EFFECTIVE ACTION AND RELIABLE KNOWLEDGE

In this book I have argued that Mumford was right. Glass transformed man's whole relation with the natural world, and with him or herself. It changed the sense of reality, privileging sight over memory, suggested new concepts of proof and evidence, altered human concepts of self and identity. The shock of the new vision de-stabilised conventional wisdom, and the more precise and accurate vision provided the foundations for European domination over the whole world during the next centuries.

The story of what happened now seems relatively clear and can be summarized as follows. In central and eastern Eur-Asia the shape of the history of glass is basically uniform. The knowledge of the substance and how to make it with early methods spread from its source in Mesopotamia pretty early, probably by at least 500 B.C. in the cases of India and China. The revolutionary new method of glass-blowing was known to all of them by about 500 A.D. at the latest. In India practically no glass industry developed as a result of this except for bead and bangle manufacture. Likewise in China and Japan glass was seen as a cheaper, but inferior, way to make decorations for secular and religious purposes. It reached a high point in Japan in the eighth century and then faded to nothing and the art was lost by 1500. In China it reached a high point in the Sung dynasty, but again faded away after about the twelfth century. Islam was a bit different, lying exactly between the two extremes. Glass making flourished and by the eleventh century Syria and adjacent areas were the most sophisticated glass-making centres in the world. But then glass making declined abruptly and hardly any glass of any quality was made between 1400 and 1750.

In western Eur-Asia, the history of glass was very different. Here we find the full flourishing of glass. In the southern part, Roman civilization gave the impetus to wonderful domestic glass for utensils, especially for wine, and hence to Venetian mirrors and wine glasses. In the north, Christianity plus the climate were conditions that encouraged flat and coloured glass in the medieval period. So the glass technology improved rapidly, spurred by luxury, trade, religious zeal and the desire for comfort. Early on, the skills and knowledge of mathematics was good enough to make spectacles and the desire to overcome presbyopia made this popular. With lenses, prisms and spectacles a growing interest in the constituents of light could be tested which later led through to microscopes and telescopes. Likewise the development of glass utensils and of mirrors had profound effects on chemistry and astronomy. The effects on the perception of space, the dominance of vision, health and agriculture were enormous.

We can examine this story in a little more detail by dividing glass up into its major uses. There is firstly what the French class as 'verroterie', that is glass beads, counters, toys and jewellry. The use of glass for these purposes is almost universal, at least in Eurasia, though even this was absent in the half of the historical world comprising the Americas, sub-Saharan Africa and Australasia. This is really the exclusive use for glass in India, China and Japan over most of the last two thousand years. For this purpose, glass blowing is not absolutely required, nor does

this use have much influence on thought or society; its influence is in the field of luxury goods and aesthetics. Basically glass is, an often inferior, substitute for precious stones. Hardly any of the potential of glass as an instrument for knowledge or for improving humans physical environment is made use of.

The second French word is 'verrerie', that is glass vessels, vases and other useful ware. This use was historically restricted to the western end of Eur-Asia. There was very little use of glass in vessels in India, China and Japan. Even in the Islamic territories and Russia, the use declined drastically from about the fourteenth century with the Mongol incursions. In relation to China in particular, this use can be seen as mainly an alternative to pottery and porcelain. The great developers of this use were the Italians, first the Romans, with their extensive use of glass, and then the Venetians with their 'cristallo'. Much of the technical improvement of glass manufacture arose from this use and it is particularly associated with wine drinking. Thus we have a phenomenon much more specific in scope, finding its epi-centres in Italy and Bohemia. There are various links to science here, for example the fact that the fine glass needed for microscopes was made from fragments of Venetian wine 'cristallo'. Likewise the development of tubes, retorts, measuring flasks, thermometers, barometers and so on for chemistry and physics developed out of this use.

