BHĀRAT KI CHHĀP
THE IDENTITY OF INDIA

A companion book to the film series on the history of science and technology in the Indian sub-continent

Presented & supported by
National Council for Science & Technology Communication
Department of Science & Technology
Government of India



Reflections on science, history & society

भारत की छाप
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रविप्रौसंप NCSTC

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Published by

Comet Project, Bombay

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Start note

When *Bharat ki Chhap* was first telecast, we received many letters and personal messages. Teachers from various disciplines, students, parents, libraries, science popularisers— all wanted copies of the video cassettes. Many non-Hindi speakers wanted the films remade, or at least dubbed, in their languages. Others requested us to bring out books, since no literature of its kind was readily available.

When the films were being made, we had put in a great deal of study, met a host of researchers in diverse fields, talked to craftsmen and farmers and activists, and travelled all over the country. This is of course obvious from our credit titles. Our endeavour was backed by the continuing support and kindness of Prof. Yash Pal throughout a very difficult production period, of the members of the Advisory Committee and of Dr. N. K. Sehgal of the National Council for Science and Technology Communication, the agency whose patient funding made the whole project possible.

During this time, we underwent a sort of intensive educational course which we designed for ourselves, grabbing at what seemed obvious, groping through other things we did not fully understand but sensed were important. What we absorbed from this unique education we have tried to present in the films.

But there were many things we had not been able to say in the films. There were things which we had assumed everyone was familiar with. There were discussions about what had or had not been part of the films. There were ideas which now, in retrospect, we wanted to share.

So we decided to bring out a booklet to accompany each cassette. And now that we are putting them out as one book, we return to the question we asked ourselves at the start — what do we want to include in it?

In the first episode Maitreyi says that we are not out to change society. Well, nor are we experts in the science-history-society area, despite being steeped in it so deeply. This book is not an encyclopaedia. Nor does it aim to make you into research scholars. We want to share with you a certain process we experienced.

When we first entered the threefold territory of science-history- society, we discovered a vast continent of knowledge. comprising often unconnected territories, some sketchily explored, some mapped in great detail. We read, and heard, widely differing opinions about almost everything. In the beginning we frequently despaired of ever being able to link it all up and devise a framework that would hold it all together. Many things, new and strange then, were to shape the way we would think later.

Once a frame begins to form in your mind it doesn't just stop there at a given subject, it keeps expanding. One continues to make connections between what one knows already and what one goes on to learn. So a newspaper report about a communal riot or the import of a new technology is no longer a discrete bit — it links up with all that you hold in your mind. Today when people talk of demolishing a mosque because a temple may have stood there originally, one also wonders what would happen if some people claiming Harappan descent ordered the rest of us out of the subcontinent.

While many things about the past gave us reassurance, many others made us uneasy. It was thrilling to discover that we had a rich scientific tradition, but we were often disappointed to find potential that was not realised, or puzzled by the question of why certain developments took place elsewhere but not here. Engaging ourselves with these concerns as a group, we find that even as the things binding us have grown stronger, we have also, as individuals, moved independently in our thinking. We often disagree, especially about those aspects which have a bearing on present-day problems.

It is important to know what researchers have covered, to have a sense of their differences and of the current debates. However, we cannot leave the solution of our problems to academics. It is upto us — you and ourselves — to tackle these problems and issues in the course of our day-to-day lives. We have to find our own ways, form our own viewpoints, keep looking critically at current developments in the light of the past and in view of the future,we want to build.

In the films we had our anchorpersons and reporters — Maitreyi, Nissim, Shehnaaz, Ramanathan, Amrita, Ranjan and Raghu — as the people who conducted the dialogue between you and us. They grew into characters whose individual voices we learnt to recognise, voices that were shaped as much by the actors concerned as by the films' script writers. In this book, it is the characters from the films who continue to speak, expressing our general spectrum of ideas in their personal ways.

This book, then, is not about finding ultimate solutions or about discovering experts who can give us the last word, but about the ideas that have stimulated us, experiences that we have gathered, the questions that we have learned to recognise as important — collectively and individually. And that is what we want to share.

Comet Project Team

INTRODUCTION

1

This episode introduces us to the anchor people and the reporters, and shows them engaged in preparatory research. A song by the reporters, using the journey metaphor, takes us to locations such as the ancient Kanheri caves, Jaipur's Jantar Mantar and an impressive modern construction site.

The methods of knowing the past are outlined, highlighting the importance of material evidence.

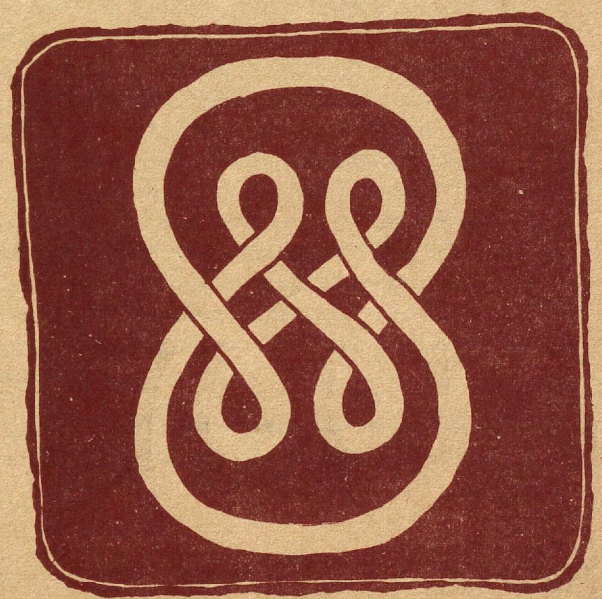
An attempt is made to sift myth from history through an interview with Prof. B. B. Lal, excavator of sites mentioned in the *Ramayana* and the *Mahabharata*.

Excavations by the Deccan College, Pune, at Inamgaon reveal ancient house plinths and Dr. M. K. Dhavalikar discusses indications of drought three thousand years ago.

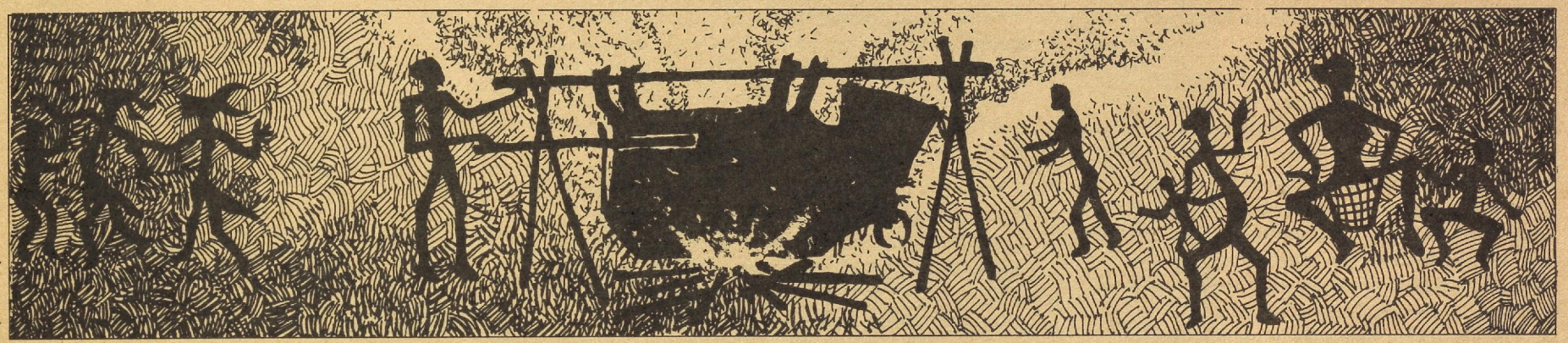
We understand how carbon dating of organic remains determines their age, and Dr. D. P. Agrawal shows us how the process is carried out at the Physical Research Laboratory, Ahmedabad.

A discussion among the anchorpeople and the reporters gives us glimpses of things to come — places to be visited, questions to be explored.

This episode establishes the historical scope, the social concerns and the form of the serial.



What then is science ?



Raja Mohanty

When humans first learned to use fire and later to make fire themselves, this was a major step for science. A number of chemical and physical processes emerged from this knowledge. Drawing based on stone age painting at Bhimbaitka rock shelters

'What is science?' This was a question we faced again and again in the course of making these films. What began to emerge was an answer that had many dimensions to it. In the beginning we tied ourselves into knots over it. I particularly remember one incident. Soon after I joined the *Bharat ki Chhap* team, I accompanied my friend Mitra, who is a science teacher, to the school where she taught. She was new to teaching then, and I had just begun to read up for the films. She still had the beginner's enthusiasm for experimenting with and evolving new teaching methods.

We started the class with the same question, "What is science?" There was complete silence. Then a smart young boy got up and said, "Miss, is this part of our course?" It was as if everyone was waiting for this cue. A common consensus was being formed and expressed by the class. "This question has not been asked at any of the earlier examinations!" We did not know what to do. I was beginning to feel quite sorry for having dragged Mitra into it. But Mitra had in any case to become a teacher, and she handled it fairly well. In full teacher's fashion she sat down and said, "Now no shouting, please. We will set this question aside. Today we shall learn about science in prehistory. Ranjan here is part of a team that is making a film series called *Bharat ki Chhap* ..."

Mitra kept talking, explaining my presence and trying in some way to bring us back, indirectly, to the question we had in mind when we started. The class was now alert, ready to take down notes. After all, something, it had been said, was going to be taught. "In those days there was nothing like the science we know today. And to understand what there was then — if it was nothing like what we see today — we need to know what science means. Ranjan will tell us about the prehistoric sites that he has seen, and also about prehistoric science."

I began. "What we know as science today is a way of understanding nature by breaking it into pieces ..."

After a while — perhaps to draw attention to himself, perhaps to pull my leg, perhaps simply to interrupt all this talk about science — someone's hand went up.

"Sir, today there were two people talking in my bus. One of them was saying that getting into a crowded bus and then managing to get a seat is a science in itself. You have to take into account the direction in which the other people are pushing, or pulling, and then calculate how much and in which direction you must push, or pull, and how much force to use. Only after calculating all this can one manage to enter through the narrow door. Isn't this science?" A small wave of laughter swept through the class. It had come alive again. Everyone was ready to think of more such examples. The same class that was quietly preparing to take down notes was now utterly transformed, something we did not quite expect or understand.

Once again we did not quite know what to do. While the class had suddenly become alert and enthusiastic,

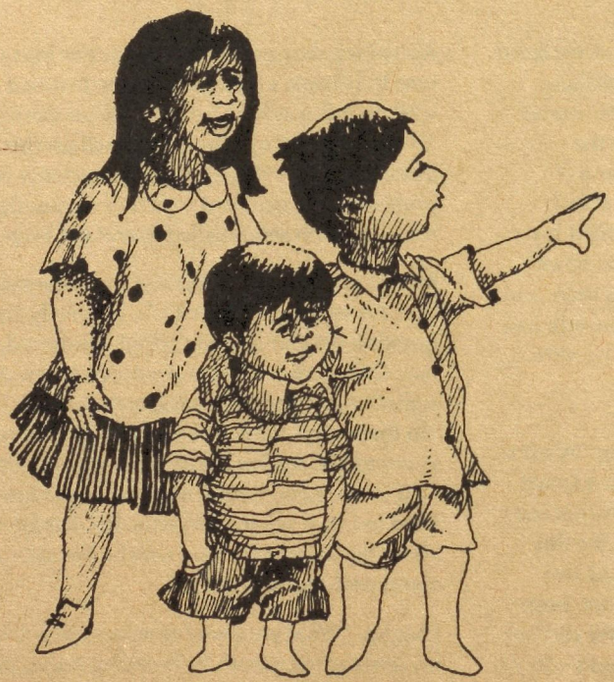
we were drifting further and further away from the subject that we had raised. Again we invoked our authority as teachers. Without further preamble I told them about science in prehistory. The class was over soon, but the questions the children had asked would not go away.

Before I began to work on these films, like the children, I knew science only by its various disciplines. The science of numbers was mathematics. The one concerned with physical things was physics, the one with chemical properties, chemistry. Based on, and making use of all of them was biology. All these came under the head of natural or physical sciences. Then came definitions and counter-definitions of society, and the science of its dynamics — the social sciences. And crowning them all was philosophy. Increasingly, each of these subjects is splitting into finer and finer specialisations. To understand the knowledge each contains, their different languages and the subtleties of their distinctions is, today more than ever, beyond the reach of any one individual.

In Mitra's class, we had tried a different approach. We had tried to cut across these divisions, to get the children to cross them too, and their answers and their laughter had irritated us somewhat. But if we dispense with the accepted compartmentalisation of science and its particular language, every happening around us does begin to seem related to science. In each event, we can find some scientific principles underlying it and being applied consciously or unconsciously in handling it. What then is science?

Today, after I have gone through the process of making these films, I doubt whether we can circumscribe science by any one permanent definition, or whether any one definition can encompass all its aspects. To understand events that took place centuries ago, and to understand the 'science' of those times, we will have to change our thinking about science. What we think of as science today depends very much on today's realities, today's state of knowledge and today's perspective. In understanding history, the prevalent concept of a science neatly divided into its disciplines will not take us very far. We will have to set it aside.

I think all of us learned a lot in the making of these thirteen films that carry us from prehistory to the present. We learnt that science is not tied down to its various disciplines. Science is also part of a search for a whole way of life — a worldview. It is also a search for, and an understanding of, ways of living and thinking. This is not a journey that can end with the films. The journey continues.



Raja Mohanty

Hale Observatories, Pasadena



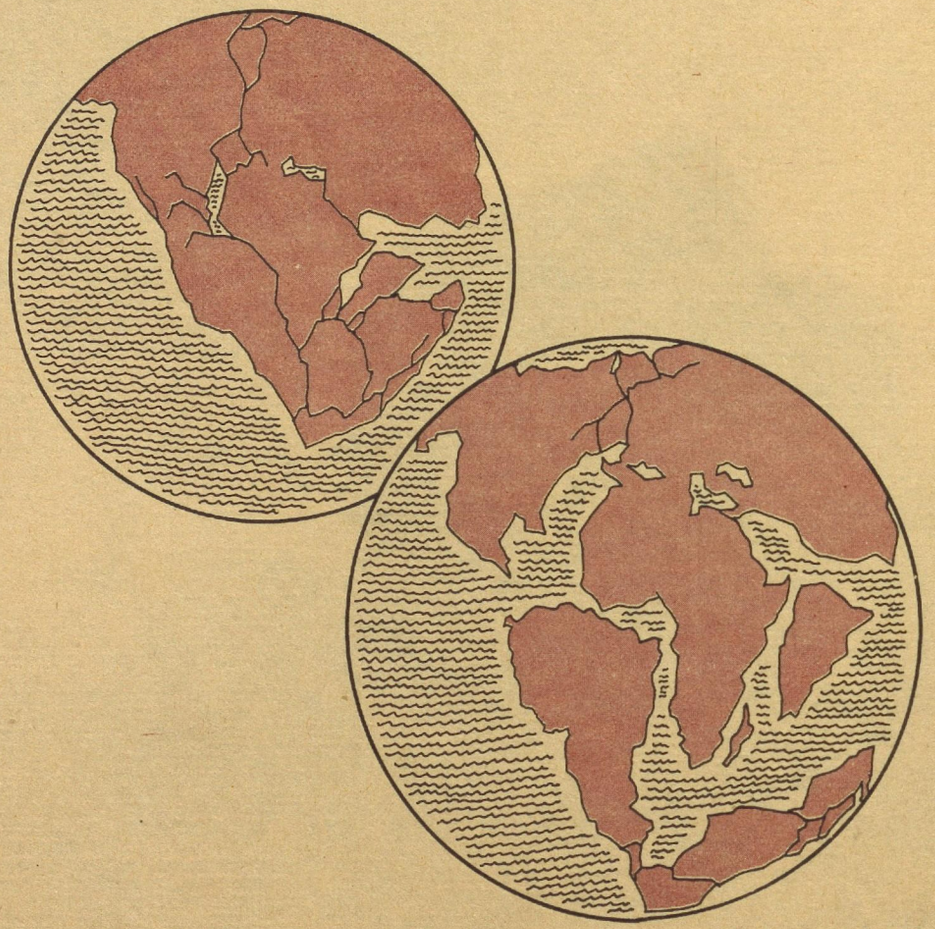
The moving continents

As we grew more and more involved in our research for these films on the history of science in the Indian subcontinent, one thing kept cropping up in our study of both history and science. A question that was related to our ancient past: when did this 'Indian' identity arise? And a series of related questions extending it further: how did the first human beings evolve? How did life originate on this planet? How did the universe come into being? And, especially because we were talking about this subcontinent, it became important to know what 'subcontinent' signified, how and when was it formed.

