The Discovery of Time

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Astronomy is the discovery of space, geology the discovery of time, none of them to be experienced directly only inferentially. It is noteworthy that astronomy, dealing with what which is only accessible to us by sight, was developed so much earlier, while the earth itself with its rocks, plants and animals, so much more palpable, turned out to be much more intractable. The obvious reason is that the former is much simpler and amenable to elegant mathematical elucidation, while the latter is a mess. The mindset of a mathematician is rather different from that of a biologist. On the other hand space is there to be explored, you can, within obvious limits, roam freely in it, but time is arrowed, it flows in one direction and you cannot go back in it. The past has an existence, but none that you can touch. It both exists and does not. The past is past. It has a reality but one which is beyond you, just as the Platonic realm of forms. You can only infer it by the shadows it casts in the present, i.e. by the traces it leaves. As R.G.Collingwood points out, you can never bring the past into the present, you can only make reconstructions of it, and those are of the present, not of the past, and will change with the discovery of new traces. The most direct trace is that of your memory. But your personal memory is feeble and notoriously unreliable, although its vividness can rival that of the perceptions of the present[1]. As an aside it is an interesting question whether you by memory alone would be able to tell your own age, or at least how many summers have passed during your conscious life. It is notoriously difficult to remember events in chronological order and hence to retroactively identify summers and put them in the right order[2]. The keeping of years and dates aids the process enormously. Then you can go further back in time through the testimony of older people in their community, so called second order memories, those in their turn have second order memories which if communicated turn into third order memories. The process potentially infinite is in practice rather limited. In modern times I doubt it goes much beyond third order memories maybe going back not more than a century or two. In cultures with no written records such memories are precious and it is not unusual that certain people in the community are entrusted with keeping them alive and in that way preserving the history of the community several centuries into the past. It is also symptomatic that in such communities, such as the aborigines in Australia, an intricate system of denoting relatedness between people has been developed, which is another kind of memory relating

[1] It is argued that early childhood memories are not real but made up from stories being told about you by your elders, or even pure phantasies. Mine are, however, so vivid that to doubt them would be doubting that one plus one makes two, or that the perceptions in the present are but illusory. One may of course doubt the reality of any memory and that the past as one remembers it, is but a temporary construction, leading to temporal solipsism.

[2] R.G. Collingwood claims that for that reason you cannot write an autobiography solely on the basis of your memory, on the other hand for many crucial aspects of your biography there are no other sources.

to a tree of genealogy only whose most recent branches are present. But it is not only episodes of the past which are preserved in those ways but also stories, which for the ease of memorization tend to be cast in standard formal schemes. Now with time communal episodic memory merges with that of stories and become legend, and it is notoriously hard to separate fact from fiction. Such oral traditions are of course fascinating, and if extensive enough, also so to outsiders. The invention of writing changed it dramatically. Socrates warned against the dangers of writing as it would enfeeble memory. This might strike us as unduly alarmist, but Socrates had a point, any technological invention has unintended consequences as well as making many things obsolete, including precious matters, thus entailing permanent losses. It is true that the invention of writing has made our collective memory so much richer and more extensive, and also more reliable, because a memory always changes a little by the effort of recollection, which is not so much a retrieval as a reconstruction[3]. Thus a written record can be repeatedly consulted without changing, and perhaps more to the point, not be influenced by the purpose for which it is consulted. This is what is traditionally referred to as objectivity. Then it is another thing that any consulting of a document, be it written or not, is a matter of interpretation, but an interpretation of a document is different from the document itself, which is not the case with a memory. Now there is a crucial difference between first order memories and higher order memories, the latter is translated into speech, and speech can to a very large extent be codified in writing[4]. While first order memories may be interpreted in words, for easier reconstruction, they can be apprehended nevertheless even by those lacking language[5]. The superiority of the written record has throughout history led to attempts at efforts at rescuing oral traditions from the threat of oblivion by putting them down. One may think of Snorre Sturlasson in the 13th century working in Iceland or Perrault in the 17th and the brothers Grimm in the early 19th centuries. Especially during the time of the Romantics oral histories were indeed felt as something precious, a manifestation of the *Volksgeist*. But with the written codification the oral tradition became obsolete and disappeared, as Socrates had warned about. This reminds me of the recent practice of photocopying, or more recently digitalizing, written documents (such as old newspapers) and then destroying the originals in the interest of saving space.

Now the written record allows the establishment of a chronology, in fact this seems an inescapable consequence of a civilization, and here astronomy meets history, because astronomy is not only about space but also time, providing an accurate clock. The movements of the celestial bodies provide cycles, but as there are many, there will also be many different cycles, which when combined can cover larger stretches of time, there will also be seemingly unique and spectacular events, such as solar eclipses, which are local in occurrence[6] and hence pinpoint certain episodes in the past with a high degree of accuracy.

