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Research article

The Origin and Dissemination of Scientific Knowledge

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Abstract

André Leroi-Gourhan (1911-1986) was a French ethnologist, prehistorian and paleo-anthropologist who is today appreciated also for his influence on the philosophy of technology. His first publications on *L'Homme et la matière* and *Milieu et techniques* (1943, 1945) secured his reputation as a specialist in the study of material civilizations and in comparative technology. This perspective was enriched by evolutionary and anthropological considerations in his best known work, *Le geste et la parole* (1964, 1965). This book has appeared in English as *Gesture and Speech* in 1993, but not all of his relevant publications have been translated, and several aspects of his technological approach remain little known. The translation here of his March 1952 lecture at the Maison des Sciences in Paris, as part of a lecture series on "The structures of the universe and their scientific perception," is an opportunity to highlight the interest and relevance of Leroi-Gourhan for contemporary reflections about technology. For example, a jointly haptic and cognitive "material engagement" is for Leroi-Gourhan characteristic of specifically human manufacture, of "materially creative activities" as undertaken by artisans of all times. We can recognize here Leroi-Gourhan's adhesion to Henri Bergson's philosophical tenet regarding the epistemological primacy of action over contemplation, and consequently the active, dynamic, vital origins of knowledge.

Keywords: André Leroi-Gourhan; Technology; Rationality; Physical and social evolution; Prehistoric flintknapping; *Chaine operatoire*

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Научная статья

Происхождение и распространение научных знаний

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Аннотация
Андре Леруа-Гуран (1911-1986) - французский этнолог, специалист по истории доисторических времен и палеоантрополог, которого сегодня также ценят за его влияние на философию технологии. Его первые публикации о “L'Homme et la matière” и “Milieu et techniques” (1943, 1945) закрепили за ним репутацию специалиста по изучению материальных цивилизаций и сравнительному анализу технологий. Эта точка зрения была обогащена эволюционными и антропологическими соображениями в его наиболее известной работе “Le geste et la parole” (1964, 1965). Эта книга вышла на английском языке под названием “Gesture and Speech” в 1993 году, но не все его соответствующие публикации были переведены, и некоторые аспекты его технологического подхода остаются малоизвестными. Публикуемый здесь перевод его лекции, прочитанной в марте 1952 года в Доме наук в Париже в рамках цикла лекций на тему “Структуры Вселенной и их научное восприятие”, является возможностью подчеркнуть интерес и актуальность Леруа-Гурана для современных размышлений о технологиях. Например, совместная тактильная и когнитивная “материальная вовлеченность”, по мнению Леруа-Гурана, характерна для специфического человеческого производства, для “материально-творческой деятельности”, которой занимались ремесленники всех времен. Здесь мы можем отметить приверженность Леруа-Гурана философскому принципу Анри Бергсона, касающемуся эпистемологического примата действия над созерцанием и, следовательно, активного, динамичного, жизненно важного происхождения знания.

Ключевые слова: Андре Леруа-Гуран; Технология; Рациональность; Физическая и социальная эволюция; Доисторический кремень; *Chaine operatoire*

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INTRODUCTION

Nathan Schlanger

The early 1950s represented something of a watershed for André Leroi-Gourhan (1911-1986). A lecturer in "Colonial ethnology" at the University of Lyon since 1944, he was beginning to reorient his research interests towards prehistoric archaeology, including prospections and excavations in nearby caves. At the same time, he was clearly keen to explore new research domains and bring together hitherto unrelated perspectives and fields of knowledge. To his previous concerns with the characterization of "material civilizations," as inherited from the 1930's *musée de l'Homme* of Paul Rivet and Marcel Mauss, he now added an interest in the all-encompassing notion of technical behavior [*comportement technique*]. Setting aside ethnology – travel in space –, he was reaching towards prehistoric archaeology – travel in time – as well as technology,[1] comparative psychology and, admittedly in a more allusive way, cybernetics too. Thus, alongside modern and ancient humans, the horizons of his empirical research and philosophical reflections expanded to include also animals and machines (see on those issues Schlanger 2023, chapter 7, and Leroi-Gourhan 2024).