There was one more reason. Scientists had in the early 20th century made some startling discoveries. Many thousands of years ago, plants from tropical climates thrived in Greenland, which is now covered with ice. And present equatorial regions like in Africa and South America were once covered by glaciers. Later, studies showed that that there was great similarity between mountain ranges on different continents now separated by vast oceans. For example, the stratification of mountain ranges in the eastern parts of North America is very similar to that of mountains in Britain. Fossil studies revealed that rocks from Asia, Europe and the Americas formed about 100 million years ago had similar types of fossilized mammals. How could such distant continents have had such similar types of mammals? How to explain the presence of particular plants common to them? What is one to make of the old glaciers around the equator?

These questions bothered scientists who studied the earth, life on earth and its history. Only one answer could satisfactorily explain all these facts. If similar types of mammals were found in Europe and America then these continents must have at some

From the supercontinent of Pangea to the world we know today: an approximate view of the process of continental drift, which began 200 million years ago





Raja Mohanty, based on Earth Before Life Began, Europa

time been linked to each other in some way. It began to become increasingly necessary to believe that land masses have changed their positions and that there has been a continuous, slow drift of the continents over millions of years. Today scientists rely on this theory to explain these sets of peculiar facts. Even today, all the continents with their various parts are moving in different directions at different speeds.

According to the theory of continental drift, the earth's land masses were part of one big continent 200 million years ago. That supercontinent has been named Pangea. The situation before that is not very clear, but it is possible that perhaps there were some scattered land masses earlier.

After a few million years, Pangea divided into two parts which swam away from each other. These parts have been named Gondwanaland and Laurasia. From these two super-continents, many land masses then separated, and drifted away to occupy their present positions. Of these, most have continued to drift at the approximate rate of one inch per year, but some (like the Indian portion) have been drifting faster, at the rate of about two inches per year. As is clear from the accompanying maps, the Indian portion was once near the South Pole, from where it drifted and 'bumped' into the part that is Asia today. This collision gave rise to the Himalayas.

According to this theory then, the drifting of the continents still goes on. On the basis of available information, scientists are trying to determine the positions of the continents in the coming billions of years. Some speculate that Australia will collide with Asia, and the west coast of North America will get detached and drift northwards. Africa and South America will drift further apart, and the Atlantic ocean will grow even bigger. In order to make such estimates, it is necessary to understand the reasons for this drift. Only then will we be able to have an accurate picture of the earlier or future state of the continents.

EVOLUTION OF LIFE ON EARTH

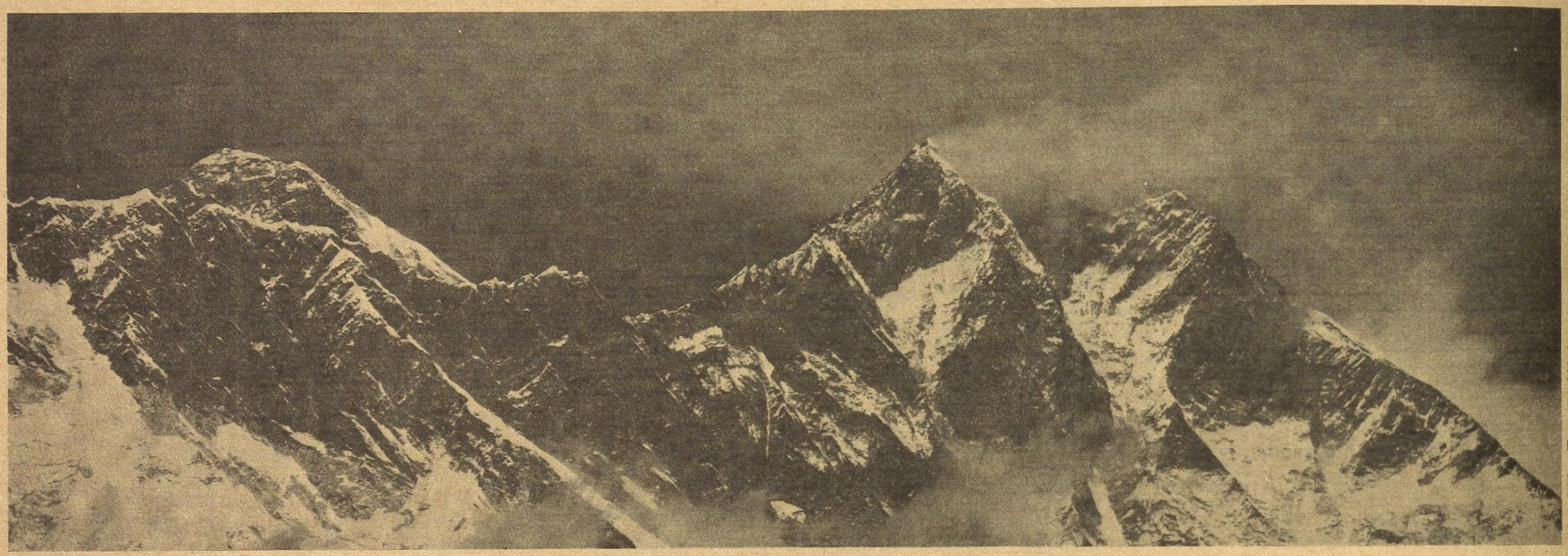
Geological Era, Period, Epoch	Archaeological period	Millions of years before present	Life on Earth
Precambrian		4,500	Formation of the earth
		4,000	Formation of the primordial sea Formation of the earth's crust
		3, 200	Earliest known life, single-celled algae and bacteria appear in the sea Extensive mountain building
		1, 000	Primitive organisms develop cells with specialised functions
Palaeozoic		600	First invertebrates with shells
		480	First vertebrates, jawless fish
		435	First land plants Air-breathing animals in sea
		405	First amphibians and insects Swamp forests Early seed plants
Mesozoic		350	First reptiles Coniferous trees
		270	Formation of *Pangea*
		225	First dinosaurs Sea mammals
		180	First birds Small land mammals *Pangea* begins to break up
Cenozoic		130	Dinosaurs die out First flowering plants
		70	Modern mammals proliferate First primates
		60	Separation of South America from Africa
		35	First apes
		25	Gondwanaland locks with Asian plate, formation of Himalayas
		4.5	Oldest known tool made by human ancestor *Homo habilis* in Africa
Quaternary periodof Cenozoic era		2	Major ice ages alternating with warm inter-glacial periods
	Lower Palaeolithic	1.8	Human ancestor, *Homo erectus* emerges in Africa and Asia
		1.4	Earliest known toosl made by *Homo erectus* in the Indian subcontinent

Geological Era, Period, Era	Archaeological period	Thousands of years before present	Life on Earth
	Middle Palaeolithic	800	*Homo erectus* populate tropics and temperate zones, throughout the world
		700	Earliest *Homo erectus* remains found in Narmada valley
	Upper Palaeolithic	100	*Homo sapiens* bands emerge in Europe and Africa
		70	Finer tools appear
		60	Ritual burials in West Asia suggest idea of afterlife
		40	Earliest cave paintings in India and Europe
		35	Tools go on improving
		28	Humans settle in Australia
		25	Lunar calendar on bone in Europe, oldest written record found
		20	Warming of Indian subcontinent Humans settle in North and South America Human and animal figurines suggest nature worship Semi- nomadic human groups flourish in India
	Mesolithic		
Holocene Epoch of Quaternary Period	Mesolithic and Neolithic overlap, even the Palaeolithic continues in some parts, as developments take place in a variety of ways in different environments	11	Jericho, first large permanent settlement Domestication of animals Wheat and barley widely cultivated in West Asia Settled villages become common pattern in West Asia Oldest pottery finds Oldest evidence of basketry
		10	Mehergarh, earliest site on Indian subcontinent showing agriculture and settled village life
		9	Agriculture spreads to Europe Evidence of loom in West Asia
		7	Copper being used widely in West Asia

LAST ICE AGE

Prepared in consultation with D.P.Agrawal

This table charts the development of life on earth from its appearance in the primordial seas. It also traces technological achievements until Neol ithic times. This chart is not to scale. It only attempts to correlate the long geological eras to the archaeological ages concerned with human history. These dates are being pushed back all the time by fresh findings. Hence the relationships between events, rather than specific dates, is what we are interested in.



Ashvin Mehta, Thames and Hudson

The collision of the Indian plate with the Asian plate gave rise to the Himalayas

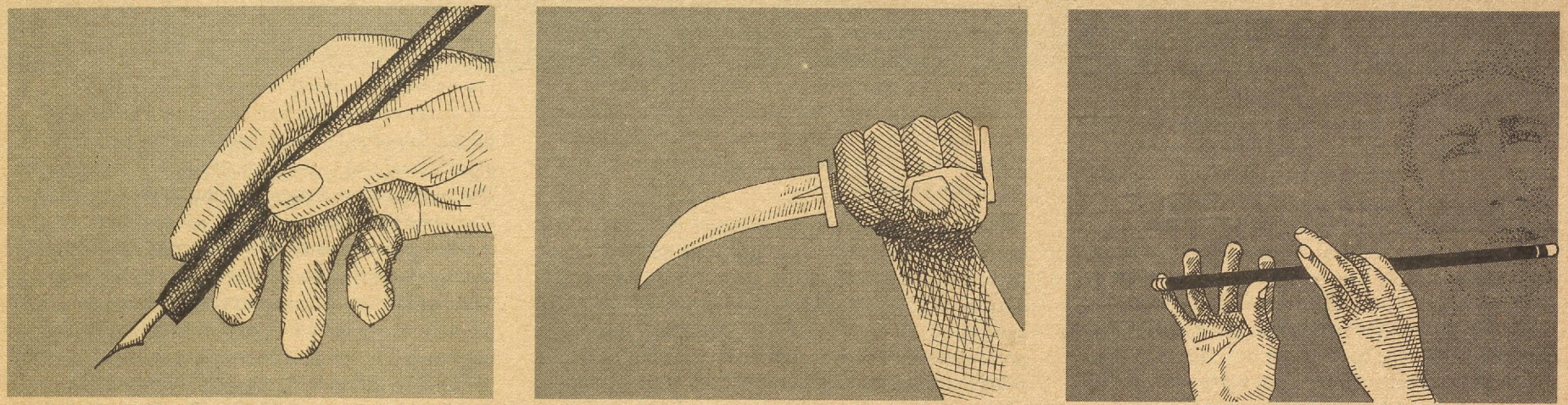
While there is much reasoning and speculation, no hard facts are as yet available. One of the earlier hypotheses was that not everything deep down in the earth is solid or stable. After the uppermost layer, the lithosphere, which is about a hundred or so kilometres thick, there is molten rock. In the inner layers the temperature is very high, causing molten-mass convection currents to be formed. These currents force the land masses above to move, to drift and to break apart.

Today a different view is emerging. It is now believed that the drift is because of the movement of the plates of the lithosphere itself. These plates carry the oceans as well as the continents. All of the earth's surface is divided between these plates. The plates are aseismic regions, differentiated from each other by narrow mobile belts characterised by earthquakes and volcanic activity. It is the movement of these plates that causes the apparent continental drift. But why the plates move, or from where they get the large amount of power to move such huge land and water masses, remain matters for conjecture.

But why am I talking about this subject here? Partly because it concerns a distant past when humans did not exist and a remote future when we may no longer exist on this planet. None of the life forms we see today was to be seen millions of years ago. This is the way our present points to the distant past and future. Today we are a long way from that past, but our present, our very existence, is intimately connected with it. These are sobering thoughts, and they are intimately linked to the questions of origin and of identity.

Today we talk so much in terms of 'our' science, 'their' science, 'our' history, the different cultures of the East and the West, but perhaps the relationship between the present 'we' and 'they' was very different once. Not even the continents are fixed or eternal; nations, countries, regions are even less so, being very much our own creations. Geography is not a static, immobile thing. Nor are we. Everything is subject to change, and this basic aspect of our existence is something we need, perhaps, urgently to recognise.

Understanding evolution



Uttam Ghosh

Only humans can oppose the thumb precisely to the fingers: this enables them to grip objects better

I was thrilled when I came to know that I would be part of the *Bharat ki Chhap* project. When I joined the team, all kinds of questions began to raise their heads. I realised that many of the questions had lain dormant within me from my schooldays, even though I had later chosen to specialise in literature, and seemingly had nothing to do with science in history. One important question among them was that of evolution — the gradual, rather than drastic change in life forms.

I have always felt close to nature, and have been moved since my childhood by the idea of being part of *homo sapiens*, the highest species on earth. Sometimes, I wondered why we were considered such superior beings, when we seemed to use nature only for our own ends. Whenever such doubts surfaced, I tried to remind myself of the human achievements we are all told about. The huge domes and cooling towers of a nuclear reactor was one such image. An electric power house was another, and so also were locomotives. At that time I did not know why, but I used to sense an undercurrent that being a woman, I had a somewhat lesser claim to being part of that superior species. And, I also used to sense a similar undercurrent about dalits and blacks. Later as I studied world literature, I found that this discrimination was part of depicted life everywhere. But then, are we truly superior beings? What after all, does evolution mean? Questions remained, unresolved.

Then, one day, I visited an anthropologist friend's house where I came across a book with fascinating pictures of a variety of monkeys and primates; despite their variations, they showed human characteristics, especially in their intensely human facial expressions. I felt that the immense variation in our own species perhaps has something to do with the fact that they are said to be closest to us.

My anthropologist friend quickly pointed out the difference between the primates, our true cousins, and monkeys. Many of the things she said went over my head. But what struck me in her discussion were the limitations of viewpoint, the hierarchical approach and the man-centred criteria. But I kept silent, because I was somewhat in awe of her learning, and did not want to interrupt her in the monologue she was delivering for my benefit.

"Classification is an important tool in defining species and in studying the similarity of traits and the origin of all living beings... All living beings are divided into the animal and plant kingdoms... Step by step, we identify the similarities and variations of the species and arrange them in a hierarchy... The steps of the hierarchy are— kingdom, order, suborder ... and we belong to the genus *Homo*, and finally to the species *sapiens*. We are classified this way on the basis of our two-legged posture, the co-ordination of upper and lower limbs, the broader pelvic bone, our brain size and our capacity to think. These characterstics are the result of our evolution during the last one million

Ashvin Mehta, Thames and Hudson

years, the last lap of the seventy million years of mammalian history!"

By now, I was getting nervous and my attention had begun to waver as more and more questions flooded my mind. Why study evolution? What is so important about it? I see very little that is specially superior in human beings. We continue to wage wars, spread destruction, violence and death— are these then the mark of a superior being? Or are those man- made discriminations, those false hierarchies, that uncaring interference in natural processes, that disruption of nature's balance— are they the mark? My friend, in full steam by now, went on. "There are a lot of ways in which superiority may be defined. For example, we do not have aggressive features like claws, horns, or fangs , nor do we have self-defence mechanisms like the ability to change body colour or secrete poisonous substances. Basically we are a peaceable species. The lack of such characteristics has been compensated, however, by other means ...

"Since we are bipedal, our hands were free to develop. We have versatile fingers and the only hand with a truly opposable thumb. This has helped us to hold things, work materials and shape tools and other artefacts. Moving on two feet, we are capable of great mobility and agility but this has required more co-ordination, leading to a larger brain size. Our compound vision also needed a larger brain."

" The story does not end with the increase in the size of our brain. With that increase, human beings started to think. We started gaining consciousness of our existence with respect to space and time. We learnt to speak. Language developed. Conversations took place. We learnt to store knowledge and pass it on. It is these 'qualities' which go into making superior beings."

All this while, as my friend spoke, my mind was wandering around. I remembered sitting under a tree one evening as the birds flew back to their roosts, and the twittering and chirping reached a crescendo. What an amazing range of vocal expression! Is this not also communication and conversation? Or take the sense of time, the precision with which every winter visitor arrives has been well established by bird watchers. Or take co-ordination, it is displayed by street dogs when they spot a stray dog in their staked territory. The sense of belonging that binds them together as they drive it out and the way they organise their collective efforts, is at once a superb and terrifying sight.