[3] cf. Collingwood's remark above to the effect that the past cannot be moved to the present, although of course much of the charm of Proust consists in the possibility that at least small fragments, usually having to do with taste and smell, can be transported wholesale from the past.

[4] Of course not perfectly, there are many aspects that can be conveyed eye to eye and which cannot be formulated in a letter, the cause of many tragic and unfortunate misunderstandings.

[5] Higher mammals may have extensive memories quite possibly superior to that of humans

[6] One can actually detect the slowing down of the rotation of the Earth by discovering that they

Because of the success of Christianity the records of the Jews - the Old Testament- with its creation myth took on a paramount importance in Western culture, in particular it led to a very restricted time span of a few thousand years. Yet, no matter what civilization should have provided the temporal norm, that span would not have been significantly enlarged. To adhere to those strictures led to insurmountable contradictions when confronted with another set of documents, namely those of nature. The discovery of seashells imbedded in rocks on mountains indicated that the surface of the Earth had undergone drastic changes unrecorded by man, except for the allusion to the great flood in the Bible, a story that would not only fire the imagination but also influence subsequent speculations. The idea that the segmentation of rocks is due to sedimentation goes back at least to the Dane Steno of the 17th century, and thus giving a temporal sequence; but biblical strictures prevented him from pursuing the idea and he lost interest and was swallowed up in a clerical career[7]. Descartes too presented similar ideas, but did not for a variety of reasons pursue them either. Attempts to reconstruct the past, in particular the age of the Earth, were done in the spirit of 17th century scientific awakening, in the following century. Halley noted that the salinity of the oceans may be used as a means of bounding the age of the Earth, and du Buffon noted that the present temperature of the Earth would given the laws of cooling an estimate of its age but by necessity assuming an initial temperature corresponding to molten iron. Crude as those measures were and relying on questionable assumptions, they nevertheless indicated timespans far in excess of the biblical, and more importantly suggested new ways of estimating them not based on the Scripture, thus separating human history from natural history first by a divergence of methods and later by content. During the 18th century there were different schools of geologists, Plutonists who emphasized volcanic activity in the forming of the Earth's crust i.e. its rocks and Neptunists, of whom Goethe was a notable proponent, sedimentation in the oceans. In modern geology there is a little of both. Plutonism, in the hand of Hutton, would transform into uniformitarianism, envisioning an unending cycle of erosions and uplifts, with the oft-quoted phrase 'No Vestiges of a Beginning, no Prospects of an End' . Thus in particular envisioning an unending cyclical time, and one is tempted to conclude with no beginning nor any end, thus infinite in both directions, but given the tenor of the times, Hutton would have been careful to deny the event of a creation, although such a radical idea would not been entirely amiss during the Enlightenment, only pointing out that by the methods of geology that event could not be dated. Lyell in his bestselling 'Principles of Geology' perfected uniformitarianism as an ideology of methodology. It became the criteria of good science based on impeccable methods and no ad hoc explanations. The basic assumption was that only those geological processes observable today should be accounted for, and in particular no catastrophes, in particular no biblical floods should be invoked. Anything that smacked of special pleading was anathema. Thus in particular he opposed Cuvier and his theory of geological periods ending in catastrophes and starting afresh with new creations of fauna and flora. Those apparent discontinuities in the geological record, were merely illusory, and due to regional peculiarities. In principle the uniformitarianist approach, given the tardiness of geological processes, would indicate a very old age of the Earth, although the

occurred at 'wrong' places in the past.