The third French word is 'vitrail' or 'vitrage', that is window glass. The use of glass is here also restricted, but to a slightly different area. Historically, window glass was only found at the western end of Eur-Asia, and China, Japan and India hardly developed this use. More surprisingly, perhaps, nor did the great 'verrerie' area of the Mediterranean, Islamic and Roman areas. Although they knew of the possibilities, the glass window was little developed. The great window revolution occurred in Europe north of the Alps. Two of the main factors were cold climate and religious architecture, the Gothic stained glass window. From about the eleventh century stained and then domestic glass, with its attendant technological developments, spread and transformed architecture, social life and thought, but only on a large scale in north-western Europe.

A fourth use of glass, not encompassed in the French language, comes from its reflective capacity when backed with the right substance. The use of good glass mirrors was again circumscribed in time and space. The development of glass mirrors covered the whole of western Europe, but largely excluded Islamic civilization, perhaps for religious reasons. Glass mirrors were also not developed in India, China and Japan. Nor were they really developed by the Romans. They are thus temporally contained, only becoming common and of high quality from the thirteenth century, and geographically limited to western Europe. Yet they are a crucial feature in the development of the sciences of optics and astronomy, and of perspective in art. Without them, much of what has happened in the increase in reliable knowledge of the natural world to which we give the terms the Renaissance and the Scientific Revolution would not have occurred.

A final major use is for lenses and prisms and in particular their application to human sight in

the form of spectacles. Again, while the concept of the light-bending and magnifying properties of glass were probably known to all Eur-Asian civilizations, only in one did the practice of making lenses really develop, that is in western Europe. As with mirrors, the developments also occurred quite late, mainly from the twelfth century onwards. This coincides precisely with the medieval growth in optics and mathematics, which fed later into all branches of knowledge, including architecture and painting. It also fed into a specific and important sub-branch of lenses, the development of spectacles. Spectacles were not used in Japan, China, India, Rome, Islam. Only in western Europe from about 1270 onwards did they begin to spread, later to form the crucial step to microscopes and telescopes.

From this we can see that the more than half of the Eur-Asian population which was constituted by India, China and Japan only had glass for one of the five purposes. The middle section, Russia and Islam, added, at least until the Mongol invasions, some use of glass for windows and for prisms. Western Europe as a whole made use of glass in four ways, by adding mirrors and lenses, but only from the thirteenth century. North western Europe had all five major uses in profusion by adding windows.

So what is one to make of this? We could well argue that there is more than a coincidence between some of the major divergences in the knowledge systems of civilization and the development of glass. Firstly there is the coincidence in space. The area where glass developed in multiple ways, western Europe, was the area where a new world vision roughly lumped under the terms 'Renaissance' and 'Scientific Revolution' occurred. Despite the fact that Islamic and Chinese knowledge was far more extensive up to the twelfth century, it was not in those areas that the break-through occurred. Secondly, there is the coincidence of timing. The rapid development of glass, particularly for windows, mirrors and lenses, occurred in western Europe from the thirteenth century, and this is just the period when the major break-throughs in optics and mathematics and perspective began to be noticeable. Meanwhile, Islamic civilization which had been well in advance, began to give up glass from the thirteenth century and abandoned it almost entirely from the later fourteenth; scientific thought withered away in that area. In reverse, when scientific glass instruments were introduced on a large scale into Japan in the later nineteenth century they led to major developments in science.

If this were just a coincidence in space and time, with no plausible causal connection, we might dismiss it as just a curious parallel growth. But it is not difficult to see the actual effective links. It is apparent in the lives and works of most of the major figures in the west who developed the new world views. There were Alhazen, Roger Bacon and Robert Grosseteste with their explicit use of glass instruments in the development of mathematics and optics. There were the great Renaissance experimenters in perspective and the more accurate observation and representation of nature, from Brunelleschi and Alberti, through Leonardo and Durer. All used mirrors, flat planes of glass and lenses to experiment with vision and light. Then there were the great seventeenth century scientists, Galileo, Kepler, Newton and others whose work centred on the investigation of light through glass instruments. As we saw earlier, almost every great scientific invention needed glass at some stage. Furthermore glass helped to destabilise and

extend the most powerful of human organs, the eye. This only happened in a great rush in one part of the world.