On the strength of his manifest pluridisciplinarity, Leroi-Gourhan was invited in March 1952 to contribute to a lecture series at the Sorbonne on the broad theme of "The structures of the universe and their scientific perception." Like other conferences in this cycle, his lecture was subsequently published in *Structure et Évolution des Techniques* (SET), a journal which notably served as the semi-official organ of the *Cercle d'études cybernétiques* – itself launched soon after the publication in 1948, simultaneously in France and the USA, of Norbert Wiener's *Cybernetics or Control and Communication in the Animal and the Machine* (Wiener, 1948) As intended by its editor, the philosopher of technology Pierre Ducassé, the journal aimed to provide an interdisciplinary venue for debating techniques, their forms and developments. Thus, issue 31-32 of the SET included contributions by historical epistemologist Gaston Bachelard and by Jacques Lafitte, author of the 1932 *Réflexions sur la science des machines* (Lafitte, 1932); issue 35-36, dedicated to "*La cybernetique*", featured papers by mathematician Louis Couffignal, neurophysiologist Alfred Fessard, and Nobel prize winner physicist Louis de Broglie. Issue 33-34, the first of a "documentary publications" series, was dedicated to Leroi-Gourhan's article here translated.

Addressing the eminent scientists in the audience, Leroi-Gourhan provided a long-term perspective (what would be called much later a "deep history") on the origins and development of scientific thought. The trajectory he outlined in these 10 pages extended from primate-like proto-hominids all the way to the rise of agriculture, sedentism and

[1] In the French research tradition, from Alfred Victor Espinas and Marcel Mauss to André Leroi-Gourhan and Pierre Lemonnier, the term "technology" essentially designates the logos or study of techniques, just like musicology is the study of music. Among other advantages, this specificity serves to distinguish between technicians, practitioners and engineers, and students of technology in the social and human sciences. As well, this designation helps us avoid commonplace or a priori demarcation between small-scale or ethnographic "techniques" and modern, science-based and industrial "technology" (see more in Sigaut, 1994, Schlanger, 2023).

literate civilizations – a succinct overview that prefigured the sweeping "anthropogenesis" panorama he went on to elaborate a decade later in his 1964-1965 masterpiece, *Le Geste et la parole* (Leroi-Gourhan, 1964; 1965). In this 1953 publication, it must be noted, his linear conception of cumulative progress was occasionally simplistic and partly outdated, regarding for example the supposed cleanliness of *Homo sapiens*, the role of military hierarchy in later prehistory, or the recourse to unwarranted ethnographic analogies. Where Leroi-Gourhan proved to be highly innovative, however, was in his understanding of both the processes of prehistoric stone tools manufacture and their wider implications. To the latest experimental results secured by prehistorians Léon Coutier and François Bordes he added insights from comparative psychology, partly inspired by the physiologist and behavioral psychologist Henri Piéron. This led him to conceive of flintknapping as a structured sequence of fairly complex operations involving various degrees of foresight, memory and consciousness – a process he was beginning to call the "*chaîne opératoire.*" This 1953 paper represents in any case a pioneering contribution to the study of "the prehistoric mentality" – nowadays known as "cognitive archaeology" – whereby, as Leroi-Gourhan put it in a contemporary paper for the *Revue de synthèse historique*, "to follow the gestures, flake by flake, is to reconstruct with certainty an important part of the mental structure of the maker" (Leroi-Gourhan, 1952, pp. 83-84).

This approach informed his contribution to the question at stakes, namely the origins of scientific thought: can we indeed see in the gestures and tools of the most ancient humankind (as evidenced in lithic technology) "a rational perception of causes and effects, which represents a fundamental characteristic of scientific research"? A key notion here, on which Leroi-Gourhan repeatedly insisted, was the close and continuous "contact" between the technical operator and the material in their hands. Specifically to stone tool manufacture, this tactile proximity reflected the inherent indetermination entailed in flintknapping, since both the variable properties of the raw materials (the flint nodules) and the uncertain delivery of the knapping blows make it necessary for the technician to constantly monitor and adjust their course of action. For our author, this confirmed that from the onset technical operations necessarily entailed technical speculations, which in turn heralded speculations *tout court*. Interestingly, in view of his own ideological (Catholic) commitments, Leroi-Gourhan also tied the emergence of speculation with that of religion. Far from setting religion and science in dichotomous or potentially conflictual relations, he saw in the former the fount of non-utilitarian practices and beliefs. Since the Reindeer age of the Upper Palaeolithic, at least, these beliefs found their expression in the symbolism of painted and engraved cave art and were thereby superadded to the "strictly technical" pursuit of subsistence needs. As Leroi-Gourhan further indicated in the text translated here, the "priests" who practiced such religious techniques were the first to be so "liberated, " thereby effectively leading the way towards the full-time specialized votaries of modern science.