Oblivious to my wandering attention, my friend continued, "You know, social life is not the prerogative of human beings alone. All animals have a social life. These traits are now studied by a few specialised scientists called socio-biologists. As an anthropologist, I do not quite believe in all of it. I think that even the behavioral pattern of one section of human beings cannot be generalised and applied to those from a different cultural background. How can one generalise from studying members of a totally different zoological species?"

I was surprised by her unexpected critical note, and I felt the need to listen to her, to allow her to talk on and see if she could resolve some of the questions that had surfaced in my mind. I had read somewhere that the DNA of apes and humans is not much different. What does this imply? Does it mean that the entire human capacity to think analytically and survive is just that small difference in the DNA? Is this all that evolution has meant?

"Yes and no," she replied. "It is true that every cell contains DNA. But more interestingly, the DNA of all the various forms of life is derived from the same twenty amino-acids and four bases. And so in a fundamental sense, all life is based on the same chemical process. But besides the DNA, other factors on which evolutionary changes depend are also recognised. One is the ability to reproduce. Another, which is widely known and bitterly criticised by many, is 'natural selection'. And through natural selection, those life forms which are useful, which are the fittest, are allowed to live while the others die out."

I had returned to my thoughts. My exposure to comparative literature had taught me a number of things. Important among them were the various tools of criticism I had to use in analysing literary material. The language, the content and the values expressed, all go into the making of good literature, into excellence. Immersed in the comparison of literature through the ages, I had almost implicitly begun to believe that the written word is the only valid medium of expression. I realised that I held such an implicit belief, and how narrow it was, after I started working on this project. After all, writing is a late development in human history. There had to be other non-literary avenues of expression; would they be lacking in excellence simply on that account? Can we apply the narrow criteria of literary criticism to all art?

What my friend was talking about, I think, had an undercurrent similar to these narrow notions. What are the criteria of deciding the 'fittest'? Who is to decide what helps this pre-defined 'fitness'? Nature, which men have tried to dominate and perhaps already irreversibly changed? All in all, I sensed a narrow man-centred perspective supporting a self serving concept of fitness. And today we have reached a point where men, a section of them, have brought nature and natural processes under their control. Human intervention has already reached a point where it is capable of determining what shall be 'natural' in the future. In such a situation who holds the power to decide, with what criteria, and for whose benefit?

THE STONE AGE
till 3500 B.C.

2

One method of knowing about our first ancestors is by observing contemporary tribal communities who continue to practise certain stone age techniques. Two reporters travel to the interior of Bastar, where they discover how women gather forest produce.

We look at stone tools that span lakhs of years of our biological evolution. An expert makes two stone tools, demonstrating the finesse involved.

The cave paintings at Bhimbaitka speak of the impulse to art and perhaps reflect a prehunting ritual. One painting dissolves into a fantasy in which the animal is hunted, killed and roasted over a fire. We see how revolutionary the discovery of fire-making was in many ways.

Preparations for a *wazwaan* feast are under way in a Kashmir village which, along with the shepherds of the nomadic Gujjar tribe, helps us to understand the transformation that occurred when we learnt to domesticate animals and cultivate plants.

Navratri celebrations in Bombay bring home to us the fact that many of our present rituals hark back to the barely seven thousand year old discovery of agriculture.





Working through the layers of questions

As I watched Dr. Vasant Shinde make his stone tools on the banks of the Krishna at Wai, some questions arose in my mind. Dr. Shinde knows what stone to use, how much force to put into his blows, and in which direction to apply it. Comparing his stone tools with authentic stone age tools, one realises that their makers too must have started with a preconceived image of the end product. However, there is a significant difference— Dr. Shinde has access to the accumulated knowledge of the millenia which separate him from his stone age ancestors. Today, we have classified all varieties of rocks, we understand their properties, their possible shapes, and we can explain these in terms of their molecular structures. Based on this knowledge, we can understand why a certain type of edge requires a particular type of material with a particular type of molecular structure. Perhaps in future, when these matters are understood even better, experts will make copies of stone tools with even more ease than Dr. Shinde does.

How is this related to science? Being able to use materials in specific ways, without being able to explain the underlying principles— is that science? Or finding out why one type of blow produces a sharp edge while another one does not— is that science? Or is it science only when you can look closely at any stone and— without doing anything to it, are able to say what type and shape of tool can be struck from it? I think science includes all these levels.

If we say that understanding our world is the main purpose of science, then the levels of understanding gained from all these questions go into the making of science. Sometimes knowledge derived from one type of question is essential to ask a question that belongs to another level. At other times, the questions arise independently of one another, and they take us in



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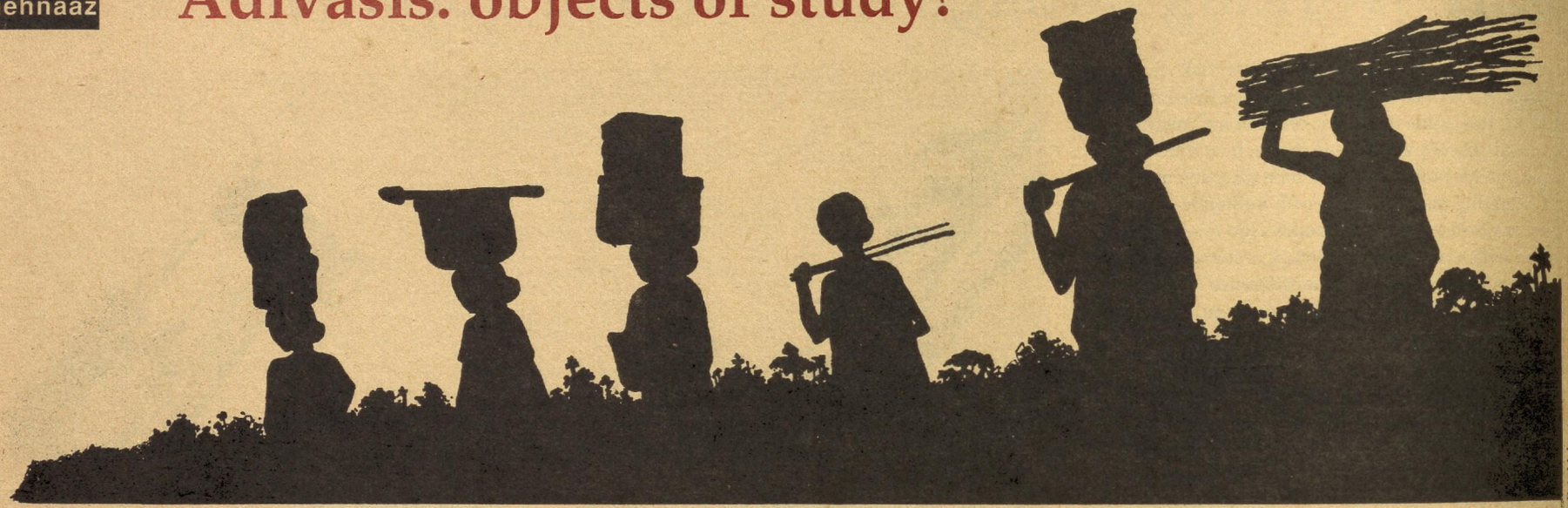
apparently different directions while developing our total understanding.

For example, after repeatedly experimenting with different types of rock, some sort of rules regarding the making of stone tools can be evolved. This leads to the next level — generalisation. This means defining the characteristic qualities of materials that are essential for making a particular tool. While working on this, we might gain some insight into how rocks at a particular place were formed , or why some other geological feature came into being. When we try to order these different types of questions into a hierarchy— from the more scientific to the less scientific— we run into difficulty. The point is that science is about one question leading to another; it is concerned with the entire process of searching for answers to a series of interrelated questions. Even if certain questions have already been answered by others, to begin to ask such questions afresh, to initiate the process within oneself, is part of the tradition of science. And this is a necessary step towards becoming a good scientist.

Such numerous and different levels of questions are present in everything we do, in the practice of all the skills we learn. What practising scientists do, is to search for the answers. We have all read the stories about what happened when individuals asked questions about ordinary things like falling apples and singing kettles. We have all enjoyed the benefits, perhaps unknowingly, of the knowledge that has arisen from such questions. But to be able to cast such questions in the proper form, to be able to formulate principles from the findings and to express them in abstract conceptual terms, requires something else. For this, one has to develop a special orientation, possible only when one's knowledge has been worked through several levels of questioning.

Such 'why' and 'how' questions come to mind all the time. Not suppressing them, but asking more of them, pursuing them across the levels, internalising the knowledge that emerges— this is what makes science part of one's being.

Adivasis: objects of study?



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Moving around the forest with the Bastar women, I was reminded of the slogan *'Adivasi nahin, vanvasi'* (not *adi*— original— dwellers, but *van*— forest— dwellers). This attempt to deny the links of tribal cultures to early human society sparks off some related thoughts.

Where do we put the tribal people in our mental map of the peoples of India? As a student I had come across a number of anthropological studies which described the lives of tribal people living close to nature, in seeming oblivion of the modern world. How could a society be frozen in time like that, I often wondered.

Later, when I got interested in the question of social equality, I came across other writing about tribals which underlined their 'primitiveness' and urged 'progress'. The presumption behind such thinking disturbed me. Then, there are also those who want to preserve tribal lifestyles in social zoos. Presumably this will protect them,and enable modern society to understand its past. Can there be any justification for deliberately holding people in ignorance and isolation?

The tribals in Bastar, I found, are well aware of the city. Those who have worked in cities as unskilled labourers are familiar with their worst aspects. They also use many industrial products in their daily lives. I was interested in the special features of their lives which could give us some insight into prehistoric cultures. This is what scholars call ethno-archaeology.

Tribal communities are spread all over India, over a wide range of environmental conditions. They speak different languages and follow completely different lifestyles and customs. Because of their dependence on nature, the degeneration of the environment has changed their lives dramatically in the last few decades. Not far from Bombay, there live certain tribal communities who, it is said, subsist on agriculture. Yet a whole year's labour yields food sufficient for only four months. It is urban employment which makes survival through the remaining eight months possible. How meaningful, then, is a study of their 'tribal way of life', when that life covers only one third of the year and meets barely one third of their needs?

One often comes across well-meaning, dedicated educationists and social workers in tribal areas. When they speak of 'progress' and 'development', they automatically put the tribal people in the category of 'backward' people. Their own mission is seen as one of 'civilising' them. It distresses me deeply to see many tribal traditions being destroyed in this process.

Though our worlds are so far apart, I felt more secure among the people of that forest village than I ever do on the streets of Delhi. I did feel self-conscious entering their world, a clumsy stranger too, but never threatened or unsafe. I cannot build a scale of backwardness and place our society at the top. Life in Bastar may appear uncomplicated compared to that of the cities, but it is an extremely strenuous life.

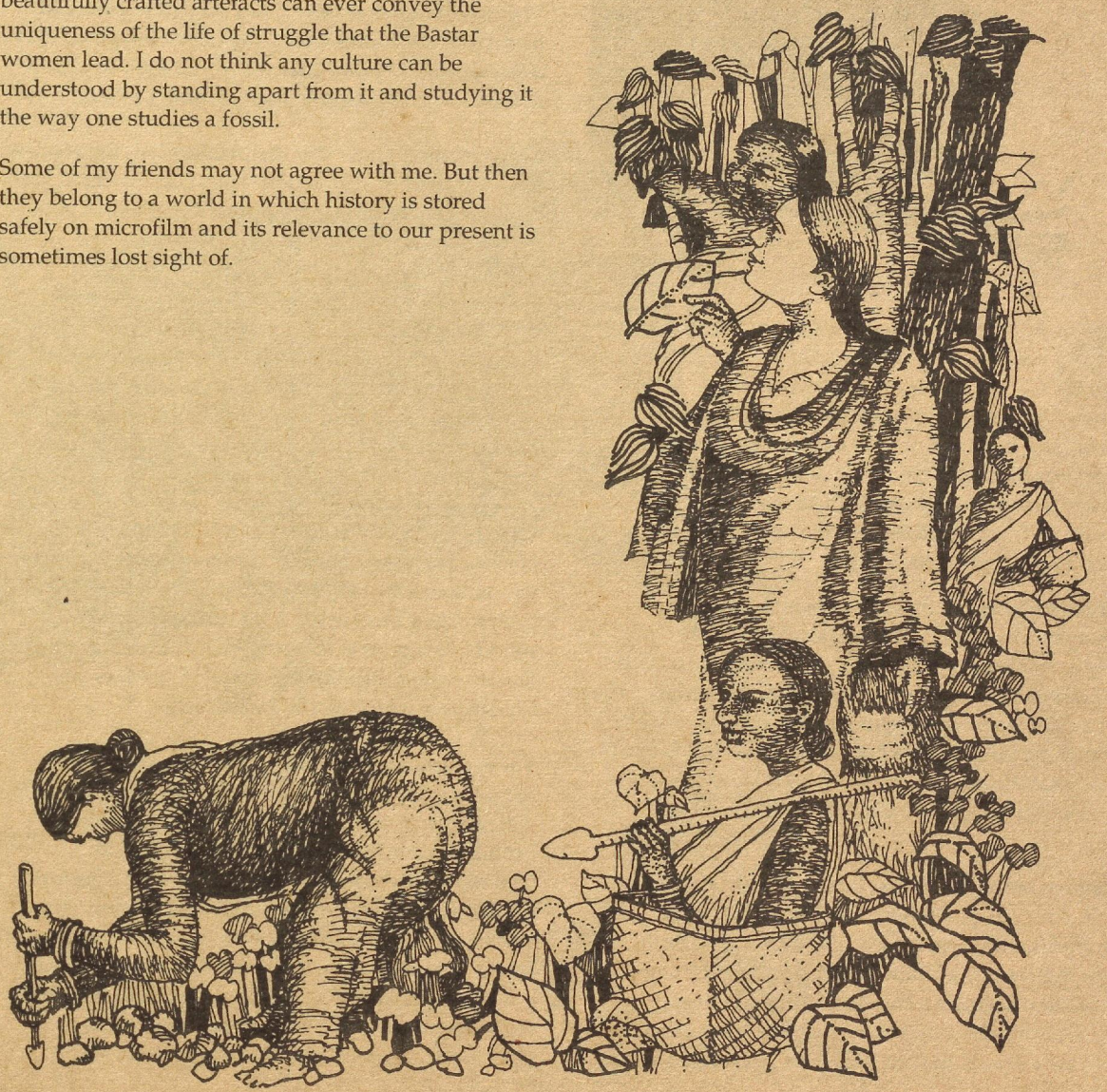
Every member of the community is, however, in some sense secure. A child is considered a full member of society, and the mother need not be married for her child to attain that status. Their attitude to the care of the elderly is also quite a contrast to that in our own world.

I had once asked an adivasi friend what the religion of his tribe was, and he replied, "Are you asking because tribal beliefs are not encoded in scripture?" He spoke about the growing trend of subsuming tribal deities by identifying them with Hindu ones, so as to be able to claim the tribals as Hindus. "What will become of us?" asked my friend. "They are taking away even our gods and goddesses!" He wondered if traditions such as full participation by all in festivals would survive. Or the idea that no mediator need come in between one's faith and oneself.

My friend has much to be angry about. Take tribal art. Very little is known about their rich tradition of song and story which is an entirely oral, mostly unrecorded, tradition. Yet those forms of tribal pictorial and sculptural art which can be reproduced on a mass scale and marketed, are well known. Similarly, their dances — which lend themselves to performance in public and on television — are widely covered. In the process, these art forms and their practitioners become commercialised. Divorced from its sources, such art becomes a form of mere copying, devoid of content, and is unable to develop. My friend wonders what these trends will do to tribal culture.

So today when I go to an anthropological exhibit at a museum, I come out disturbed. I do not think that a display of an exotic, close-to-nature lifestyle and of beautifully crafted artefacts can ever convey the uniqueness of the life of struggle that the Bastar women lead. I do not think any culture can be understood by standing apart from it and studying it the way one studies a fossil.

Some of my friends may not agree with me. But then they belong to a world in which history is stored safely on microfilm and its relevance to our present is sometimes lost sight of.