We are, of course, naturally wary of all single-factor and reductionist explanations. It would be ridiculous to argue that glass was the only thing needed. As we have seen, its use is dependent on the context and there were many other factors which also determined the massive increase in reliable knowledge which is the foundation of our world. It was at the most a necessary, but not sufficient in itself and alone, factor. Yet it does not seem too much to argue that if one had to pick one factor above all others, more important than the growth of cities, the revival of ancient learning, clocks or printing, then it would have to be glass. Without its development, it is difficult to see how the new world vision could have been established.

Yet this does not mean, of course, that there was anything inevitable about the outcome, or that there was any particular design or purpose involved. Glass was developed for other purposes; it was its beauty and utility which recommended it to people. Only by a set of giant accidents was this substance also one which would bend light in a way which would change human vision of the world. We cannot do better than end where we began with Dr.Johnson, who so elegantly captured the paradox, the unintended but immense consequences of this development.

'"Who when he first saw the sand and ashes by a causal intenseness of heat melted into a metalline form … would have imagined that in this shapeless lump lay concealed so many conveniences of life as would, in time, constitute a great part of the happiness of the world. Yet by some such fortuitous liquefaction was mankind taught to procure a body … which might extend the sight of the philosopher to new ranges of existence, and charm him at one time with the unbounded extent of material creation, and at another with the endless subordination of animal life ... enlarging the avenues of science ....enabling the student to contemplate nature...' (Dr Samuel Johnson) [1]

* * *

Accidental though it was, the effects of this technology were immense, but only in one area of the world. The story of glass again shows the very different effects of a new technology in East and West. Like gunpowder, movable type printing and clocks, which had little or no revolutionary effect in central and eastern Eur-Asia, glass revolutionized western Eur-Asia. What, in summary, were these effects?

There is the dramatic transformation of a basically aural, text-based, culture, similar to that in all other civilizations, to a visually dominated one. The sense that really mattered in reliable knowledge came to be sight, seeing is believing. Here I have argued that the increase in the power of the human eye and mind through the development of glass technologies is one of the

[1] McGrath, Glass in Architecture, 5

most important influences, without which this would not have happened. Though it cannot be absolutely proved, it looks highly probable that glass was one of the most important factors in the peculiar development of a visual, experimental, rationalistic, 'scientific' and realistic world. That disenchanted world which we associate with Descartes and Newton grew out of glass. Glass helped give the critical impetus to the revolutionary developments in the generation of reliable knowledge between the thirteenth and eighteenth centuries upon which our world is founded.

Thus I hope to have sketched out a possible story of the way in which increased knowledge feeds into better tools of knowledge, which in turn again feed into more knowledge. This helps to solve the long-debated problem of why it was Europe, and not Islam or China, that made the crucial break-through to a new and more reliable understanding of the natural world which we call the Renaissance and Scientific Revolution.

It is also worth reminding ourselves of the way in which glass was not just important for changing the way in which we think, but also the way in which we live. For example, through windows, drinking vessels, lanterns, light-houses, green-houses and later cameras, television and many, many other things. It even affected what humans believed (stained glass) and how they perceived themselves (mirrors). So it entered human civilization at all sorts of angles, but at first only in one part of the world. These different aspects were also all interconnected in complex ways. For example windows improved the workshops, spectacles lengthened the working life, stained glass added to the fascination and mystery of light and hence a desire to study optics. It is this rich set of inter-connections of this largely invisible substance which makes it so powerful and fascinating.