Returning in conclusion to the key notion of material contact, two further implications can be suggested. From a phenomenological perspective, this jointly haptic and cognitive "material engagement" is for Leroi-Gourhan characteristic of specifically human manufacture, of "materially creative activities" as undertaken by artisans of all times. In some of his more fundamental anthropological conjectures, notably in *Le Geste*

et la parole, he insisted on the quintessentially human imperative of making and creating with our ten fingers – a constitutive engagement radically distinct from the ultimately impoverishing use of a single finger to flick machines and mechanisms into preordained motions.[2] At another level, we can recognize here Leroi-Gourhan's adhesion to the philosophical tenet, advanced notably in Henri Bergson's L'*Évolution creatrice*, regarding the epistemological primacy of action over contemplation, and consequently the active, dynamic, vital origins of knowledge (Bergson, 1907). Indeed, to use another Bergsonian notion which considerably preoccupied Leroi-Gourhan in these years (though not explicitly in the paper here translated), the challenge was to show just how important was the continuous and cumulative contribution of *homo faber*, the fabricator, in the emergence of the rational and scientific *homo sapiens* that we are.

THE ORIGIN AND DISSEMINATION OF SCIENTIFIC KNOWLEDGE3

André Leroi-Gourhan

This evening, I would like to explore with you the paths taken by humankind from its origins to the point at which it entered the period of major scientific speculation, to see when the first concerns with rational research emerged in the history of human societies.

Prehistory and ethnology may be able to answer the questions we must ask at the outset, at least partially. We can ask whether technical progress is really linked to [scientific] research as we understand it today. We can also ask what can be grasped of the first forms of scientific awareness and to what extent humans' first gestures and first tools indicate a rational perception of causes and effects, which represents a fundamental characteristic of scientific research. We can therefore ask from what exact moment researchers can be distinguished from manufacturers [*fabricants*], and indeed whether this distinction should be made at all. This prompts us to untangle the links existing for many animals between psychical reactions and technical behavior, between the latter and the manufacturing techniques specific to human beings, between manufacturing techniques and invention, and between invention and scientific speculation.

Let us first define the means available to us for carrying out this research.

Before us we have the whole field of history, but it is actually extremely short, covering a bare three or four thousand years, if one includes in it much of proto-history. Beyond it lies the field of prehistory, whose extent defies the imagination when compared to historical times. Indeed, if we take the timespan between ourselves and the beginnings of Egyptian civilisation to be a single unit, it would make up perhaps no more than 1/100,000th of the time between us and the first manifestations of properly human activity.

[2] As Leroi-Gourhan put it, for humans "not having to think with their ten fingers amounts to missing part of their normally, phylogenetically human thought" (Leroi-Gourhan, 1965, p. 61-62 [translated Leroi-Gourhan, 1993, p. 255]). Such questions of material engagement and skills are nowadays associated with anthropologist Tim Ingold, who is himself much indebted to the thoughts of Leroi-Gourhan and of Bergson (see Ingold 2004; 2013; 2014).

[3] "Origine et diffusion de la connaissance scientifique". Conference given at the Maison des Sciences, Paris, on Wednesday 5th March 1952, see Leroi-Gourhan (1953) [note added by editors].

What documents can we use?

In truth, the prehistorian possesses very few elements for these 999/1000th of the time of humankind. For the most recent phases of prehistory, from about 40,000 to 10 or 15,000 years before the present era, we have stone objects and also a large number of works of art whose content and situation give us a vague idea of the intellectual concerns humans had in the age of the reindeer.[4] Further back, that is, between 40,000 and perhaps 500,000 or 600,000 years, we have only the sparsest vestiges of human beings, most often limited to a small fragment of the jaw or the skull, along with the thousands of knapped flint objects that have survived all the geological periods without deterioration, and bring us proof of the presence of beings from hundreds and thousands of years ago (we shall not call them humans for the time being, but we return to this shortly). It ensues that these beings could make objects of a certain form and for a certain end. On the basis of this very sparse material evidence, prehistorians have managed to divide prehistoric times into three periods: the Lower Palaeolithic, the Middle Palaeolithic and the Upper Palaeolithic. We will see later that the Upper Palaeolithic corresponds to the period when humans quite similar to us lived, from about 40,000 to about 10,000 years ago; further back, in the Middle Palaeolithic and the Lower Palaeolithic, they were physically very different from us.