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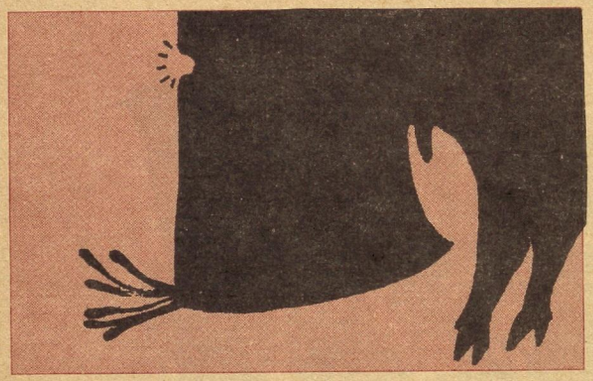
Messages painted on rock



The pictures at Bhimbaitka are painted continuously on the undulating rock surface. Composing them into my camera's rectangular frame, I suddenly felt uncomfortable. Was I snatching them out of their context, attaching my own meanings onto them? What had their creators wanted to say through these pictures? How was their context different from the one that led me to look so searchingly at these drawings?

Talking of contexts, these cave paintings were discovered by a child. Her archaeologist father was busy searching for stone tools on the floor of a cave, without even an upward glance at the cave walls. The girl looked around without preconceptions, and she noticed the paintings. What we find, has much to do with what we are looking for. And how we see what we find has to do with what our framework is.

What we see as a painting has to do with the role of art in our culture. Perhaps these pictures had a completely different meaning and function for the stone age people of Bhimbaitka. Maybe they were a means to understand the world better, to face practical problems and conceptualise solutions. Or were they drawn for fun, a kind of relaxation? Were they a form of communication, not just amongst people, but also an attempt to commune with nature? The cave temples of later times may have emerged from such traditions. Could they have imagined that a few thousand years later we would look so closely at these pictures, seeking their meaning so intensely?

These pictures show that the painters had internalised a certain level of abstraction. They had mastered the representation of the three dimensional world in two dimensional form, on the flat rock surface. The paintings also give us an idea of their practical skills— a variety of plants and minerals went into producing these lasting pigments. Even with all the visual training and exposure that we receive today, we all know how difficult it is to actually make the conceptual jump necessary to produce a drawing. To be able to draw, is an important step in developing one's technical and scientific abilities.

Cave paintings often use symbols. When we see objects and time sequences represented with symbols, we can guess that the beginnings of language have been made. Constructed from combinations of sounds, language is the most effective medium of human communication, encapsulating ideas and experiences which can be exchanged.

These paintings have played an important role in helping us try to understand the worldview of stone age people. In our times, we bury time capsules containing our ideas and artefacts, for future generations to discover. This is a conscious gesture, indicating a certain attitude to history. When these paintings were made, their creators could have hardly had us in mind. Yet, every fresh discovery of cave paintings has added to our understanding, and from their interpretation emerge some of our most significant ideas about prehistoric human life.

The animal pictures tell us about species prevalent in a particular time and area, including extinct ones. These in turn lead to ideas about the climate, and other animals and plants which could have flourished in that environment. The postures of certain animals and symbols depicted with them lead to speculations on that society's feelings about those animals. If hunting is shown in a large number of paintings, we can guess that this was an important activity.

Such thinking assumes that they were documenting all aspects of their lives in these paintings. It may be possible that these pictures only show areas of concentrated effort. Perhaps they were trying to refine their hunting skills by drawing scenarios. Other aspects of life, dealt with more easily, may not have called for such attention. We must take care to



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Creations from our distant past, seen through the window frame of our present. Do we see too little, or too much, or too differently?



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Langurs, Neolithic to Chalcolithic period, found at Shahad Karad, Madhya Pradesh



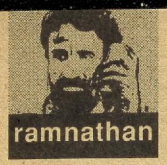
Raja Mohanty , based on drawings by V.S.Wakankar

Paintings in 'x-ray' style, Mesolithic or earlier period, found at Hathi Tol shelter, Raisen, Madhya Pradesh

remember that such speculations have their own limits. Our ways of seeing are a product of our times, and we have to always be aware of the window frame of the present out of which we gaze at the unknown landscape of the past.

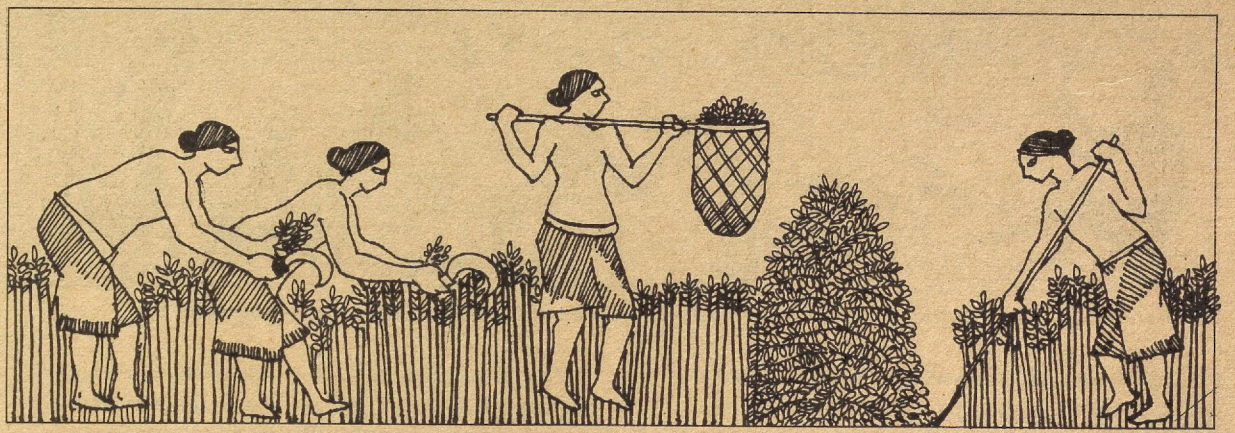
Framing my pictures out of the continuous drawings on the rock, I felt a rush within me. Thousands of years separated the artist drawing that picture and myself copying it in an instant with a camera. Yet, the bonds linking the two of us are so real. There must have been a similar closeness,though expressed in different terms, between the artist and the few humans of that time.

Cave paintings the world over resemble each other, and in this they reflect a common worldview. Arrived at independently, across a range of environments, we see a universality of expression. It is the recognition of this shared consciousness that makes me at once one with the people who made these pictures.



A new way of life

The neolithic site of Burzahom does not belong to the same time bracket that other neolithic settlements in the world, especially the European ones, belong to. Archaeologists hold geographical diversity responsible for this difference. Whatever the reasons, I now realise that terms like 'neolithic age' are not names of specific periods in history. They refer to a technology and a lifestyle that grew around it. Because change and development in human society do not occur simultaneously everywhere, stages like the neolithic, bronze or iron 'age' are found at different times in different parts of the world.



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The actual remains of a civilisation provide a firm basis for speculation, but for archaeologists, more significant than the individual objects, are the kind of objects and the way they relate to each other . Burzahom and other neolithic sites in India are called 'neolithic' not simply because grain samples were found there; the discovery of permanent dwellings, the use of fire, containers for storage, implements for ploughing and for other agricultural activities— only together do all these give us a basis for characterising it as a distinct neolithic culture.

A community of food gatherers or hunters does not need to store anything for any appreciable length of time. With a shift to agriculture, production exceeds immediate requirements and this excess food had to be stored. New techniques, for instance, pottery, were born from this need. Another outcome of agriculture is a more sedentary lifestyle, which leads to construction of permanent dwellings— houses.

Neolithic settlements have been found all over the subcontinent, usually on the banks of rivers, or on open stretches of land near water bodies. Metal was unknown to them, polished stone tools were in common use, and we often find quarry sites with suitable stone close to the settlements. The neolithic inventions of rearing animals and growing food are significant milestones in human history; for the first time, we showed ourselves capable of significantly shaping natural processes. This also marks the beginning of a change in our attitude to nature.

Agriculture meant a series of activities carried out according to plan. Since these activities depended largely on understanding and making use of the cycle of seasons, it meant having to observe nature closely. Surplus food was required to be stored to meet the risks of floods and droughts, and along with other preparations to deal with such calamities, adequate storage pots, containers and vessels needed to be developed. Cooking, or more accurately, food-processing techniques were also developed. Some of these neolithic implements, like the mortar-and- pestle, are still in use today. Perhaps most important, agriculture led to the development of different plant varieties and new types of food.The variety in the food we eat today has its origin in these neolithic settlements— as for the uniformity, it is we who are responsible!

Finally, from sites like Burzahom in every period, prehistory tells us an important thing: that not only are development and change not simultaneous everywhere, but they also do not necessarily follow the same sequence. In other words, every population does not have to go through the same stages in the same sequence.

Our present has many aspects that can be traced back to that early past, but we are ignorant of these links. The discovery of sites like Burzahom reminds us that we are the descendants not only of the recent and celebrated river valley civilisations, but also of earlier cultures to whom— in our foods, festivals and even in cooking implements— we still remain bound by threads that span several thousand years.

Where have all the women gone?



Raja Mohanty

These stone age images depict the work done by women. When did women start becoming invisible?

"There is only one woman in our area who sows seed and ploughs the field." This statement by an adivasi lingered in my mind. Women are allowed all other agricultural work except ploughing.

I am getting accustomed now to discovering such norms and practices. It is now widely accepted that women — accidentally, in different parts of the world — invented farming. From that time till today, so much has changed that I am sometimes confused. That 'accident' was an important event for science. The need to investigate and understand it better cannot be denied, as it has, since, become useful to all of humankind. However, we women who bear that heritage are still in burqa and are increasingly alienated from many of the farming tasks. How far our civilisation has progressed! And yet, after that 'accidental' invention of farming, right upto the present our contribution has remained invisible and unknown, our status in society eroded.

How has the role of women — who invented something as important as farming — become invisible? Today many women anthropologists and social scientists are raising such questions. Their attempt is to penetrate through the patriarchal perspective which nullifies women's role, to search for this heritage and to make visible the invisible contribution of women. Till now, most research in prehistory, too, has ignored the existence of women. There are so many things that hurt, and in the context of the present they are even more disturbing. Is the conclusion going to be that half the human species had no contribution to make? Are we going to study the past, too, with this blinkered perspective on women ?

Today the ability to reproduce and bear children has become the basis of a woman's existence. It is important to society to ask whose child it is. The mother's identity is, of course, quite obvious, but which man's sperm has participated in conceiving the child — this alone is considered significant. The attempts to answer this question 'satisfactorily' are of a piece with *sati*, the control of women's fertility, and the building up of family structures which favour men and whose purpose is to ensure the man's lineage. To produce a male heir to property has been made the prime task of women. We have come to consider this so natural that we cannot even imagine social structures not governed by the importance of the bloodline through the father. There have been other ways of organising relationships, but such arrangements — where too people have managed to live together, look after the young and the old, and nurture each other — are beyond the pale of our imagination and outside today's definitions of 'family'. Here women would definitely have a better status; man-woman relations would be different too.

I have noticed one important feature of tribal societies. Their attitude towards man-woman relationships is more broadminded. Marriage is seen more as a relationship between individual men and women than as a relationship between families. It is not so much moulded to suit the needs of a man, or of wealth or social structure— the criteria of choice allow individuals to go further than that. It is the emotional bond between the couple that is respected as the basis of a marriage. The dichotomy of individual and society, in which less weight is given to the individual in the face of the need to conform, does not really arise or come in the way.

So I wonder why, when science analyses the process of society, the contribution of women is not considered. Is it that scientific enquiry, also, remains bound by the norms of society and cannot rise above them? It is partly because of such questions that I am working on this project. I want to combine the viewpoint of science with that of women. Further, I am also searching for how women perceive science and how science looks at women. I want to carry this through, but sometimes I feel it is impossible. At the end of it all will I have only this fact— that women invented agriculture? Besides, I also have to face the usual exhortations— stay within the safe boundaries of the home, why jump into these kinds of complications? I do not have all the answers, but my search will continue. It is a long journey, part of the quest of all women for their own place.

THE HARAPPAN CIVILIZATION
3500 B.C. to 2000 B.C.

3

The discovery of Harappa and Mohenjo-daro altered the view that Indian history and civilisation began with the Vedic age. Since then, more than seven hundred large and small sites have been unearthed over an area of some fifteen lakh square kilometers.

A song in the *bharud* style names some of the essential features that a city presents. The Harappan site of Lothal helps us to recreate Harappan city planning and drainage systems. Model animation explains how standardised bricks were laid in the pattern known today as the 'English bond'.

Harappan crops and agricultural technology are described. The episode explores and celebrates the richness of Harappan artefacts: beads, terracotta objects, copper tools and the famous dancing girl cast in bronze.

In Khetri, a stone's throw separates the modern copper smelting works from ancient copper mines — was this where the Harappans mined their copper?

Harappan overseas trade and navigational technology are discussed, and we take a look at their still undeciphered script. So much is known and yet so much remains a mystery.

Finally the reporters visit the large, till then unexcavated site of Dholavira, near the Indo-Pak border in Kutch. Under the ground may lie some answers to the old questions, while new questions will certainly arise.

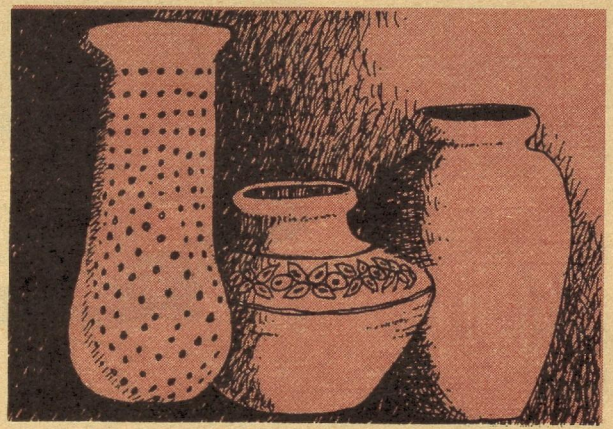


The Harappan in the present

After all the rushing around we finally managed to meet the Harappan people at the National Museum, and there I stood before the dancing girl. A rare privilege, for she was the real bronze beauty and not the plaster cast that stood in her place. She was kept locked away to protect her from art thieves. We had only fifteen minutes with her and, as I looked at the inches-high figure, something in the way she carried herself touched me.

Her armful of bangles ... I found myself playing with the bangles I wore, unwittingly recognising and acknowledging a common bond. They also reminded me of the recent experience of a friend who had deliberately chosen not to wear bangles or any other ornament. In the train a Muslim woman had approached her, asking for help in slipping on some bangles. She had about a dozen glass bangles in her hand. "A bare arm doesn't look nice. Please help me put these on. A few may break, don't worry about that." My friend tried, but was unsuccessful. She was quite disturbed by the incident. As she told me about it, she wondered whether her decision against adornment had disconnected her from this continuity of culture.

From the bangle-laden arms of the Mohenjo-daro dancing girl to the interaction between these two city women... a continuity of culture, crossing present boundaries of religion and caste. It moved me, and I remembered those itinerant Muslim bangle-peddlers of my childhood, experts at easing one's hand into glass bangles just the right size, whose visits played such an important part in women's lives. I wondered if this dancing girl, too, with her armful of bangles shared with the women of her times a similar craze for buying and wearing bangles!



Raja Mohanty

Typical shapes and motifs of Harappan pots

In that moment I felt an intense closeness with the dancing girl. I felt as if she wanted to talk about her life. Her past, spent in the splendour of the Harappan civilisation, and her present, in which that region stands divided by the boundaries of two nations — boundaries so rigid that today they threaten to divide even her past and ours. We could not get permission to film at Harappa and Mohenjo-daro because they are now in Pakistan! We were able to visit only a few sites of this vast civilisation that had spread over fifteen lakh sq. km.— from Sutkagendor on the Makran coast (in Afghanistan) in the west, to Alamgirpur (in present U.P.) in the east, and from Ropar (in Punjab) in the north, to Daimabad (in Maharashtra) in the south.

By now my imagination had been fired and I felt myself growing distant from my colleagues. And even as time ran out, I wanted to continue my communication with the dancing girl. She was witness to so many changes and so many experiences! What had attracted all of us was the similarity of our



Contemporary motifs drawn on pots in Dholavira village, Kutch, resemble those of Harappan pottery

own and the Harappan urban civilisations, separated by thousands of years. We were fascinated by the Bhimbaitka and Adamgarh caves too, but it was more a feeling of wonder and awe, not of intimacy. The deserted urban centres seemed in many ways much closer to us.

