resolve and, thus resolving the uncertainty, will count as a signal. These ambiguities arise even if we set aside the significance of the semantic content of any message I receive. Suppose I am desperate to know whether you are alive or dead. The letter A for alive or D for dead will each carry one bit of information in the engineering sense. The significance of each letter, however, is boundless. Each carries a huge piece of information that is not captured in the tine of a fork.

The extension of information to encompass events in (unobserved) rocks and electrons *à la* Chalmers is the ultimate consequence of separating the notion of information not only from meaning and significance but also from any conscious being who is informed and who has a sense of uncertainty that needs resolving. The profound difference between a signal that resolves uncertainty from that which the signal is *about* has been collapsed. By this means, every event can be made over into an information-bearing signal, so that the unfolding of the universe becomes a unidirectional accumulation of information—thus the background to the connection between the information arrow and the thermodynamic arrow, between information and entropy, and the assumption that a disordered system, which has more unpredictability and requires more messages to

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

describe, is richer in information than an ordered one. The informational richness of a signal sent by one conscious being to another into the system or region of matter it describes is projected, by something akin to magic thinking, into the universe itself.

That this notion gets past many quite serious thinkers reflects the extent to which we are (far too) accustomed to talking about information being embedded in the material states of affairs that information is supposed to be about. Such talk collapses the gap of "aboutness" and finds information in the material world. Overlooking "aboutness" lies at the heart of many of the wrong paths taken by the metaphysics in the physics of time.

The removal of consciousness from information is a key step in connecting the thermodynamic trend towards higher entropy with the difference between a remembered past and a future of which we are ignorant. The present state of any evolving object would be a bidirectional glimpse into a past (which would in turn be related to its own past) and into a future. The lowliest item in the physical universe would have the very tensed time that "believing physicists" (according to Einstein himself) hold exists only as an illusion in the human brain (including the brain of physicists)—an item that, as a material object, should not have the physical capacity to house the tensed concepts their owners believe in.

Seeking the directionality of time in "the flow" or "accumulation" of information, therefore, results in conflating the difference between (tenseless) "earlier" and "later" with the (tensed) difference between a past we can remember and a future we may anticipate; between a past of which we can have certain knowledge and a future about which we can only speculate. The putative intrinsic directionality of time is conflated with the asymmetry of the temporal gaze of a conscious individual located in time. The information arrow (to reiterate an earlier point) confuses an epistemic difference—connected with what we know or can know—with something more substantial; between a determinate past and an indeterminate future. The difference, in short, is not merely epistemic but also ontological or constitutive. Not knowing the future is different from ignorance of the past because there is nothing to be known about the future—though it can be guessed at with more or less shrewdness—as it hasn't gone one way or another yet. Regarding the future, we are all (relatively) in the same boat. Even when I have a privileged position (as when I can see two cars on a collision course, though the drivers cannot see one another, or when I have insider information relevant to the stock market), I still cannot be sure that there will be a collision or that the shares I am

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

considering buying will rise. The determination of the future as it enters the present is not merely a matter of becoming potential information: it is about something out there that has changed.

In summary, confusion of the directionality of tensed and tenseless time, and of epistemic limits and ontological realities, in the information arrow is not at all surprising, given the proliferation of meanings in the contemporary usage of the word "information." As such, the arrow of information is decidedly uninformative about the directionality or asymmetry of time.

Quivering the Arrow

The deeper problem with the arrow of information, as with the arrow of thermodynamics or any other arrow of time, is with the idea of the arrow itself. It is, first and last, a muddled response to the erroneous notion that time is a dimension—a notion that is of course central to our thinking about time and space.

We are used to representing dimensions by means of lines and lines have a direction and therefore time, being a dimension, must also have a direction. However, it does not follow from the fact that dimensions are *represented* by lines that they are intrinsically directional. Even if the individual lines representing the dimensions had a direction, they would extend infinitely in two opposite directions—away from and towards the origin. When we depict the three dimensions of space, we draw lines at right angles to one another representing respectively the x, y, and z axes. But none of these dimensions has an intrinsic direction; they simply have a directional relationship *in contrast with* one another. The x axis has to be at right angles to the y and the z axes. The y axis likewise: it has to be at right angles to the x and z axes. It is the mutual separation by 90 degrees that defines the axes, and these in turn will define the direction of something that *does* have a direction—for example a movement of an object in the space defined by the axes. The axes themselves no more have a direction than "length" has a length, "height" a height, and so on.

In short, if we take seriously the idea of time as a dimension on all fours with the three of space, we should not countenance the idea of it as being directional in the sense either of moving in a certain direction, or of being statically directed. So the temporal arrow is incompatible with the very idea of time as a dimension that prompted it. Nevertheless, this does not stop the habit some thinkers have of outsourcing the directionality of time to other properties of the physical world, though we find, in the end,

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

that nothing else can fix the temporal sequence of events other than their *de facto* order of occurrence.