However, are these testimonies – some very rare human physical remains, and the innumerable worked stones that have survived the disappearance of all that surrounded these humans at the time – sufficient to provide us with some trace of the evolution of human thought, are they reliable enough for us to be able to identify an evolutionary pathway? We can answer Yes, at least in the broadest terms. There is no question here of producing a complete history of the evolution of human thought, but we seem to be able to follow up two or three particularly clear paths. These humans of the Lower Palaeolithic were very different from us, and on the whole they corresponded to forms that can be considered to be intermediaries between primates (of which current days anthropoid primate give us only an approximate idea, not being bipeds) and the *Homo sapiens* we ourselves represent. What can we imagine the mind of these beings to be? What do we know about their technical thought?

THE ELEMENTARY STAGE OF TECHNIQUES

For these intermediate beings our evidence comes almost exclusively from large shaped stones which are called bifaces, and are found over an extremely long period, not only in France and Western Europe, but in most of Africa and large areas of Asia. We shall consider the biface to be the most characteristic object from this period (there are others, but we know this one best). What were they used for?

Everything suggests that these were the knives of the period, and not, as has sometimes been proposed, handaxes [*coup-de-poing*] or axe blades. They were the tools

[4] The chronological values mentioned here are symbolic only. They are based on geologists' speculations and express probable orders of magnitude, confirmed in part by the methods of astronomy and physics. However, we still have no absolutely tried and tested method for measuring geological time over the whole of the Quaternary period.

with which humans cut up rhinoceros or the deer they had killed, and with which they probably chopped down the branches they used to make clubs and spears. They were an all-purpose tool, like today's knives or machetes.

I will use this example to follow up the development of technical thought over time with you, and to see to what extent we can go further than purely material forms of stone. Take this object, which weighs 500-600 g. It was knapped out of a flint block weighing approximately 1 kg at least. At the beginning of the Quaternary Era, humans obtained from this 1 kg a useable blade of about 20 cm. So we know that in the Lower Palaeolithic period, 1 kg of flint was required for 20 cm of cutting blade. I should add that experiments have shown that a flint blade wore down quite quickly, so knives had to be changed frequently. When we get to the second Palaeolithic period, the Middle Palaeolithic, we find human beings who are already entirely different physically; humans of this period belonged to the Neanderthal type, that is, with a reduced cranial capacity for the most ancient, and equal to ours for the most recent, with very low foreheads, enormous eyebrows, and much more prominent and longer faces than ours. Their limbs still retained certain primitive features, and what we know of how they lived seems to indicate that their material customs were at the very least quite similar to the Tasmanians or Fuegians encountered by nineteenth-century travellers. They hunted, gathered roots and tubers, and lived either in the open or in the shelters they could find, and we know from. excavations of prehistoric sites what these "interiors" must have looked like. Large quantities of the Neanderthal's food remains were found in these caves. There is often a sort of bulge around the edge of the rooms, some 50 to 75cm deep, composed of bisons' ribs, the remains of horses' hooves, of reindeer antlers, rhinoceros fragments, etc., all smashed into bits in order to extract the marrow before being thrown to the edge of the room just as they were after eating. One can well imagine the comfort of these dwellings, not to mention the prevailing odours.

What do we know about the intelligence of Neanderthals?

We have a large number of documents in our possession that can give us a more human idea of their techniques than we might have supposed from their living spaces and the form of their skulls.