The cities, their planning, roads, sanitation, special arrangements for drinking water, baths, toys, units of measurement in multiples of four— all these give us a sense of continuity. Even today in many places food is cooked in a corner of the courtyard at the back of the house; till recently the size and structure of the bullock carts in Sind closely resembled the Harappan bullock cart; and in many places in Sind and Rajasthan, the same mortar-and-pestle, and tandoor, and method of ploughing and intercropping. And the continuity of rites and rituals too— animal sacrifice, worship of the phallus along with the mother goddess, fire, trees and animals. And the continuity of indigenous plant and tree varieties— varieties that must have evolved in this very region— the pipal, the

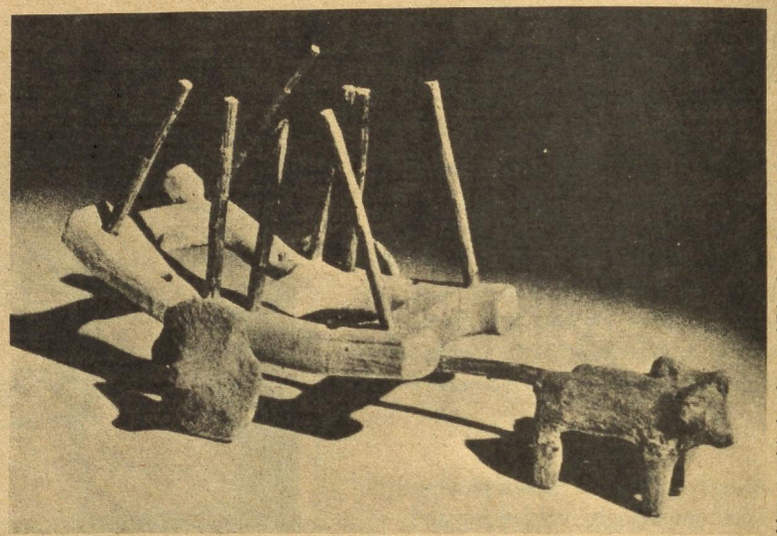


Uttam Ghosh

National Museum, New Delhi

Like the dancing girl of Mohenjo-daro, women and little girls in Kutch wear fitted bangles all the way up the arm

Harappan toy cart. Bullock carts similar in design were common in Sindh till recently



Museum of Archaeology and Ethnology, Cambridge University

banyan. When I think of this ancestry, I begin to feel that a lot of what has been termed 'Indian' is often 'Harappan'!

I cannot help wondering whether this encompassing and growing sense of continuity will be of help in the present. Today we are striving for a sense of identity. But also today this search has often begun to acquire violent manifestations. Can this thread connecting us to the past be of some help in coping with the helplessness and frustration that so many of us face today?

Unease mingled with satisfaction— all this plastic art, the beads, the bangles, the dancing girl— were all symbols of continuity, and yet I also felt a strong sense of loss, a tension that had mounted as we visited the ancient Harappan sites.

Standing before the dancing girl I felt a sense of reassurance. The centres of power of this civilisation— the cities— had declined and lay deserted, but part of the culture associated with the civilisation had spread, evolved, changed and entered deep into different parts of this land mass. Traces of it were even present in a metropolitan product like me!

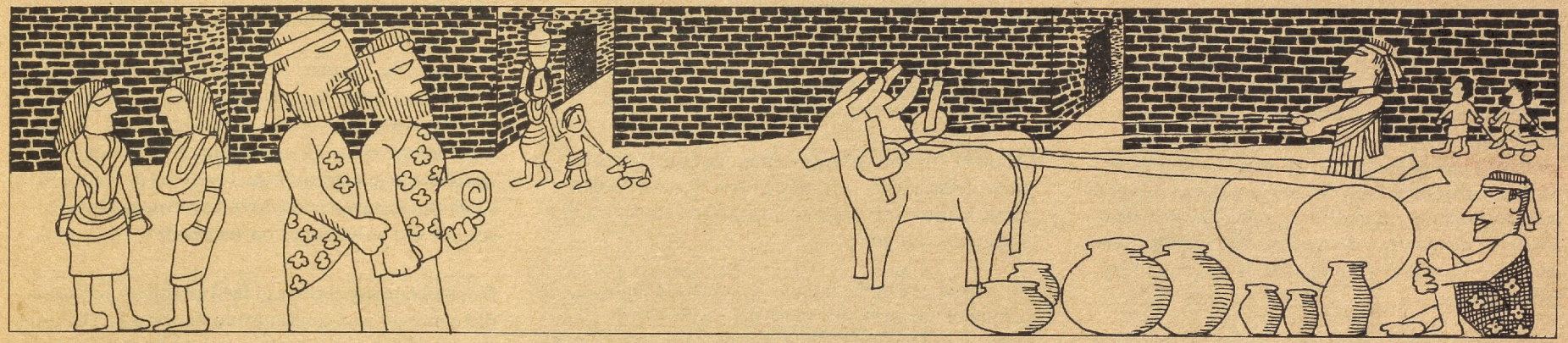
As I finally turned away from the dancing girl, I came back to the present. We have a lot more to learn about those times. We know even less about the other cultures that must have thrived simultaneously in other parts of this subcontinent. We do know that there were paleolithic and neolithic settlements, and that there were other cultures similar to, and yet different from, the Harappan civilisation. They are, in a sense, the rural counterparts of the Harappan cities.

How did these contemporary civilisations coexist? Were they dependent on each other? Do we also carry the cultural heritage of their interactions with each other? Today we have a highly industrialised city just an hour's train journey from the totally different life of nearby adivasis living in and on forests— two very different and almost conflicting lifestyles. Would our study of the Harappan period help us in our effort to coexist, without damage to the identity and dignity of each other? The spell of intimacy was broken. But then recognising and accepting this sense of continuity and belonging with an openness that accepts its possible limits— that alone would have made it worthwhile, wouldn't it?

Museum of Archaeology and Ethnology, Cambridge University



The bronze age cities: a warning



Uttam Ghosh

Cities. The word brings to mind today's huge metropolises— London, New York, Paris, Bombay, Tokyo, Calcutta— cities so large that a couple of them would house the entire population of the Harappan civilisation. Cities with a pace of life so fast that Harappan life would, in comparison, seem a slow motion dream. Yet the Harappans also had an urban civilisation.

I am a city dweller, no doubt, and the milieu of science today is also undoubtedly urban. As I read and gather more information about the ancient cities, I become more and more uneasy, because though I find many reassuring aspects in all urban cultures, there are as many that cause apprehension.

In Ramnathan Maharaj's *kirtan* in the film we sang about some of the typical features of urban life. Other people have described the city in various ways, using different yardsticks. I find two of those characteristics most important. One is that the population of a city is many times greater than that of a good-sized village. The other is that most city dwellers do not grow their own food. And these characteristics of cities are deeply linked to those aspects of city life that reassure me, as well as to those that cause apprehension.

In the city, for the first time it becomes possible for a large human group to lead a way of life that need not depend directly on nature for its day-to-day needs; a life shaped much more directly by human rather than super-human affairs.

The experience of leading such a life is capable of giving rise to the belief that it is not always necessary to be subservient to the forces of nature, and a confidence that nature and its power can be understood. This belief, this confidence, is a necessary and vital component of science.

In a city, the number and proportion of artisans is much higher than in a village, and they enjoy many more facilities. They have much more opportunity to watch their skilled co-practitioners, to interact with them, and to learn from them. They also have greater access to other trades and skills.

It also becomes possible for a city-dweller to find time to think, to give attention to matters of theory, to forming and testing hypotheses, to trying out new things and new ways.

Trade exchanges open further possibilties of pooling different fields of knowledge. This can pave the way for an intellectual interaction across disciplines and cultures, a dialogue that is so necessary for science.

Thus, every wave of urbanisation has brought in its wake a host of developments in science and technology, realising this potential of urban culture to a greater or lesser degree. But again, things never happen in a straightforward manner. When certain possibilities are realised, they combine on the way with many other possibilities as well. It is these other possibilities which make me uneasy.

Let us start again, for example, with the fact that city dwellers do not grow their own food; they nevertheless do have to procure it somehow, from somewhere. In ancient cities they could do this with income which either came through direct patronage by the rulers and the dominant classes, or indirectly through a market resting ultimately on such patronage. These rulers were as often as not cruel, oppressive and whimsical. They might not have ruled the waves, but they did exert authority over science and technology which often became their instrument of power.

Looking at it as I do, through the constantly moving window of the present, this nexus between science

and power makes me pause. I can begin to see how small steps have unwittingly decided the broad direction and destination of events.

For example, that city dwellers are not directly dependent on nature is a fact that cuts both ways. If it makes it easy for city dwellers to think they need not be in awe of nature, it is also easy for them to go a small step further and imagine that they can endlessly mould and bend nature to their needs and whims— that their knowledge grants them power to rule over nature. After all, only a thin line separates ability or the power *to know*, from domination or the power *over*, nature. It is a line that is respected very little today.

And once knowledge is seen as power *over* its object, how easy it is to take one more step and think that the head should rule the hand, and further, that those who think should rule over those who labour, and that the cities should rule over the countryside. Domination, of humans as well as of nature, is the other possibility that seems to be inherent in urban culture.

History bears this out. The ancient cities emerged primarily as centres of power and administration. Even Jericho, the world's first known city, is no exception. Inseparably linked with the wheat and barley growing rural hinterland we see it repeatedly separating itself from that hinterland with walls. Jericho flourished in the same region where a grim war has just been fought for oil— a mineral that has become so vital for our present-day civilisation. The world's first city, too, was a frequent battlefield, its walls razed and rebuilt several times.

A few centuries after Jericho, which had come up in the twlight between the neolithic age and that of metals, came the copper and bronze age. A wave of urbanisation followed. It also inaugurated the long age of metals, not yet over. From Egypt and Mesopotamia to Harappa in Asia and Shang in China, copper-bronze civilisations everywhere built up cities. Cities that have left us a double lesson.

All the bronze age cities rested on an extremely fragile ecosystem. This ecosystem depended on the silt deposited by annual river floods, and their waters carried through irrigation channels. Fragile it was, but it was undoubtedly productive.

Another kind of weakness stands out clearly in all these civilisations— there is a wide chasm between those who had access to science and technology and those who did not.

Of course, one of the reasons is connected to the nature of the metal that gives the age its name— copper, and the bronze that was made from it. Copper is the easiest metal to smelt. Mixed with zinc or arsenic (or perhaps by mixing the ores), it may be alloyed and made into bronze. Though copper is soft, bronze is superior even to steel in some respects. But copper ore is not abundant and bronze finally turns out to be quite expensive. This was a reason why bronze technology remained restricted to the prosperous households. The final result is that the benefits of technology went only to those who had the benefit of wealth and power.

In this respect, the Harappan civilisation is no exception. It does differ in one aspect, though scholars are divided over its significance. In comparison with other bronze age civilisations, fewer and inferior weapons have been found at Harappan sites. It is difficult to say whether this was a result of poor technology or of a peaceable non- warlike culture.

The most striking fact about the Harappan cities is their rapid decline after about 2000 BC. They were overrun by roving, nomadic pastoral tribes, in the course of a movement that originated in Central Asia, which seems to have been caused by the same climatic changes which also contributed to the decline of the Harappan cities. These nomads brought new ideas with them, and a new metal— iron. But they did not, in comparison, bring a more developed science and technology. For a time we almost enter a technological dark age.

How did this happen? The social base of advanced science and technology in these bronze age cities was narrow and fragile. Much of the science and techonology was concentrated in the hands of a very small dominant stratum. And with the decline of the cities and the associated dominant classes, that science and technology, too, declined.

No doubt, many aspects of the Harappan civilisation did continue, and continue into the present. These are aspects which were much more widely dispersed, decentralised and had in some way or the other become part of daily life. To my mind, this reinforces the lesson that when science and technology become the monopoly of a power-wielding, centralised, dominant section, they become very vulnerable. Harappa and the bronze age cities have left us another lesson, a lesson I realised as I watched Ramanathan give voice to his unease in the falling dusk among the ruins of old Lothal. I saw how desolate a deserted city looks. Especially after one knows the heights of prosperity it had once scaled.

I am writing this in the aftermath of the Gulf War. In this war, the bombs dropped on Iraq surpass the bombs dropped on Vietnam in their destructive power. Ultimately, for what? Oil. That is as much, if not more, fragile a base as river floods. Today Iraq is in ruins. But the USA, Britain and their energy-eating consumerist societies should not be too complacent about their success. Besides, if we follow in their footsteps, our own foundation too will be as weak. If we do not take the right decisions today, I am sure that one day, our not-very-far-away descendants will similarly discover the skeletons of our dead cities.



The riddle of the Harappan script

I now often feel disturbed by the Harappan artefacts. It is as if you had a friend, all her things were in front of you, but the friend herself was invisible and silent. No thoughts, no words from her that you can listen to. Just things which belong to her all around you. Some of her writing too, which you cannot understand, or make much sense of. All this has begun to throw its shadow over the Harappan artefacts.

The attempts to decipher the Harappan script began with the finding of the first seals. Today, we do understand something of the script. It is now conclusively taken to be proved that the Harappan script is pictographic by the same criteria that apply to other pictographic scripts. This might seem obvious from looking at the seals, but it is not. If we used a picture to depict each letter and vowel suffix of Devanagari, would that make it a pictographic script? A pictographic script uses symbols for whole words. This is made apparent by the frequency of occurrence of the symbols and by their relationship to one another. In a script which uses pictures for letters, rather than for words, this frequency and the interrelationships would be quite different.

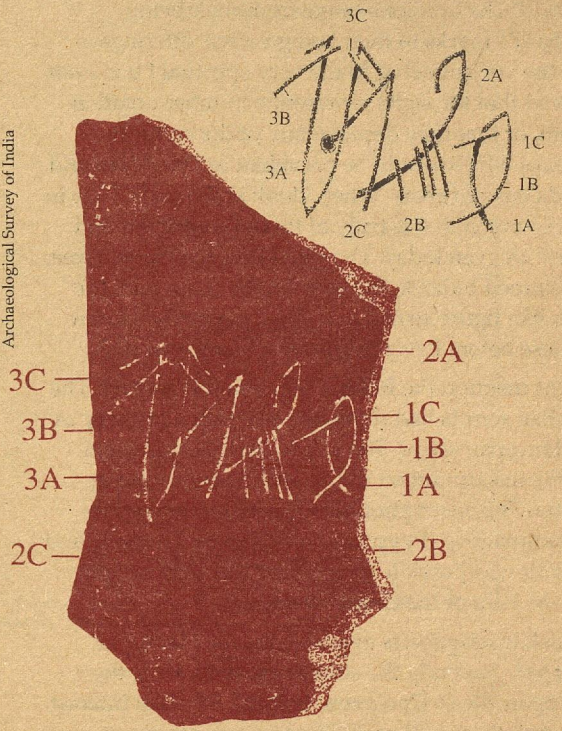
Scholars are divided over the issue of which signs form the basic core of the script. There seem to be anything between 150 to 450 signs. And it is now established that the script is written from right to left like Urdu or the old Kharoshthi. Beyond this lie tangled controversies.

To decipher a script we need to identify the group of languages from which the enscripted language has been derived. After all, a script only symbolically represents the language itself. The possibilities in this case range from the Indo-European group of languages like Sanskrit or Hittite, to a language from the so-called Asia minor languages like Sumerian or

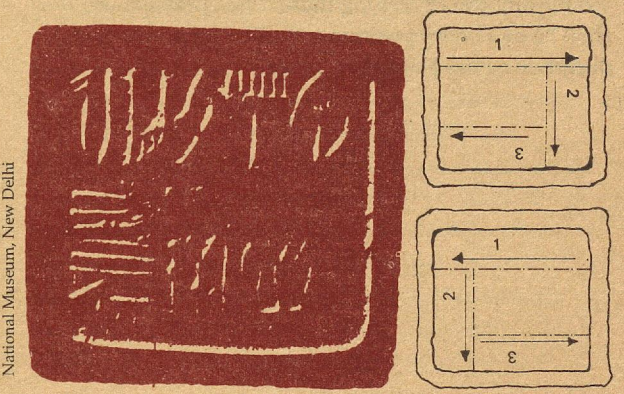
That the Harappan script is written from right to left is a fact many experts have accepted and demonstrated.One of them is Prof. B. B. Lal. We are giving below a short summary of some of his arguments. They represent the kind of attention to detail and careful reasoning that it requires.