* * *

This all now seems so obvious. Yet if we look through what has been written on the origins of modern thought or the role of glass, the connection seems to have been largely overlooked - with the notable exception of Mumford. So why has glass been so invisible and little studied? Specifically, why has it not been realized that it is a crucial part of the answer to the largest question in intellectual history, namely why parts of the world witnessed the knowledge revolution of the fourteenth to seventeenth centuries, comprising the Renaissance and Scientific Revolution? Assuming that there is indeed a connection, the omission is important for it leads us to reflect on the methodological approaches needed to study a phenomenon like glass. It also encourages me to state as clearly as possible why I believe that an amateur in this field should, apparently, have seen a connection which is so important, but has remained invisible to many specialists.

The factors which are specific to the peculiar qualities of glass itself are discussed in the introduction to this book. Here I will briefly summarize some of the methodological considerations which would affect the study of this and many phenomena in the past.

One way to approach this is to see how far my own views on the subject seem to have been influenced by the fact that for some thirty-five years I have combined historical research with teaching and reading in the discipline of anthropology.[2] What are some of the characteristic features of anthropology which help us to approach a subject such as the connections between glass and reliable knowledge?

One well known feature of anthropology is that it is a broadly comparative discipline. I teach and read on all parts of the globe and in my daily practice am constantly investigating what is common and what unique about particular institutions or societies. I am constantly trying to detect absences, to look at co-variations, to test the strength of causal links by looking to see what seems invariably to fit together. This is the essence of anthropology and it is what I have done in this book by looking at five different civilizations, namely Western Europe, Islam, India, China and Japan, in order to see how their histories compared and to test causal theories.

This comparative method also leads us to notice things which are ubiquitous in our own environment, like glass, for by setting them against other civilizations where they are absent we have a back-drop against which their oddness becomes apparent. It is the method which I used extensively in a previous work on demography and medicine and it has many benefits.[3] Putting it simply, I would never have 'seen' glass and its importance if I had remained as a historian of a particular European country, or even Europe as a whole. One has to go outside the whole system to see something so obvious. If one stares at a phenomenon straight on, one often looks right through it. By altering the angle of vision, suddenly new and important areas suddenly stand out.[4]

A wide gaze is also needed because in many phenomena, such as the increase in reliable knowledge, the topic can only been studied as a network of interconnected centres spread widely apart. As we have seen, glass technologies in Western Eurasia moved from place to place and the whole area from Syria and Egypt to Scotland and Scandinavia was one intersecting system of people and ideas. It was this many-centered, diverse, competitive system that was the secret of what happened in this area. One could not have seen this if one had confined one's interest to one country.

A second feature of anthropology is its very great time depth. Anthropologists have been concerned to trace the whole evolution of **homo sapiens** from his ape ancestors up to the

---

[2] It is probably the combination of a foundational training in history (an M.A. and D.Phil. in history at Oxford), combined with a foundation (M.Phil. and Ph.D.) in anthropology, complemented by over twenty-five years as a member of the anthropology department at Cambridge that is important.

[3] See the methodological discussion in last chapter of Macfarlane **Savage Wars**.

[4] Another example from my own recent experience is my realization of how the history of tea drinking is a key to modern demographic development, as explained in **Savage Wars**, pp.

.

present and a thousand years is quite a short period in anthropology. This is very different from the practice of historians, and in particular current historians whose time periods are getting shorter and shorter. One is a seventeenth century historian, or a nineteenth century historian, and within that a specialist in a particular area of life and a particular country - a historian of nineteenth century politics, seventeenth century Dutch art or whatever.

The effect of anthropology is to make one draw right back and consider the last hundred-thousand years as a whole. One can then get a sense of long-term development and widening trends. This wide historical frame allows us to put events such as the Reliable Revolution (science and art) into perspective. One can investigate before, during and after the event without being imprisoned within the event. It is then much easier to pick out long-distance connections, to see 'buried' links, things that run underground, or are important for further development but lie well back in the past. A relatively short-term example would be the fact that to understand how the steam engine was developed we need to move back from the eighteenth century through glass used in the discovery of the vacuum in the seventeenth century and then back into medieval glass blowing.