[7] which led to a posthumous beatification in 1988

patient work of many geologists establishing maps over large part of the planet, did provide a rather detailed division of the past in geological eras, but this chronology was merely relative, the determination of an absolute chronology would not be possible until well into the 20th century by the methods of radioactive dating. Intimately connected to geology was paleontology, the study of fossilized traces of a previous fauna and flora embedded in sedimentary rocks. From this it became clear early on that the organic life on Earth had changed over time, and this was exploited by the early 19th century geological map-maker William Smith in getting a shortcut in placing rocks in a chronological sequence (the method based on stratigraphy was the basic one which everything else in principle referred to, but this was a method useless for isolated specimen, only possible to do when comparing sediment sequences from different locations, a time-consuming work.). Also Lyell availed himself freely of it. And the life work of Cuvier was an anatomical study of extinct animals, or at least locally so. As late as the beginning of the 19th century the American President Jefferson speculated that Mastodonts may still be around in unexplored areas of the West. However, one should not confuse this awareness of the fact of a changing flora and fauna with evolution per se, as the latter presupposes descent, meaning that species transform into others. Such ideas had been proposed by Maupertius and above all Lamarck in the 18th century, but had been met with ridicule and destroyed reputations. Already Aristotle, unfairly accused of a lack of empiricism, had spent most of his time and effort studying and classifying the organic world. He had noted that it formed more or less a continuum, between any two organisms there were any number of intermediate forms. He also made the fundamental proclamation that there was a ladder, a progression from the lower and more primitive to the higher and more complicated and sophisticated, something which would have an enduring influence. Yet the notion of a well-defined species was still controversial, and Linnaeus did much to establish the notion though his classification scheme. It then became a dogma, and every discovery and proposed theory was judged from this vantage point. Cuvier, as an accomplished anatomist, noted that each species was so perfected that any significant deviation from it would not be viable. The early decades of the 19th century was indeed an exciting period of scientific advance, in fact the English notion of a 'scientist' was coined during that period. The geological record was painstakingly mapped out, huge exciting fossils from distant ages were being unearthed. And there was in addition to a small elite of scientists drawn from the academic as well as the clergy also an educated public who attended scientific congresses and read the seminal works written not for colleagues but for a wider public at large, the notion of popular science had not yet taken root. It was in this milieu that Darwin grew up. His father was a doctor and his grandfather Erasmus a noted scientist himself. He was of the solid upper middle class, one of a handful of noted professional families in England during the Victorian age, liable to intermarry. He was thus not a nobleman but a gentleman sent to the universities both in Edinburgh and Cambridge without leaving any mark. He was a gifted young man without a mission in life and hence lost. Then he was invited to be the naturalist on the ship Beagle, and embarked on a world trip of several years duration, and the rest is history as the saying goes. His magnus opus - The Origin of Species - would be almost a quarter century in gestation, during which he threw himself into his work with abandon, claiming ill-health as an excuse to avoid social obligations. Unlike his

predecessors he was not content with mere speculations, as they had been accused of, but wanted to present, as far as it was possible, a watertight argument for the case of evolution, without being able to provide any mechanism for it. He used the term Natural selection to distinguish it from the willful artificial one familiar with breeders since time immemorial. He had very hazy ideas of inheritance, and only with the advent of genetics (as illustrated by Mendel) was a far more complete picture able to emerge, the synthesis of the 20's, and to which belong the modern formulation of darwinism. Darwin himself was no stranger to Lamarck's transmission of acquired characteristics, in fact he advocated it as a very reasonable explanation. Thus Darwin replaced the haphazard classification of rigid species by a tree of life, the details of which are clearly beyond our capacities, that documents the evolutionary history. So Darwin is after all the one who put evolution firmly on the ground, changing it from mere speculative hypothesis to as close as a scientific fact as one can expect. True the ideas had been in the air, and one of his correspondents - Wallace - was about to become his serious rival as to priority, whose claims precipitated his decision to get out of the closet. The publication in 1859 set up an uproar because after all it was a materialistic view of the work of the Creator seemingly making him superfluous even as a first mover, on the other hand that was what uniformitarianism was all about, although its consequences had never been spelled out so strongly before. However, he was not short of serious detractors, and the new theory had many weaknesses in spite of the marshaling of overflowing evidence, there were logical gaps and ad hoc explanations. How was inheritance effected, and the embryological process showed evidence of archaic features, such as gills in mammals, with no selective advantage, and how did variations come about, and maybe most seriously of all the noted physicist lord Kelvin made an estimate on how long the sun could have been shining with an adequate brightness and came up with a figure far too short for terrestrial evolution to have been completed. Maybe evolution proceeded at a quicker space in the past than now, although this would go against uniformitarianist dogma. Or maybe there were unknown forms of energy sources, Kelvin had made his calculations based on the forms known, what else could he have done? As it turned out a decade or so later radioactivity was discovered, and Darwin was vindicated. As to the more technical objections they would resolve themselves as biology progressed.

Now this may end the book, but the authors adds on a chapter on the possibility of history in the physical sciences which are characterized by simple, elegant and eternal laws. Cosmology provides one example, the formation of the Solar system in an already existing universe more or less as we know it today, was tackled by Kant before he became a philosopher and later on based on the same approach by Laplace. There is always the development of stars, but this is hardly history, even individuals are born, age and die, and we do not consider them as history. But what about the universe itself and Big Bang? This is treated here in 1964 as a daring speculative hypothesis formulated by a Catholic Abbé (how compatible with Genesis!) and compared with Hoyle's steady state universe involving spontaneous creation of matter. As to the redshift it has any number of explanations. As the light from distant galaxies is very old maybe it merely reflects the change of physical laws. They also point out that the redshift only measures radial velocity we have no idea of transversal, but some thought reveals that this does not really change matter, if they would move in straight lines not passing through us, you would statistically expect redshift

from only half of them.

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