Prof. Lal came to this conclusion from two pictographs— one etched onto a pottery sherd found at Kalibangan, and the second on a Harappan seal. On the Kalibangan sherd the etching of the signs had overlapped one another. When one line is etched over another the one underneath looks broken and the one on top looks continuous. If you look at our representation with this in mind you will see that 1B has been drawn after 1A, 2B and 2C after 2A, and 3A after that. And do you notice that last line, 3C? I find in that long scratch the sort of individual flourish that so many of us have when we end a word. Can you make out the direction of the writing now?

And now the Harappan seal. By the side of its representation we have filled in numerals in two squares in the same way — in one of them written from right to left, and in the other from left to right. Here too, the direction of writing stands revealed.



Archaeological Survey of India



National Museum, New Delhi

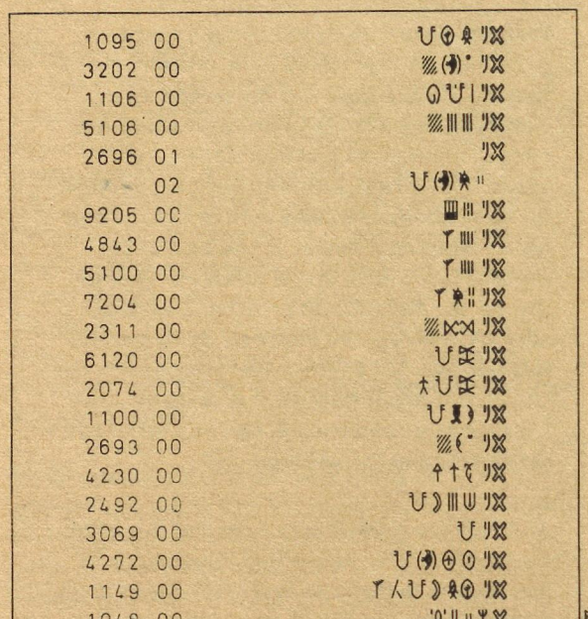
Elamaiic, to the Dravidian or Munda groups. A substantial majority of scholars believe however, that it is part of the Dravidian group.

Other controversies exist: what was the function of the seals? The opinions range from their being merchant's marks to their being votive offerings— from the very material to the very spiritual ! It is even believed that the signs represent a number notation system, or that they depict many of the cultural practices which would be prevalent in Dravidian and Munda culture areas. When I look at the seals, I see in them so much that is truly of this subcontinent and around us even today. The pipal tree, the banyan tree, the humped bullock, the buffalo, the rhino and the Shiva-like figure seated in a yogic posture— I knew all these before I ever even saw a Harappan seal.

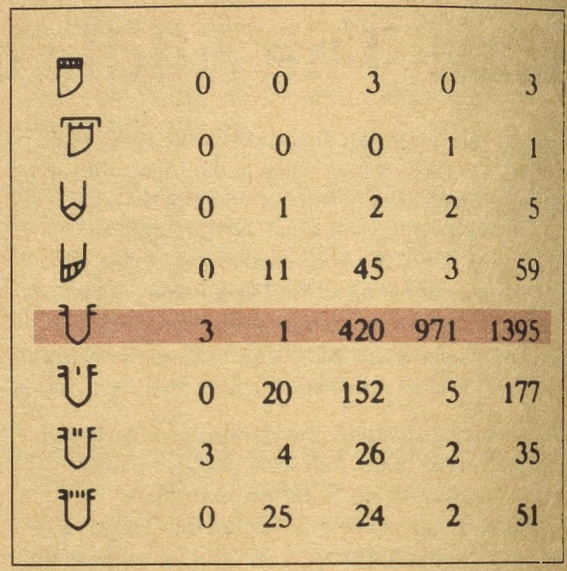
I might mention the Rosetta Stone in this respect. The Egyptian scripts had remained as much a mystery as the Harappan script. The key to deciphering them was the inscription on the Rosetta Stone, found at Rosetta. This inscription was given in three scripts and languages— Egyptian hieroglyphic, Demotic and Greek. It was possible to decipher the other scripts with the help of the Greek inscription.

No such inscription is available for the Harappan script yet. Recently the start of excavations at the Harappan site of Dholavira is cause for fresh interest. The work there will probably continue for many years, but we may hope to find artefacts with a sizable amount of writing there. Then perhaps we shall be in a better position to tackle the problem of deciphering the Harappan script.

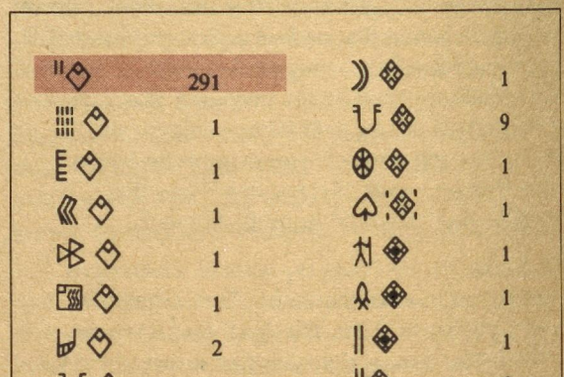
Iravatham Mahadevan's monumental work on the concordance of the Harappan script, in the 1970s studied 3,573 lines of text culled from 3,455 seals, pottery sherds and other objects found at major Harappan sites. 417 signs in the script were identified. An elaborate computer programme had to be developed, to determine the frequency and positional distribution of each sign. Mahadevan's work is a complete index of every sign in all its occurrences. It constitutes an important stage towards the deciphering of the script.



An excerpt from Mahadevan's book giving the full textual context sign shown



This sign is most frequent, occurring 1, 395 times



This pair combination is the most frequent, occurring 291 times

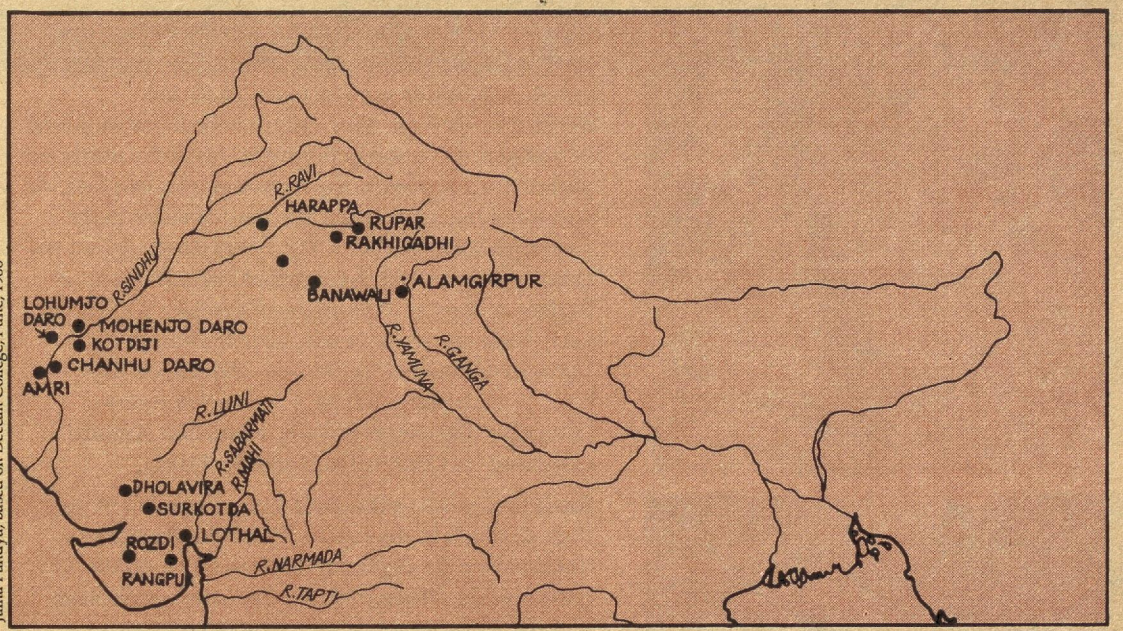


What happened to those cities ?

On seeing the remnants of the Harappan civilisation, a question that bothered all of us was— why did these cities disappear? Where did their people go? I was given the responsibility of reading about the work being done in this area.

What impressed me most while finding out the various speculations put forth, was the multidisciplinary approach necessary for such research. The picture before us today has been made possible because of the combined efforts of researchers from many disciplines, including historians, archaeologists, physicists, chemists, geologists, geographers, and so forth. While working in their own areas they evolved and accepted a collective perspective and direction which helped them resolve matters concerning the end of the Harappans, to whatever extent it has been possible. I want to further stress that what we have are speculations; we may never be able to say anything with certainty. These speculations, however, are not baseless. They are based on observation and experiments. For example, techniques like radiocarbon dating, which help determine the age of a bio-derived object, or other geographical and climatic observations which help us to understand the historical changes in the environment.

First among the speculations is the suggestion that the nomadic Indo-Aryan speakers came here from Central Asia, and pushed out the people residing in the river valleys. It is assumed that in these attacks a large number of people were killed and the cities were deserted. This was the crude speculation to begin with; slowly, however, one came to know that there was no one big attack by the Indo-Aryan speakers. They kept trickling in over a period of time and repeatedly clashed with the Harappan people .



Jaina Pandya, based on Deccan College, Pune, 1986

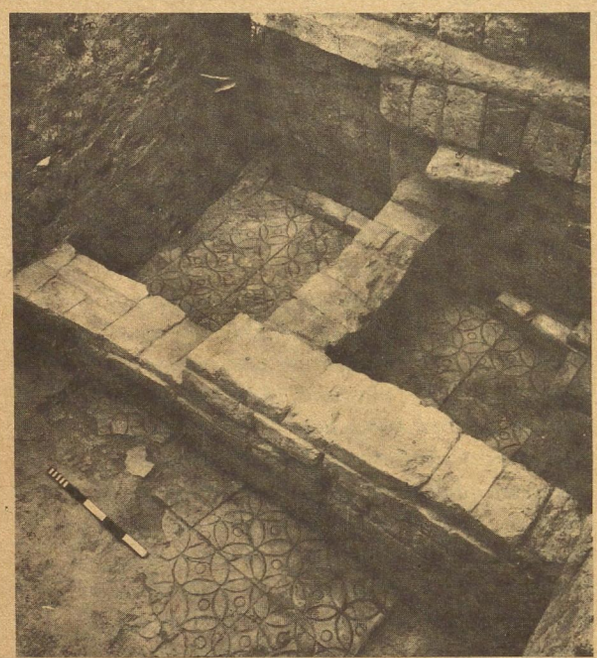
Some sites of the Harappan civilisation.This map is symbolic and not to scale

Besides, there is corroborative evidence that just as these nomads came here, groups of them also migrated to other river valley civilisations. Historians think that global climatic changes forced the nomads to go far and wide in search of pastures.

Why did the Harappan cities collapse under these attacks? It is believed that the answer to this question also lies in these climatic changes. The strength of these river valley civilisations was based on access to water. Changes in river water supplies would necessarily affect the power of these civilisations and a weakened state would succumb much more easily to external attacks.

The well known archaeologist, and our close friend and adviser, Prof. D. P. Agrawal has this to say about rivers: "In the long run, rivers have never been dependable. Like politicians, they change their courses and their allegiances; they join other rivers, go underground and even behead other rivers." Harappan cities relying on rivers were also probably destroyed by this vagrant behaviour of rivers. There is evidence to show that Harappa was submerged and destroyed in the floods of the Indus river and was rebuilt, perhaps repeatedly. The river flowing near Kalibangan, however, totally vanished, destroying the city. Tectonic activities on the earth's





Streets and houses, Kalibangan

Archaeological Survey of India

surface may give rise to geophysical changes which lead to reduction in river waters and a changed climate.

Persistent and repeated studies have today brought to light facts that indicate that the same climatic changes that forced the Indo-Aryan nomads to migrate in search of pastures were responsible for the destruction of these river valley civilisations. A glacial period and reduction in temperatures in the northern part of the globe led to the formation of a lot of ice. As a result of this ice-locking, the flow of water in the rivers gradually reduced. The rivers dried up and the climate became arid. A combined effect was loss of fertility of the soil. Present day Rajasthan is a land of such dried up rivers. In fact, from the east of the Indus to the west of the Yamuna there must have been at some point of time, a number of rivers—Ghagghar (the old Saraswati), Markanda, Sarsuti, Chautang (old Drishadvati) and the Hakra.

Satellite pictures of the earth show a number of old river channels in the region. These channels are indicated by the slight depressions and humidity in these regions. These channels criss-cross each other and present a complicated picture, that is now gradually being unravelled. The complications have arisen because these rivers have not dried up all at once and neither have they maintained a constant direction of flow. They have at times changed their paths, sometimes joined other rivers or branched out, gone underground or just vanished at certain points and resurfaced at some other place. All in all, their lives have been very eventful.

To find out about various stages in the life of a river, a number of techniques are employed. One such important technique has been correlation with archaeological excavations. After marking out the river channels, excavation has been carried out on its banks and its bed as well. Such excavations have shown that there are a number of pre- Harappan and Harappan settlements (like Kalibangan) on the banks of the Saraswati. There are, however, no findings of post-Harappan sites. On the other hand, only post-Harappan sites are seen on the banks of the Chautang. This probably means that the Saraswati is an older river than the Chautang and it also dried up much earlier. On the banks of the Saraswati, there is no evidence of settlements after 3700 B.P. Its bed, however, yielded pieces of painted grey ware which were in all likelihood, prevalent in the period 2800-2500 B.P. The conjecture is that probably by this time the river had started drying up and subsequently, vanished altogether.

Based on archaeological findings and satellite pictures, the picture that now emerges is something like this: settled populations in those times were dependent on the fertility of the soil and availability of water for irrigation. The geophysical and climatic changes affected both adversely. As a result of this, prosperity declined, and the civilisations themselves were shaken. At the same time, these very climatic changes forced people in other parts of the globe, leading a very different kind of life, to migrate. The already weakened and crumbling river valley civilisations, faced with the Indo-Aryan speakers, underwent major changes.

This was a period of worldwide change. In every part of the globe, the climate altered, leaving an indelible imprint on the history of every region, uprooting millions of people. I wonder if modern-day advanced meteorological techniques that study global climate would be able to give history a different direction in the face of any such drastic climatic changes.

THE IRON AGE
2000 B.C. to 500 B.C.

4

An excerpt from Dharamvir Bharati's play, *Andha Yug*, has Ashwatthama hurling the mythical *brahmastra*. The imagery evokes a nuclear holocaust. Was this the science of the Indo-Aryan speakers?

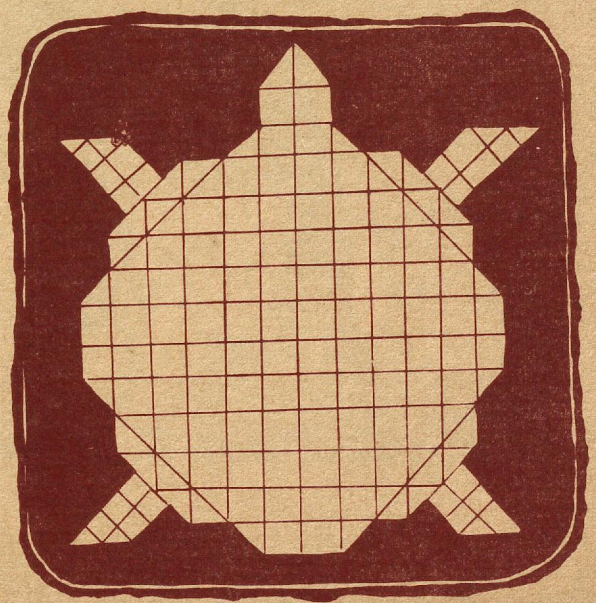
The answer lies in the material evidence: they had iron, superior horses, socketed axes, spoked wheels — all much more important and relevant. Myth provides poetic inspiration and cultural identity; to confuse it with history is to wrong both.

We follow the social consequences of iron technology. The clearing of forests and improved agriculture with the iron-tipped ploughshare laid the basis for new cities. This happened a thousand years after the Harappan decline, in the basin of the Ganga and its tributaries. In the break-up of the old tribal order the protoscientific concept of *rta* as universal law was lost.

The megalithic cultures, predominant in the South, serve to give a more complete picture of the period. Bastar iron smelting today is almost identical to the megalithic technology, as understood from the remains of an excavated furnace.

Kaushambi and Rajgir are city sites we explore. The rise of brahminical orthodoxy is discussed, along with the geometry arising out of prescriptions for the construction of sacrificial altars.