THE DEVELOPMENT OF RATIONAL TECHNICAL OPERATIONS

A considerable distance has been covered since the rudimentary bifaces of the Lower Palaeolithic. If we keep to the example of the flint core weighing 1 kg that was used to make the biface, we can reconstruct the operations used by Neanderthals to manufacture their knives. Using a pebble to trim the mass of the core, the Neanderthal shaped it so that he could quickly obtain, for example, some thirty triangular flakes, which were just as efficient as cutting tools as was the biface. So we now have thirty flakes, the equivalent of three metres of usable cutting edge. This is very important, because it is the first precise picture we have in the history of humankind of a technical process of such complexity: the systematic knapping of triangular flakes characteristic of the Mousterian represents a series of a dozen gestures following each other in an absolutely rigorous order. This is the first evidence we have of the sustained unfolding of technical

intelligence. It is also the first time in all of human history that we can observe the setting up of such a complex arrangement of operations [*un dispositif opératoire complexe*]. The "serial" production of triangular flakes supposes, in strict order: the choice of the block of raw material, its roughing out according to the shape to be given to the core, the preparation of the striking platform and the ridges, which determine the precise shape of the future flakes, the preparation of the point of impact, the prior shaping of the butt of the flake, the thinning-out of the prehensile part of the flake, and finally the precisely placed delivery of the final blow, which detaches the finished product. It is important to note that the product that emerges from the block in its final form is the result of a series of technical actions, whose sequencing [enchaînement] requires at every stage a veritable technical reasoning and a best possible fit between the operatory knowledge of the flintknapper and the [unpredictable] variations of the material used.

Alongside this first body of evidence, we have another one. I was talking earlier about the countless numbers of bone fragments found in shelters and caves from the Middle Palaeolithic. When these debris are examined very closely we find traces of cutting with flint knives on many pieces. After making a precise record of all these traces, we managed to reconstruct, in a rigorous manner, the gestures or series of gestures which were performed by the Neanderthals to cut up reindeer or bison[5]. We know, for example, thanks to the traces that have sometimes survived on the cervical vertebrae, that the flint blows used to detach the head were always aimed at a specific place, the one where a butcher today places his knife to detach the head of cattle. We know for certain that, when skinning a reindeer, a flint blow was made to the carpals in exactly the same place as the skinning knife still cuts today. And when one wanted to detach the foot entirely, the blows were designed to land a little lower down. I will not go further with describing the Neanderthals' butchery procedures, but once again we have before us a sequence of relatively complex technical operations, which enable us to extract from the heaps of detritus cluttering up the inside of a cave some moving evidence of a very ancient state of technical thought. What preliminary conclusions can we draw from this?

Our findings show that even before homo sapiens appeared, that is, before humans resembling us physically became cave dwellers, the technical domain already evidences standardised operational thinking [*une pensée opératoire très rationalisée*] involving series of gestures set in precise sequence. Furthermore, at the end of the Neanderthal period we find the beginnings of concerns of a very different order, with the appearance of the first graves, and the first aesthetic preoccupations. That is, we discovered on several occasions that in the most recent layers of Neanderthal occupation skeletons that had been deliberately buried, as well as objects of curiosity such as large fossil shells or blocks of iron pyrite or pieces of red ochre, which had been collected from afar and brought back to the caves.[6] This represents the very first evidence of a psychical orientation that departs

[5] Doctor Henri Martin's research. [Léon Henri-Martin (1864-1936), a physician and archaeologist, was a pioneer in the field of archaeozoology; added by editors]

[6] Leroi-Gourhan is referring here to his recent find at his excavations at Arcy-sur-Cure (Grotte de l'hyène) of several fossils and unusual mineral items. As he would go on to argue, this "Palaeolithic collection" represented not only the first evidence of a deeply-rooted human fascination with the aesthetics of nature, but also "the adolescence of the natural sciences, for the dawning of science in all civilizations took place

from strictly alimentary concerns. Such evidence is extremely sparse, but very valuable, since we can see in these humans, whose physical appearance was not yet like ours, the emergence of certain preoccupations that would later become of capital importance.

As regards fabrication, we can see that from the outset techniques have followed a very steady line of progress. I have spared you the interminable stages between the first biface and the perfected triangular flake; these advances occurred imperceptibly, through the contact between the flintknapper and the material he had in his hands, the aim he set to achieve and the block in his possession. This manual contact shows that, at the origin, there was no possible divorce between operational activity and technical speculation [*entre l'opération et la spéculation technique*]. We will see later that this attitude of progressive contact between manufacturers and the material on which they operate is one of the foundations of technical development.