Another feature of anthropology is its functionalist approach. It asks what different institutions or technologies do for societies and whether these functions could be performed by other institutions. This is part of its comparative method, seeing apparently different phenomena in different societies performing a recognizably similar function. This is an essential part of an approach to the differential history of a phenomenon such as glass because, as we have seen, its non-development in Eastern Eurasia was not due to lack of knowledge or rationality, but because there were other things which performed the functions which glass performed in western Europe, for example porcelain and paper. We can begin to see why the Romans, without good mulberry paper or porcelain, selected glass as the centre of their domestic economy.

Another well-known feature of anthropology is its holism, that is to say it treats phenomena as complex, integrated, systems. For example, an anthropologist characteristically studies a particular tribe, village or other group in all its aspects, religious, political, economic, social, aesthetic and so on. The strong barriers between these spheres created by the division of labour, in its widest sense, with the development of 'modernity' are inappropriate in most of the areas where anthropologists traditionally worked. In the case of glass, this holistic approach encourages us to see the interconnections between the different features of the past. The conventional distinctions which are useful starting points for thought soon become reified and in the end block investigation. For example, the strong distinction between science and art which differentiates the study of the Renaissance and the Scientific Revolution, or between different types of scientific advance, for instance those in the thirteenth and seventeenth centuries. By treating phenomena holistically, one can see that we are dealing with an immensely complex bundle of interconnected features, which includes technology as much as it does religion and which can only be studied if we forget disciplinary boundaries.

Another feature of much of anthropology is what one might call its materialism. There has been an increasing tendency in thought since at least Descartes to separate the material and physical world, the province of the natural sciences, from the intellectual and social one. This is another division which is challenged by the anthropological experience. Anthropologists have often worked with living peoples and find it hard to forget the fact, which is often obscured when we only deal with written records - that the physical world, as Marx also knew, is not separate from the mental. Artefacts and technologies have always been a central concern of anthropologists. They even tend to divide their subject by technological criteria, for instance by modes of production and tools. They have often collected artefacts for museums and put on displays to show the relations between material objects and social concepts. So an anthropologist would not be surprised to find that something as physical as glass could alter our world and a number of leading anthropologists have written illuminatingly on the role of various technologies in social variation.[5]

This can be put in a slightly different way. It is very difficult for us to appreciate the way in which the material and the intellectual are inter-connected. In trying to understand this, Gerry Martin and I have been developing the idea that much of social development can be understood as a triangular movement. There is an increase in theoretical understanding, reliable knowledge of some kind. This is then embedded in improved or new physical artefacts. These artefacts, if they are useful and in demand and relatively easy to produce, are disseminated in huge quantities. This then changes the conditions of life and may well feed back into the possibilities of further theoretical exploration. This triangle has occurred in many spheres of life and the speed of moving round this cycle and its repetition lies behind much of what we describe as human development.

The history of glass is an excellent example of this movement between the material and the theoretical, which occurs again and again. For example, the improvement in theory (mathematics and optics), led to the development of improved lenses and mirrors, which were multiplied and then fed back into further theoretical developments, which led back into microscopes and telescopes, which later improved health and agriculture and allowed further research.

In fact, it becomes difficult to distinguish the material and theoretical. Anthropologists have long seen technology as a mix of things and ideas, of ideas embedded or congealed in objects which themselves only have their power from the practices which dictate their use. Thus technology is often defined, as famously by Marcel Mauss, as 'traditional effective action'. It consists of ways of understanding and changing the world, which include things and ideas. Nowhere is this more obvious than in the simultaneous development of ideas and techniques in the making of glass. It is both a tool of thought, and a tool with thought embedded in it. What is peculiar about it, is that it is the only substance which directly influences the way in which humans see their world. It is the only substance which is a real extension of a human sense organ, and the most powerful one, the eye.

[5] E.g. J.Goody, 'Technology...' and various works on guns, cooking, writing etc.