The film ends with a sense of growing social trauma and the birth of Buddhism and Jainism.





Invaders become settlers

I often wonder just what it means to be Indian, especially when in the space of the last fifty years, the entity that went by that name, India, has split into many parts. Do lines on a map alone define a country? Have the inhabitants of a country always accepted their cartographic boundaries as final?

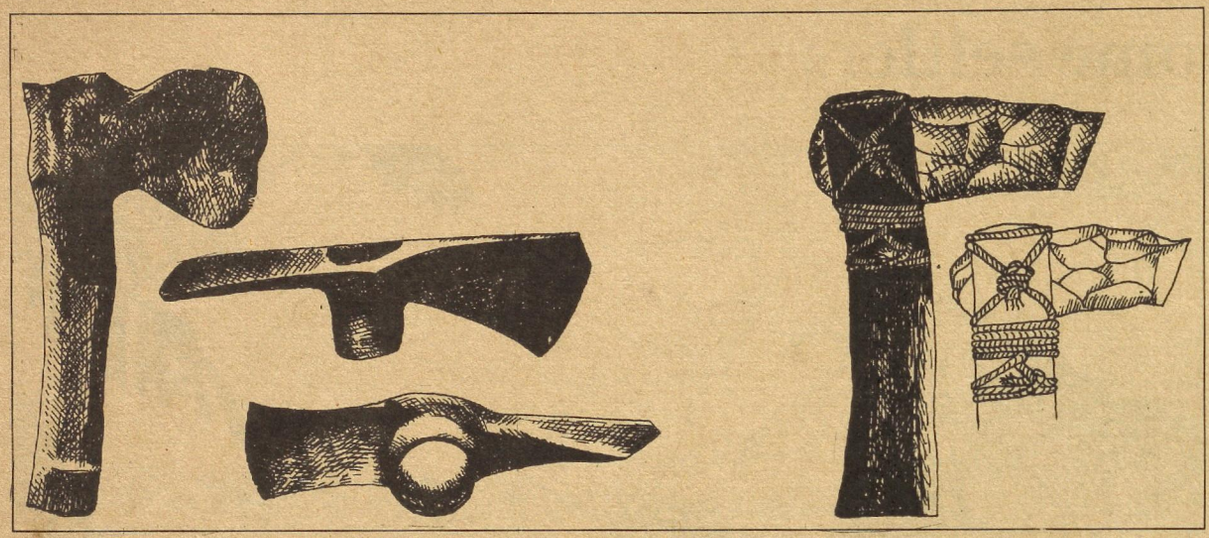
Internal secessions, external interference, and the invasion of one country by another have today become common international issues. Almost all countries are grappling with problems of nationality and community, and every such group is intent on proving its superior claim to a piece of land. In this context, the question of nationhood and an exploration of its meaning acquires greater urgency than ever before.

A certain people came into contact with the Harappan civilisation during the period of its decline and settled here. At that time, Central Asia had settlements, but nothing comparable to the river valley civilisations. Its people were primarily nomads, moving seasonally with their animals. When global climate changed, they moved with their herds in search of more suitable environments and spread out in different directions, encountering different civilisations. These encounters were to change the course of history in many regions.

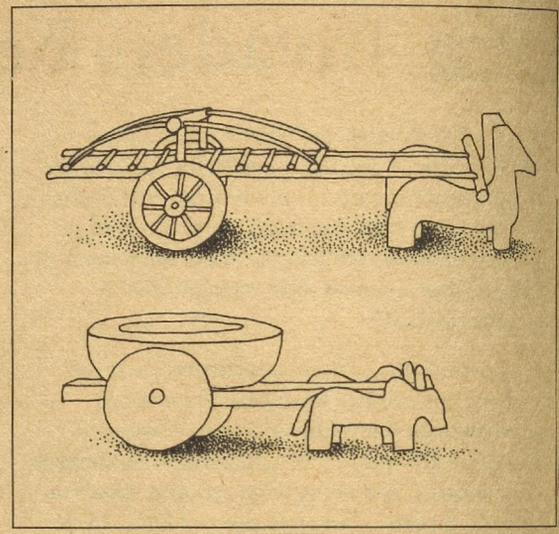
They would surely have been attracted by the river valley civilisations, which grew and stored surplus grain and hence had a different lifestyle, different needs and different ways of satisfying them. How had those who lived in such settlements looked upon these incoming wanderers? Did they see them nearly as warlike roving bands disturbing the even flow of their lives? Certainly they had to face a series of attacks. The nomadic bands from Central Asia were not a big organised horde carrying out one single,



Raja Mohanty



In the socketed axe the blade was firmly fitted into its handle, making it more efficient than the earlier hafted axe in which the blade was tied to the handle



The spoked wheel used by the Indo-Aryan speakers was lighter than the solid Harappan wheel, and made for swifter travel. It also made rough terrain easier to negotiate

sustained conquest. On the subcontinent, the migrants came in small bands, over a period of over one thousand years.

Shall we too, looking back at this process, see it simply in terms of people from one region conquering those from another? Would it be right to say that the Indo-Aryan speakers destroyed the Harappan civilisation? Or further, that our glorious past was snuffed out by these 'foreign' tribes? Shall only those whose ancestors lived here then, within an area determined by present-day maps, be entitled to be called Indian? Will they be given the right to ask all others to leave?

The moral seems to be that no piece of land has always belonged, or will belong, to any one community alone. Thus, in our own history, there are no grounds for saying that those who were here before a certain arbitrary date are the true inheritors of this land, while those who came after have no right to be here. Why do we not see it as the mingling of two separate cultures? For it is a process of each influencing the other; mutual give-and-take is necessary for their continued coexistence. The results of such interaction depend on what will make for stability and growth in that society, at that particular point in time, and within the prevailing balance of power.

When we speak of the 'Aryans' destroying the Harappan civilisation, we have also to note that they had to give up their nomadic existence which was, after all, a radical change for them too. Perhaps it is better to see the interaction as laying the basis of a new civilisation which drew upon aspects of both. On the one hand, the features of an urban, river valley culture; on the other, the so-called ordinary things of the Indo-Aryan speakers: use of the domesticated horse, the socketed axe, the spoked wheel and iron weapons and oral traditions. It was a meeting of agricultural methods and iron tools that not only enabled deeper ploughing, but also made it possible to clear forests so that more land could be cultivated. A copper-and-bronze civilisation in which only the elite used metals, rubbed shoulders with a society in which every household could use iron tools.

The big and small things of both cultures continued to come together; it is by this process that common cultures are formed and take definite shape. If we remember that innumerable such minglings have gone into the making of today's Indian culture and Indians, we may then see just how shallow and flimsy are those arguments which try to decide once and for all, who is 'truly' Indian and what 'really' constitutes Indian culture.



The 'Aryan' misconception

In the film we have deliberately used the phrase 'Indo-Aryan speakers' as against 'Aryans'— the word generally used to describe the people who came to the Indian subcontinent in the period beginning with the decline of the Harappan civilisation to about 1000 B.C. Yet, it is amazing how, even when people hear the term 'Indo-Aryan speakers,' they understand it as 'Aryans'. They are either ignorant of the difference between the two or indifferent to it. What tenacity a misunderstanding acquires once it becomes popular! The right expression does not end the misunderstanding, instead the correct expression itself begins to lose its meaning.

The reasons for deliberately calling these people Indo-Aryan speakers are important, because our misconceptions about these people are so many, and so widespread. First among these is the belief that all the Indo-Aryan speakers, who migrated over centuries, were people of one race. It is this racial idea that the word Aryan connotes. The spread of a language, and of a culture associated with it is, however, different from the spread of a race. We should take care not to confuse the two.

During British rule, and since then too, the English language and its accompanying culture also spread here. It would be absurd to say, therefore, that a white skinned, blonde, blue-eyed 'English' race spread in this country. We can see the absurdity of this because the reality is before our eyes. Yet when we speak of the spread of the 'Aryans' it is as absurd.

The concept of an Aryan race has its own history. Under British rule our self-respect had been eroded, and the concept of an Aryan race was an attempt to recover this self-respect. However, the concept was not limited to race. Another linked concept was required, that of the Aryans as the most superior and most advanced people of the ancient world. Therefore, as their descendants, we too were the most advanced, the argument said. How easily self-glorification and complacency creep in, disguised as self- esteem!

Those who set out to acquire self-esteem within the caste system display the same sort of attitude. They attempted to link themselves historically with the so called 'Aryan' tradition, to make their customs and rituals more 'Aryan-like'. Sociologists have given this process the name of 'Sanskritisation', which is really a euphemism for 'Aryanisation' or 'Brahminisation'. This approach does not question the inequality of the caste hierarchy. Only in the trends represented by people like Ambedkar, Phule and Naicker do I see an attempt to break away from this narrow approach, and to seek another way.

The Indo-Aryan speakers came and settled here in course of migrations that went on for over a thousand years. This was, in fact, an outcome of an upheaval within the Indo-European speaking tribes. The environmental changes that endangered the copper-bronze age cities— especially their centralised features— were also responsible for these migrations. It is impossible that this movement of people, to every corner of Europe and, in Asia, all the way upto the Indian subcontinent, could be the story of a single race. Languages, as much as people, were travellers on this journey.

Of these, the travellers towards the Indian subcontinent split into two groups, which we know today as the Indo-Iranian and Indo-Aryan language groups. These groups offer an interesting example of how culture-specific, the concepts of superiority and progress are . In the Indo- Aryan language group the word *sura* means god (the concept of a superior, advanced being), while *asura* is its exact opposite

Our concept or definition of the Indo-Aryan speakers is based on language. Though it is possible to understand many aspects of a culture through a study of its language, the approach has its limitations. We can only take the results of such analyses as speculations or possibilities, until firm evidence is available.

A small comparision gives a clear idea of the limitations imposed by such an approach. All the Indo-European group of languages have the same unaltered form of the word for 'cow', but strangely enough, not for 'milk'. Does it mean that the cows of the Indo-European civilization did not give milk?

A few more such examples that throw light on common cultural and linguistic traditions are shown below.

The code is:
San- Sanskrit, *Lat*- Latin, *Av*- Avestan or Irani, *Eng*- English.

Devanagari (Root word)	English approx.	Hindi related	English approx.	Related words
क्रेड	kred	श्रद्धा	shraddha	shraddha-*San*, credo-*Lat* jhrajda-*Av*, credence-*Eng*
पॅटर	pater	पिता	pita	pitra-*San*, pater-*Lat* father-*Eng*
मातेर	mater	माता	mata	matra-*San*, mater-*Lat* matar-*Av*, mother-*Eng*
स्वेसोर	svesor	बहन	bahen	svasara-*San*, soro-*Lat* shranhar-*Av*, sister-*Eng*
डोमो	domo	घर	ghar	dama-*San*, domos-*Lat* dam-*Av*, domicile-*Eng*
वेहे	vehe	शपथ	shapath	oha-*San*, vovio-*Lat* aaog-*Av*, vow-*Eng*
—	—	नियम	niyam	rta-*San*, ars/arts-*Lat* art-*Av*, order-*Eng*
दो	do	देना	dena	danam-*San*, donum-*Lat* donate-*Eng*

Along with the Indo-Aryan speakers, we had people belonging to several other linguistic groups on the subcontinent. These included speakers of the Dravidian, Munda and Austro-Asian group of languages. Before the Indo-Aryan *Bhasha* became formalised into the exclusive *Sanskrit*, it borrowed and exchanged words freely with all these languages. Local names for plants and animals, words related to agriculture and even religion-linked words, entered into Bhasha. Some interesting examples:

Words from the Austro-Asian group of languages:

तांबूल	tambul	paan or betel	yablu-Mon lamlu-Halang
मरिच	marich	black pepper	meridasa-Savar
लांगल	langal	plough	ankal-Khmer lagal-Cham

Words from the Dravidian group of languages:

कुंड* कुंतल	kund kuntal	lake, pond hair	kuntu-Tamil, Malayalam kuntal-Tamil kundal-Kannada
खल*	khal	threshing floor	kalam-Tamil,Malayalam
चतुर	chatur	clever, cunning	chatur-Tamil chaturu-Telegu
दंड*	dand	staff, pole	tantu-Tamil dantu-Kannada
पण	pan	vow, wager	punai-Tamil
पंडित	pandit	learned man	pand-Telegu
बल*	bal	strength	bal-Tamil
बिल	bil	lair of animal	vilvu-Tamil
महिला	mahila	woman	makal-Tamil
वल्ली	valli	creeper plant	valli-Tamil

* **These are used in the Rig-Veda, indicating early adoption into Bhasha**

(implying the basest and most backward creatures). The Indo-Aryan 's' is transformed to 'h' in the Indo-Iranian language group; but here *ahura* means god, and *hura* is demon!

All these people,including the Indo-Aryan speakers, were essentially nomads, on the move because of the degraded environment. A present day parallel is the annual migration of banjara communities from Rajasthan and Kathiawar to live in the forests of Maharashtra and Madhya Pradesh.

Nor were their science and technology particularly advanced, compared to that of the urban civilisations of that time. What became important were the so-called ordinary things— swift chariots, better bronze and, later, iron weapons, the socketed axe and other implements, and also a highly developed oral tradition. The tribes with which they came into conflict also adopted these devices to greater or lesser degrees.

Finally, we must realise that it was a two-way exchange. Non-Indo-Aryan words and customs were absorbed by the Indo-Aryan speakers. By the time of the Buddha, so much had changed in terms of language and customs, that to describe anything of this period as 'Aryan' merely indicates a linguistic influence. The Indo-Aryan speakers of Rigvedic times would have been amazed by the transformation brought about by this synthesis.

The moral is quite simple. It is this synthesis that we must claim, if we must claim to have inherited something from this period. We can, if we like, also be proud of be proud of our 'Aryan' tradition of usurping tribal lands and massacring entire populations. The question is, which heritage shall we choose?

Our society is, today, becoming increasingly 'Aryan'-ised in the latter sense. This trend, apparent in everything from television serials to text-books and novels to calendars, is a cause for anxiety. Though its origins lie in the search for self-respect during British rule, the 'Aryan' concept is expanding alarmingly under the 'Hindu' banner today. The British, however, left long ago. When will we be able to stop glorifying our past and being complacent about our heritage? When can we start building an atmosphere of true self-esteem?



Embroidered wall hanging, Chamba 18th century. Note the Mughal costumes and weapons in this latter-day depiction of Kurukshetra. Each age interprets the epics in its own ways and seeks contemporary meanings in them

Victoria and Albert Museum, London



Epic versus history

Working as I do with computers, I feel comfortable with hard facts. So when Amrita speaks of poetic imagination I am sometimes at a loss. Having been a student of literature, she often tries to explain passages from poetic texts. I listen, while my mind absorbs what she says in its own way. I had a glimpse of Amrita's viewpoint when she described what makes the Ramayana an epic, and the portrayals of its heroes and heroines in its fourteen different versions. I did grasp something, but the leaps and bounds of poetic fancy still eluded me.

I understand Nissim a little better— he is more mature and also has a historian's training. He insists that though the epics give glimpses of the culture, of ways of living and thinking in times past, that does not make them history, a chronicle comprising facts and events. To describe events accurately is the task of history, in order that we may comprehend our present and adequately shape our future.

I wish I could agree fully with Nissim, but when I look at today's circumstances his analysis does not satisfy me. Take for example, the Gulf War. While it raged, all nations, whether associated with the war or not, expressed their own widely differing understanding of the events. Events which tomorrow will be history, events which will in course of time pass into history.

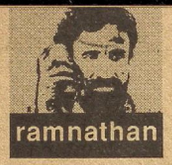
Will each historian's account of the war then, defend the position of the country to which he or she belongs? It is possible that many facts will not even be recorded. That is, all versions may be histories and may be based on reality to a large extent, but there would be many different viewpoints of that reality. The poet's imagination too, is based to an extent, on the poet's view of reality.

We need not go very far for an example. There is a recent one right at our doorstep— the *mandir-masjid* controversy. Some historians have proclaimed the possibility of a mandir having stood there originally, in terms such as, "it may be possible ...", "it seems likely ...", " perhaps it so happened ...", etc. On the surface all of it is an analysis of facts and events, but somewhere the historian's prejudices, his or her understanding of the present, has gained ascendancy.