The dimension of progressive contact is a specifically human feature. We might to a certain extent consider that the action of the human or the anthropoid who uses the first stone is comparable, at the origins, to what today's anthropoids do when they use a stick to hit an object, or to the classic scene of the monkey aiming a coconut on the explorer's head. In fact, what is at stake is something quite different; in all times, monkeys have never done anything other than throw their coconuts, whereas, as soon as the first stone was knapped by a being from the human lineage, we can see that stone evolve, in exactly the same way as an ammonite or a series of mammals has evolved through geological strata.

THE DEVELOPMENT OF AESTHETIC AND RELIGIOUS TECHNIQUES

We have now reached the Late Palaeolithic, that is, the time when, at least in European regions, human beings emerged who were very similar to ourselves. Concerning these humans, considerable evidence exists of activities that are not strictly focused on food. When excavating a prehistoric site, it is possible to tell, even from the nature of the ground alone, that something important happened after the disappearance of the Neanderthals. We no longer find the heaps of detritus left around the hearths, all the mess of a dwelling place where the inhabitants had no concern for good housekeeping, except for occasionally making a space for themselves so that they could sit down among the carcasses of reindeer and bison. We find, on the contrary, that the interior floors have been regularly swept, and that the living surfaces have been levelled, and that there is evidence of aesthetic and religious activity from the very earliest times of occupation by “homo sapiens.”

The advent of the Upper Palaeolithic marked a major increase in aesthetic and religious production. This was the period when humans covered the depths of their caves with engravings and paintings, when spears and spear throwers were carved, when shaft straighteners were used to straighten wooden lances and arrow shafts, when pebbles were

amid the bric-a-brac of so-called curios” (Leroi-Gourhan, 1965, p. 213-214 [translated Leroi-Gourhan, 1993, p. 367-368]) [note added by editors].

engraved, and statuettes sculpted. We can observe that some of the individual's time of activity is now devoted to tasks that are no longer immediately related to food.

In fact, this first impression should be rectified by pointing out that all Palaeolithic art is linked to food by magic, since apart from the female statuettes, which are part of a fertility cult, all the representations we know of are of animals that are hunted. Yet it is still important to note that an aesthetic-religious activity has now been grafted alongside this strictly technical activity. A new development has also taken place in the techniques themselves.

We know that clothing became more elaborate. While we have no evidence of what humans wore in the age of the reindeer (since all furs and skins have disappeared), we do at least have their sewing needles and a certain number of tools used for working leather and hide. And we can tell from the fineness of the needles that sewing techniques were well developed.

A much greater variety of weapons appeared. If we return to the example of knives, we can observe a significant economic change in flintworking techniques. Starting with our initial block weighing 1000g, what is produced is no longer a single biface, which needed to be replaced after a relatively short period of use, nor are these thirty triangular blades which represent (in comparison with the biface) three meters of cutting edge, but rather a hundred or so much finer and much lighter blades, which represent about ten meters of usable cutting edge. This is important from an economic point of view, if we bear in mind that flint-rich regions are relatively few in number, and that the distance generally travelled in order to procure the raw material was around ten and sometimes more than a hundred kilometers. With the progress initiated by the appearance of the biface, we have the first quantifiable evidence of economic evolution in the history of humankind. The evidence is precise, because we can weigh and measure the tools, make statistical calculations, and represent this evolution through graphs. The humans we are dealing with occupy a field identical to that of present-day populations, who are still attached to an economy based essentially on hunting and fishing.

These societies still offer only limited possibilities for the development of collective means of action, because these groups number few, if any, specialists who are freed from directly food-related activities. Only in the case of religious techniques can the specialist be said to benefit from material freedom [*libération technique*]. Given our experience of present-day primitives and from what we can conjecture (I would almost say observe) through the countless religious documents left to us by prehistoric humans, we realise that in this domain there must already have been individuals who held priestly roles. A large body of evidence also convinces us that the priest's function involved new techniques and in particular the use of graphic symbols. The symbolic transposition attested by the reindeer-age art attests opens up a new path for thought, one that leads to writing.

We have come a very long way. We can now see in human societies the emergence, in addition to technical progress that is related to a normal biological evolution that would be comparable to that of animal series, also the onset of concerns which will directly give rise to scientific speculation.