The quest for the basis of an arrow of time is, in the end, fruitless. At root is a spatializing tendency we need to resist. Another source is the projection of passage or flow from events to time, which can be challenged as follows. Consider the Event E of an object O moving from Position P_1 to Position P_2. What moves or flows is not E but O. The event itself does not pass through space: it *is* a passage through space. And while the occurrence of events is not a kind of passing or flowing of E through space, we may speak of its "passing" from its beginning to its end. "E," however, refers to the whole, completed event—not to its beginning or end or the transit between them—and this totality does not "pass" or "flow," not even in order to pass or flow into or out of being. When an event takes place, it does not pass by us as, say, an object moving from one position to another passes by us. Its dynamism is internal to it, evident when it is ongoing, no longer when it is done and dusted. The car moves down the road but the event of the car moving down the road does not itself move down the road.

If individual events do not pass in a particular direction as moving objects do (unless we falsely think of passing into and out of existence as a kind of passage), how little does the passage of *all* events taking place at any time amount to a kind of direction. Look at what is happening in the scene before you. Objects are moving hither and thither or remaining at rest, events are happening and coming to an end. There is nothing in this to suggest an overall direction of anything.

Imagine drawing a line from your birth to the present day, tracing all the movements you have made hitherto. It would have to encompass many different kinds of lines, gathering up the movements, say, associated with: tying a tie while you are walking from one room to another; engaging in a phone call; attending a meeting convened to deal with a difficult colleague; completing a clinic or a research project; or trying to get to Paris. There would be deviations, digressions, digressions from digressions, self-embedded sub-routines, jumps from one kind of space to another, and so on. No line, however elaborated, would capture any of it. The life-line, beloved by palmists, in which events are displayed along a palmar crease, however, testifies to the power of the spatial analogy.

There may be another source of the attractiveness of the metaphor of the arrow of time—one that was active in the collective imagination long before Eddington introduced it into the philosophical discussion of physical time. Arrows wound, and then kill, and the image reflects our sense of the world being out of our control and potentially dangerous; it captures

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

the way we are skewered onto the same totality of unfolding events that gave rise to us, our helplessness before the inevitability of things, the fact that the laws of nature cannot be bucked. It reflects a profound, existential anxiety that underpins the fundamental narrative of our life: the passage from birth to death. You can wind the clock back and set it to zero, and make a fresh start; but there is something you cannot wind back—time itself—in order to recover the lost days, to take back or amend what has happened and what we have done.

The notion of the unidirectionality of time, in short, is inseparable from our awareness of our mortality, of a life that has a diminishing quantity ahead and an increasing quantity behind; of birth as a one-way ticket to the grave. And a sense of our ignorance in the face of the future—contrasted with our knowledge of the past—lies at the root of the "arrow of information." We may know how things turned out; never how they will turn out.

To what extent this explains our fondness for arrows of time, I cannot be sure. What is true is that Arrovians have one thing in common; namely, that they want to confer direction upon time and then to reduce the direction to something non-temporal. More precisely, they want to treat the fact that earlier comes before later as both a fundamental property of time and yet susceptible of further explanation. But time simply *is* a matter of earlier before later and the necessary precedence of the former over the latter. That this very obvious fact seems to require explanation is also the result of seeing time as space-like and its asymmetry as therefore puzzling. If space were understood in time-like terms, we would be puzzled by its being the same in all directions, that it was possible to travel freely in it, and that distinct parts of it coexisted such that there was no order governing visits to different items in space.

According to the persuasive judgment of physicist G. J. Whitrow in his classic study of time, the attempt to understand time in non-temporal terms will always fail:

> Any theory that seeks to derive the *entire* concept of time from some more primitive considerations—for example, assumptions of a causal, probabilistic or statistical nature—is foredoomed to failure. For any theory which endeavours to account for time *completely* ought to explain why it is that everything does not happen at once. Unless the existence of *successive* (non-simultaneous) states of phenomena is tacitly assumed it is impossible to deduce them. . . . In the final count, time is a fundamental property of the relationship between the universe and the observer which cannot be reduced to anything else.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.

The arrow of time is a striking manifestation of this failure to see the irreducible *sui generis* nature of time: it is rooted in the belief that if there were time-asymmetric processes and these were universal, then time would be directional and its directionality explained.

The project of understanding time is to try to get a clear and just idea of the nature of the relationship between the universe and the observer in respect of time. By rethinking time in this way, we may elude a form of naturalism that sees us as being at bottom material objects whose nature will ultimately be described by physics. We are more than cogs in the universal clock, forced to collaborate with the very progress that pushes us towards our own midnight. By placing human consciousness at the heart of time, it is possible to crack ajar a door through which a sense of possibility can stream.

Copyright 2017. All rights reserved. See www.TheNewAtlantis.com for more information.