Another feature of anthropology is what one might call its structuralist approach. A strong strand in anthropology, particularly in France, has been the way in which it is not individual things which are important, but the relations between things, the balances and timing of forces. Thus it is not just the presence or absence of glass, but how much there is of it, how it is used, how it enters into the relations between humans and the natural world, and how it fits with other causal factors which equally need to be considered. This is often combined with a dialectical method which sees forces in an ever-restless movement through a set of oppositions, contradictions and resolutions, as in the famous dialectic of thesis, antithesis and synthesis.

Although this is not, of course, confined to anthropology, the working experience of trying to understand numerous societies and civilizations reminds anthropologists that causal paths are very complex. It is not enough to use a simple-minded idea that every effect has only one cause, or that cause and effect have to be close in time and space. Any anthropologist who puts forward this kind of simple reasoning will encounter colleagues who bring forward their own counter-examples. They learn that any effect may have numerous causes, or be the result of a long chain of causes with up to half a dozen or more links.[6] Once one is aware of the extended chains of causation it is easy to see that if one step is missing, even if it is far back along the chain, then the final outcome will be different. We saw the importance of this in relation to glass when we noted how many times glass was needed at some stage in the development leading to a discovery, even if it was not the proximate enabling factor. Only a consideration of these complex path-ways allows us to see the indirect, partly hidden, but powerful influences of something as diffuse and complex as glass.

Part of all of this approach is also the realization of the importance of unintended consequences. A historian tends to use mainly written records and this leads one to be over-impressed by the purposive, planned, rational, goal-directed nature of human life. It is easy to slip into an unexamined form of teleological thinking, to believe that the most important developments are planned, designed by human actors. The consideration of human civilizations over long periods and in diverse interactions, as well as the microscopic investigation of daily life where humans patently have little idea of the actual consequences of their actions, reminds anthropologists of the importance of unintended consequences. This helps us to appreciate more easily that the history of glass appears to have been largely a set of accidents and unintended effects. What happened conforms very closely to a Darwinian, selectionist, model. The whole story is an illustration of 'random variation and selective retention'. Things invented for one purpose are then used for others. Indeed, this is the single most important fact to emerge from the history of glass. It was developed to make beautiful and useful things for humans. Only through a giant accident did it turn out that this magical substance could also be used to extend human vision and hence alter thought.

An anthropologist who has witnessed the introduction of an important new technology into the

[6] For a more extensive discussion of chains of causation, see last chapter of 'Savage Wars'.

area where he or she is working, for example steel axes, a new crop, a new irrigation system, a new weapon, a plastic bucket, can easily see the way in which it is ingeniously exploited in many ways which were not originally envisaged. It can transform a culture well outside the area in which it operates, enabling a much wider array of new things to occur. This helps to make them understand the cumulative nature of technological development, what has been called the 'meccano effect' because it is like adding a new piece to a set of that famous building kit.[7]

It is a general principle that as each piece of reliable knowledge is added, for example the techniques of glass blowing, of making fine mirrors or flint glass, this did not merely add one more item to the stock of things humans can do. In fact, it led to the possibility of doing dozens of new things. So just as adding a wheel to a meccano set transforms the potentials of all the previous pieces, so it was with glass. The effect, unless stopped, is that reliable knowledge and effective action will expand exponentially. This has been the story of the vast growth of the last three hundred years, where human understanding and control of nature has grown at a far greater than linear rate. The history of glass is a very good example of this. Its power and effects have become greater and faster and glass itself has not just been one added resource for humans, but altered so many other technologies. As we have seen, as the technology grew more powerful it did not just lead to better drinking glasses, or mirrors, or window panes, but altered health, housing, thought, communications, travel, shopping and a host of other areas.

Another advantage of a long and wide perspective is that it helps to counter a view, particularly prevalent in our technologically overwhelmed and calculative age, that technologies once discovered will inevitably be retained and improved. Anthropology and archaeology have a wide experience of the abandonment of apparently useful technologies. They have seen irrigation systems collapse, fishing hooks being abandoned, the wheel forsaken.[8] Thus it is not great shock to find that glass should have been more or less abandoned in Eastern Asia.