THE ECONOMIC LIBERATION OF THE TECHNICIAN

The next period begins at the end of the last glacial extension, around 8,000 BCE. In the eastern Mediterranean and central Asian regions, where conditions were favourable, agriculture took over from hunting. We do not yet exactly understand the origins of agriculture. But we do know enough to imagine that, in a favourable botanical environment, groups devoted largely to gathering gradually shifted to domesticating a certain number of plants. The transition to agriculture (including animal husbandry) determined all future development, such that it is the most important event to have occurred as regards the evolution of human societies, from the beginning of the Quaternary Period to the present day.

Agricultural techniques, which spread with extraordinary speed over most of the inhabited world, brought about a complete transformation of the political and economic systems. First, populations became almost completely sedentarised, due to the obligations imposed by agriculture. People were required to stay on the land, at least as long as it took for the plants to grow. Resources were amassed in large quantities at the point where they were cultivated, which led to a much greater concentration of human beings than in the case of hunting or fishing resources. This brought about a need for defense systems against both animals and surrounding human groups. Concentration and defense systems: this is almost urbanisation. From the earliest developments in agriculture, one can find enclosures and other mechanisms for isolating the tiny agricultural communities that had managed to settle in the region at points of strategic importance. Sedentarisation, concentration and defense inevitably led to the need for a single, individual command. The hunting-fishing communities we know of rarely concentrate authority in the hands of a single individual. More often than not, there was a sort of diffuse authority that existed between the elders and between the middle-aged men, but as soon as it became necessary to build a camp or to defend it, a social hierarchy, largely military in nature, was established, which gradually led to kingships and empires. From this point onwards, the social organism took over partially from the individual, and this fact is of great importance because in the societies we were observing earlier, individuals were versatile: within the group, everyone was capable of carrying out all the tasks that enabled the group to survive, and this made it possible for individuals or isolated families to meet their needs.

A completely different social organisation emerged; its possibilities were considerably enhanced by the fact that certain individuals could be asked to do work that was no longer focused on the immediate search for food. We have proof of this: as soon as agriculture appeared, techniques appeared extremely rapidly that implied knowledge going far beyond the elementary exploitation of the environment - pottery, weaving and metallurgy, as well as surgical and medical techniques.

We have considerable evidence on this later point, since the graves, dolmens and funerary stone chests frequently found show us the marks of surgeon's flint knives on the skeletons of the exhumed individuals. We can thus observe an extraordinary technological blossoming, and simultaneously more complex social structures of command and hierarchy. This is also the period during which we see the priest's functions

reflected in large monuments and megaliths, and documentary evidence of the first calendars and astronomical activities. As a consequence, we find with the apparition of agriculture a totally different intellectual horizon from the one I outlined at the beginning of this lecture. A total transformation took place in the relations between technical activities and the technician. We observe that groups are truly in a position to act as super-individuals, as an individual-collective [*une sorte de super-individu, d'individu-collectif*], if I may venture such an expression, whose means were significantly increased and diversified than were those of hunter-fishermen. Research at this stage is still (and will largely remain in the future) connected to the processes involving material contact; the manufacturer is one who works on matter, who follows it as it were, and never loses manual contact with it – but it was the liberation of a certain number of specialists that allowed invention to flourish. A whole series of innovations appeared in the technical field. Metallurgy continued its rapid development, and in the space of a few centuries it reached the heights that led to the historical period. This is due to the fact that the blacksmith no longer devoted his time to hunting, but to making metals, the best bronze and the best iron that the community might demand of him.

From this point on, the specialists split into several currents. The religious concerns that had appeared progressively in earlier stages now led to growth in the techniques which long remained related to magic: these were the healing techniques, which gave rise to medicine and pharmacy, and the techniques linked to cosmogony, which gradually led to astrology and geomancy. Thus religious techniques began to break out of their religious confines around the figure of the priest. Another current was related to the functions of command and of military action. Military action determined the development of metallurgical research and defensive architecture: following the progress in metallurgical techniques and the geographical movements of bronze and iron over the last three millennia, we can see that everything is linked to research (still very empirical by the blacksmith or the founder), which was carried out under the pressure of the group. In another field, a trend appeared that was to be of prime importance. Command implies economic concentration which implies in turn the constitution of an aristocracy and ruling classes. It was noted that the origins of writing were largely linked, on the one hand, to economic concerns, that is, to put it coldly, to accounting and, on the other hand, to the techniques of prestige of the aristocracy of the time. Whether we look at the origins of Chinese or Mediterranean writing, we find in both initial concerns for the material recording of facts of an economic or religious nature, such as temple accounts or lists of dynasties, as documents justifying power. The other techniques, those not directly related to political and economic concentration, remained purely manual. Their progress is not related to the extraordinary impetus given by the concentrated nature of groups and their need both to defend themselves and to conquer new territories. Such techniques benefit therefore only very indirectly from this evolution, and they will constantly lag behind. This is true of pottery and of weaving, and it is especially true of agriculture and animal husbandry which, in all societies up to and including our own, have remained at a stage relatively close to that of their origins. Farming, weaving and pottery remained Neolithic until an extremely late stage, even in the most advanced societies of the Mediterranean and Chinese civilisations.