Another feature of anthropology is that, as the study of humankind, it encompasses the biological as well as the social evolution of humans. Hence the inter-actions which are explored in the penultimate chapter in the hypothesis on myopia is well within the domain of anthropology, whereas it would probably be considered outside the province of conventional intellectual or cultural history.

Anthropology is also famous for its cultural relativism. It describes and analyses different ways in which humans have faced various challenges, but on the whole it refrains from judging one as morally better than another. It adopts a 'when in Rome' approach. This is helpful when

[7] I owe the idea and the term to Gerry Martin.

[8] For a classic paper, see W.H.Rivers. For a recent study of the way in which the Japannese largely abandoned a number of apparently 'useful' technologies, for example wheels and domesticated animals, see Macfarlane and Harrison, XXX.

considering another of the major findings of this study, namely the way in which the two ends of Eur-Asia tried to overcome the difficulty of how to preserve and even increase reliable knowledge. Here we can draw an interesting parallel with another theme in this kind of comparative history, namely the distinction between the two ends of Eur-Asia in relation to increasing the physical resources for survival.

Some years ago, a Japanese economic historian and demographer, Akira Hayami, made a distinction between the civilizations of Asia which tried to increase agricultural and craft production by increasing human labour, what he called an 'industrious revolution', and the civilizations at the other end of Asia which did so by replacing human labour by machines and non-human energy, what is famously called an 'industrial revolution'.[9] In a curious way one can see the same divergence of strategies in the attempt to increase the amount of reliable knowledge in the world.

In Eastern Asia there was an 'industrious' revolution - the extension of literacy, the development of woodblock printing, the multiplication of written characters, the extensions of the schooling and examination systems. This put huge pressures on the human eye, which became, through progressive myopia, a sort of surrogate magnifying glass, able to do what could only be done by glass tools in the west. It was an intensification of intellectual production which has some interesting parallells to the extreme attention to detail and intensification that one finds in the crafts and production of wet rice.

At the other end of Eur-Asia, the human body was not forced in the same way. Increasingly the chief instrument of knowledge-acquisition was strengthened by glass instruments, just as the human muscles were supported by new tools that made wind, water and animal power a huge supplement to human labour. So a whole set of 'machines' for thinking - glasses in old age, prisms and magnifying glasses, mirrors, telescopes and microscopes, were developed. An industrial revolution of the intellect took place as a counterpart to the industrious revolution of the East.

The relativism of the anthropologist would not place one as 'better' than the other; they were just two different strategies, each of which had their strengths and weaknesses. It just happens that the path which leads through industriousness starts to reach the limits imposed by the law of diminishing returns much sooner than the path which leads through machines of thought, which is still showing potential in a world so heavily based on glass, whether in computing, optic fibre networks or television and photography.

In all of this, of course, it is essential to remember that glass is only an enabling, perhaps

[9] Refs. to Hayami. For recent discussion, see 'The Day the World', both the film (five) and the book.

necessary, but far from sufficient cause of the massive transformation in the methods of obtaining and the overall quantity of reliable knowledge. Glass, I would argue, was a necessary cause in the development of new thought systems in the west and their absence in the east, but it was not sufficient in itself. Many other things were needed. Such a complex outcome was the result of a multitude of inter-acting pressures. Thus this book is just one part of the story of the emergence of the modern world. Elsewhere I have attempted to deal with the demographic, medical, material cultural aspects, and the social and political traps that had to be overcome.[10] Here I have investigated but one, albeit perhaps the most important, of the factors that helped to overcome a number of intellectual traps and tendencies which have usually prevented the expansion of reliable knowledge.

[10] Macfarlane, Savage Wars; Macfarlane, Riddle; Macfarlane, F.W.Maitland and the Riddle; cf. also the television series and accompanying book, 'The Day the World Took Off', which overlaps with a number of these themes and adds others.