SYMBOLS, WRITING, AND SPECULATION

This process leads us to the expansion of the Greek and Chinese cultures. In the oragnisation that emerged from agriculture and sedentarisation, we see the possibility of individual research. But it only appeared at a very late stage, and partially; it was never completely separated from manual techniques. The Sumerians, the Mesopotamians, the Egyptians until the Middle Kingdom, the Chinese until their Confucian proto-history, and the great civilisations of pre-Columbian America had not yet detached speculation from utilitarian and religious practices. These civilisations still belonged to an intermediate stage between those we have already considered and the one we are about to enter.

We find the conditions of the Upper Palaeolithic in hierarchical societies, which constitute higher social forms. An important event occurred during this period: using methods borrowed from divination and techniques of prestige, writing came into being. What it introduced was not so much, perhaps, a means for preserving and transmitting knowledge as a means for expressing this knowledge in graphic symbols, abstracted from manual practices. Just as agriculture was pivotal for human societies, so the emergence of writing was pivotal for scientific thought. As soon as graphic symbolism left its imprint on thought, current forms of research appeared. In some limited fields, especially religion, particular practices became scientific speculation. As a result, we can follow the evolution of human thought towards speculation, not through reasoning (by projecting into the past the forms of our current thinking, a process which can only lead to extremely vague notions), but through the materiality of the documents provided by prehistory, archaeology and the earliest texts.

The first stage [of human development] is known to us through precise facts: with the earliest tools, contact between humans and the material world involved relationships that were initially very similar to the psychomotor reactions of animals. But since that stage, when the human body was still far from having reached its present degree of development, humankind was distinguished by the progressive character of its industry. This fact clearly sets apart even the pithecanthropoids and the sinanthropoids from anything that may have preceded them in the order of primates.

We observed a second stage when, at the margins of the technical domain, seemingly useless activities appeared. These were the aesthetic-religious activities of the reindeer age, which added something to the simple facts of material contacts. Finally, there gradually appeared a third stage, with the emergence of agriculture, beginning with intensive gathering in a favorable botanical environment. The advent of agriculture radically altered the relationships between the individual and the group. We have observed how an ever-greater impetus to progress became concentrated in the vital techniques of collective defense, after which writing soon appeared. From writing onwards, we see increasingly fluid symbolisation and a growing dissociation between manual contact and speculation. It should be noted that the relationships between the human being, the material world and ideas, which characterise all the stages we have considered, do not disappear at each new stage. Rather than substitutions, we observe an enrichment, the gradual constitution of a physical and mental system [*dispositif*] of extraordinary diversity, well able to extend into new fields. But until today, manual

practice retains its primordial value. Thus, such is the all too rapid overview I have presented to you of what we can know about the earliest forms of the evolution of human thought. We have seen that our materials of study are taken from the complementary sciences that are human palaeontology and prehistory. I have only alluded here to the field of human palaeontology, which will be the subject of another lecture in this series. I have confined myself in my presentation to what the prehistorian can perceive, but these two sciences complement each other; one shows the paths followed by hominids to arrive at present-day forms, the other shows the progressive enrichment of the techniques of material life.

There remains a very important area to examine, namely the progressive detachment of abstract thought, as we have tried to follow it up over the course of time. This progressive development represents humankind's most distinctive and original feature. I have tried to show in this lecture that in this respect [scientific] research is not totally devoid of means of investigations. While considerable gaps in the information available still remain, it is perhaps not illusory to seek in the most material and concretely verifiable facts provided by prehistory and archaeology a very first outline of the evolution of scientific knowledge.

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