Today society does not base itself, or even truly derive its values from, the portrayal of Rama in the *Ramayana*. Yet it is convenient for many people today to look upon Rama as their ideal. And this they do not receive straight from history. After all, history does not by itself provide such ideals. Ideals are for epics to create, propagate and nurture. This poses a problem, however. While an epic presents us with ideals, in doing so it spins a narrative web that does not necessarily resemble reality. The very aims, then, of history and epic differ. One gives us ideals to be emulated, while the other looks for facts. Difficulties arise when these aims get confused with one-another. In the mandir-masjid debate, epic has been assigned the role of history; what is happening in this country as a result may certainly become a bloody chapter in our history.

The more I think about it, the more anxious I feel. I find myself in a dilemma: I do not find the comfort that stems from a complete identification with either Nissim's discipline or Amrita's. Perhaps history in our times demands a different approach— the divergence between accounts based on facts continues, yet each will continue to be called history.

For my own search, the only written sources I have for this so-called epic period are the epics. Yet by now I realise one thing very clearly. I know that epics and history are not the same thing. It is not even as though their ways are separate but their destination is one. In other words, their forms are such that we cannot say that though they have different names, their goals are common. History aims at a responsible recording of events based on facts; epic is also rooted in the reality of its times and its society but its purpose is to express, to elaborate on a poet's imagination and experience.

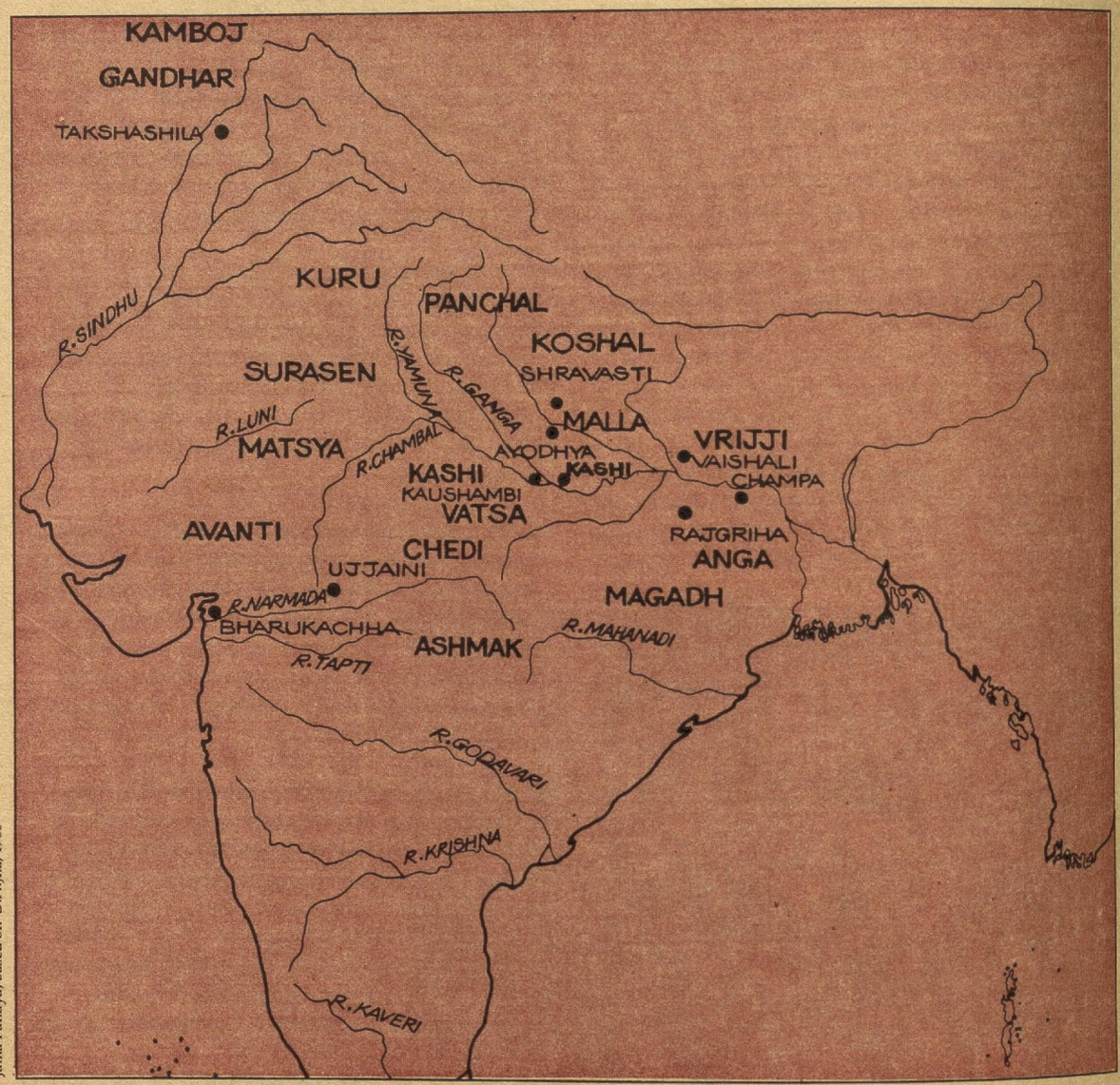


Cities in transition

The iron age cities fascinate me. The cities of ancient Greece and of the Indo-Gangetic plains are, in fact, the cities I know best. And this may sound strange, but they fill me with a sense of belonging. My colleagues often tease me about it. I laugh with them, yet I cannot help thinking that the iron age city cultures are unique in many respects.

This was the period in which firm scientific traditions were established and ideas of democracy took concrete shape in both India and Greece. New thinkers emerged. Some saw nature, and the universe, as composed of unchanging atoms; others perceived it as an indivisible whole in a state of constant flux. What intrigues me is how, so many schools of thought suddenly burst forth, all imbued by a spirit of profound enquiry into the world around them.

Some of the credit for it certainly belongs to iron, the now-so-common metal. Other than the atmosphere that surrounds us, and to an extent sunlight, nature's resources are not distributed uniformly on this earth. The distribution of minerals is particularly uneven. Were it not for such unevenness, would West Asia have become a war zone ? However, we were speaking of iron. Let us compare iron with copper and bronze, the common metals in use earlier. Copper ore is easy to smelt, and so copper was discovered first. However, the quantity of copper on this planet is small, and its distribution quite uneven. While iron ore is more difficult to smelt, it is found in greater quantities and in many more places. And so, once production and use of iron was mastered, this scientific advance had a far-reaching impact on everyday life. At the risk of exaggerating slightly, I would say that while the use of copper and bronze went no further than the warrior's weapons, iron reached the farmer's plough and the tools and



Jaina Pandya, based on D.N.Jha, 1980

The sixteen Mahajanapadas and important cities of the iron age. This map is symbolic and not to scale

implements of craftsmen, making the blacksmith a stable component of village society.

There is a similar difference between the cities of the copper-bronze age and those of the iron age. The former had an extremely narrow ecological base, on which their prosperity depended. When the ecological base broke down, the cities also vanished. In contrast, the cities that grew in the Gangetic plains during the iron age had a fairly broad ecological base. These cities were not exceptional niches; they were the logical outcome of all-round higher crop yields, trade and social organisation. They were unlikely to fade away as easily as the copper- bronze age cities.

Yet history rarely follows the simplest path. The benefits of science and of increased productivity do not automatically reach everybody. The broad ecological base and the use of iron only made it *possible* for everyone to prosper. Making this actually happen was an entirely different matter.

In the film we have touched upon the turmoil of that time. Social norms and customs linked to community life were breaking down. Attempts to seize upon the higher yields for personal gain had begun. The powerful fought among themselves for spoils. Village headmen and tribal chiefs aspired to the status of kings. The system in which people chose their officials was sought to be replaced by hereditary succession. Rituals multiplied; priests and headmen fattened on the bounty from *yajnas* and animal sacrifices. But they had as yet no fully sanctioned position or status in the social order. The old order was crumbling, the new was yet to be constructed. It must have been a disorienting and insecure time to live in.

The story of the *Mahabharata* reflects this twilight age, as do the Buddhist and Jain philosophies. After a few centuries of turmoil, a caste-based feudal order in which priests and kings had pride of place arose. Buddhism and Jainis, too, made some compromises with this new order. However, when the cities of the Gangetic plains were first coming into being, all this was a long way off; in fact, there was a strong sense of revolt against overlords and rituals. A tempered form of this revolt continued many centuries later in the bhakti movement.

"All around was a strange disquiet", as we say in the song. Those who lived through this disquiet and searched for the purpose of life are the ones with whom I empathise. Both Buddha and Mahavira proclaimed that life meant suffering. But there were many others then, most of whom we do not know. Along with Buddha and Mahavira, these philosophers also interest me greatly. The philosophies of thinkers like Ajita Keshkambali and Makkhali Goshala expressed a profound cynicism. The despair stems from their inability to come to terms with the injustice all around. They can neither justify nor prevent the rule of greed or the machinations of the mighty. To risk another exaggeration— without such despair, the Buddhist and Jain philosophies could not have been born.

This period attracts me for another reason too. Are we not living through similar times today? A snatch-and-grab culture prevails. Science is finding more and more ways to make life richer and happier; yet its benefits are monopolised by the greedy and the powerful. Those killed in war in the twentieth century probably outnumber the inhabitants of the iron age cities; and the resources wasted on these wars might be enough to 'develop' every 'backward' region of the world by this time.

Granted, our solutions will be different. No religion is likely to provide answers. It is our very way of life that must change, and we have to rely on ourselves for it. Meanwhile, the troubled times we pass through seem to link us to the 'strange disquiet' of the cities of iron age.

Oh King, you do not earn merit by giving alms or making sacrifices or offerings. Deeds, good or bad, do not bring desired results or fruits. There is no such thing as life, in this world or the next. There is no mother or father, nor the making of any life without them. There is no rishi or brahmin who has gained salvation, or who has realised this world and the next, or who can communicate this wisdom to others. The only truth is that humans are made of four elements. When they die, the earthly in them returns to earth and becomes earth once again. The fluid to water, heat to fire, air in them into the wind, and the consciousness blends into nothingness. Four pall bearers take a fifth body on a bier. Till the cremation ground they praise him, but there his bones are bleached and his good deeds and offerings turn to ashes.

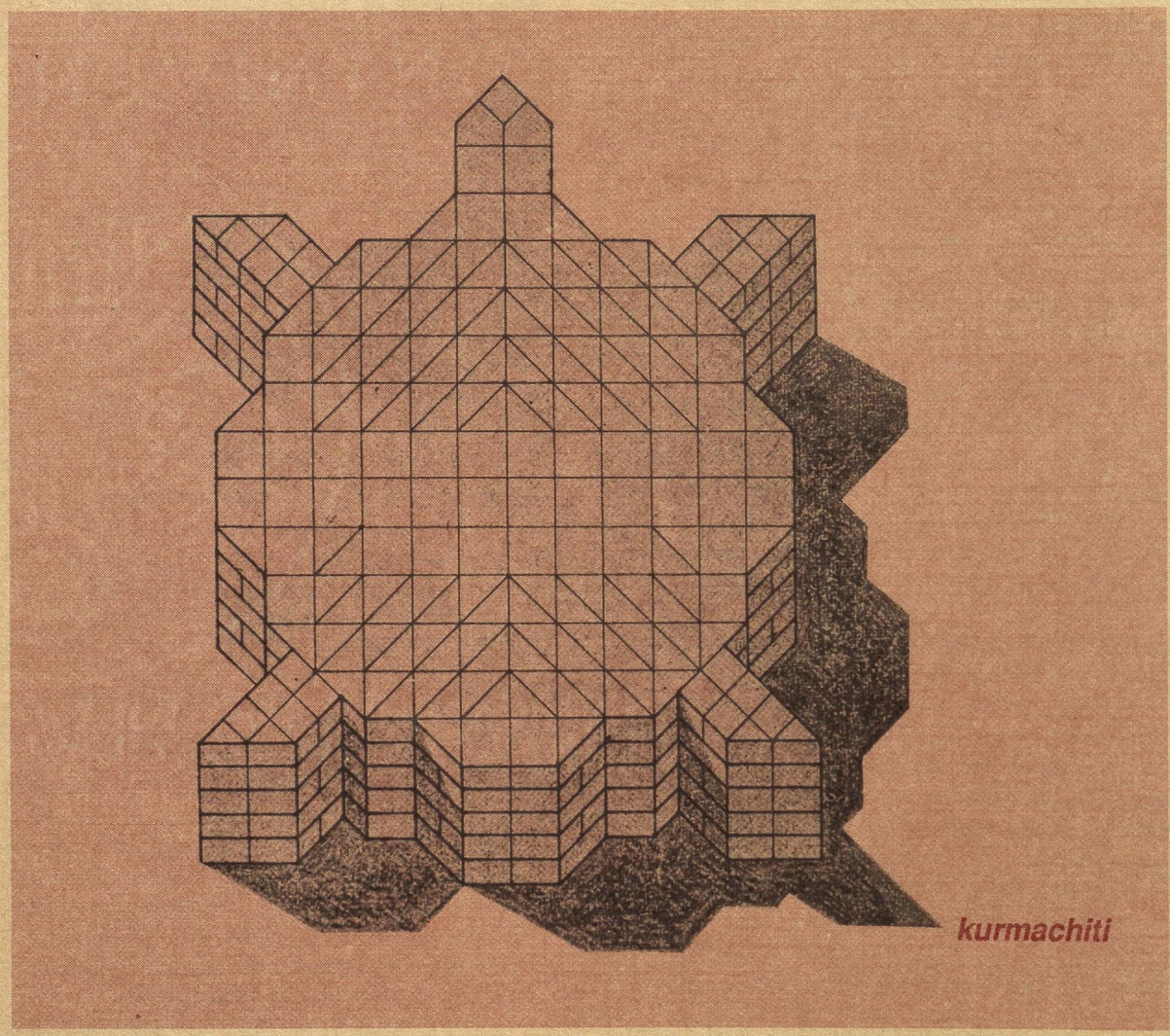
This talk of giving alms and sacrifices is the talk of fools. When people say merit is to be gained from such acts, it is idle talk. Fools and learned alike, on the dissolution of the body, are cut off, annihilated, and after death they are not what they were once..."

Ajita Keshkambali

based on T.W. Rhys Davids, 1899



Geometry with cords



Harshad Bhatia, based on S. N. Sen & A. K. Bag, 1983

The **Shulbasutras** *dealt with the rules for the measurements and construction of fire altars used in various sacrifices. Because of the differing shapes of the altars, these rules had to enable people to solve a number of geometric problems. For example , the tortoise-shaped fire altar,* **kurmachiti** *was meant for those who hoped to dwell in the abode of the gods*

I have always been interested in mathematics, and in the biographies of mathematicians. I have found mathematicians a somewhat eccentric lot and, perhaps for that very reason, extremely interesting.

At first, the books I had managed to get my hands on took for granted that ancient mathematics began in Greece. And not only mathematics, but ancient science as well. Only recently have I begun to come across a few books that bring us out of this Greek prison. By the time I started work on these films, I was already becoming aware that mathematics had also flourished outside ancient Greece. And further, that perhaps the mathematics of North Africa and West Asia laid the basis of Greek mathematics. So when I began to explore the mathematics of the *Shulbasutras*, I kept returning to that old, deeply entrenched context of Greek mathematics, and unwittingly, I kept comparing the Shulba geometry with the works of the Greek mathematicians; not any longer in order to prove the primacy of one over the other, but more in terms of wondering how the same thing could be understood in such different ways.

You have already seen one example of this—Pythagoras's theorem— in the film. The conclusion is the same, but in the Shulbasutra version there is no mention of triangles; the theorem is supposedly about rectangles. This use of the square and the rectangle was to become a bridge between Shulba mathematics and the temple architecture that emerged almost a millennium later.

There were also other differences. For example, this very theorem of Pythagoras posed, for his followers, a riddle that was to prove the undoing of the Pythagorean sects. No such problem arose in the Indian subcontinent. But that is an episode in mathematics that needs to be told from the beginning.

Let us assume that $\sqrt{2}$ can be expressed as a ratio of two integers. Assume that these two integers are a and b. If a and b have any common factors we proceed to remove them, and from them we form two numbers, c and d, which have no common factors.

So, now

$\sqrt{2} = c/d$

or

$c = d\sqrt{2}$

Squaring both sides we get,

$c^2 = 2d^2$

Since c^2 is the square of an integer and it has 2 as a factor, then 2 must also be a factor of c.

So let us assume that $c = 2e$

Substituting 2e for c we get

$4e^2 = 2d^2$

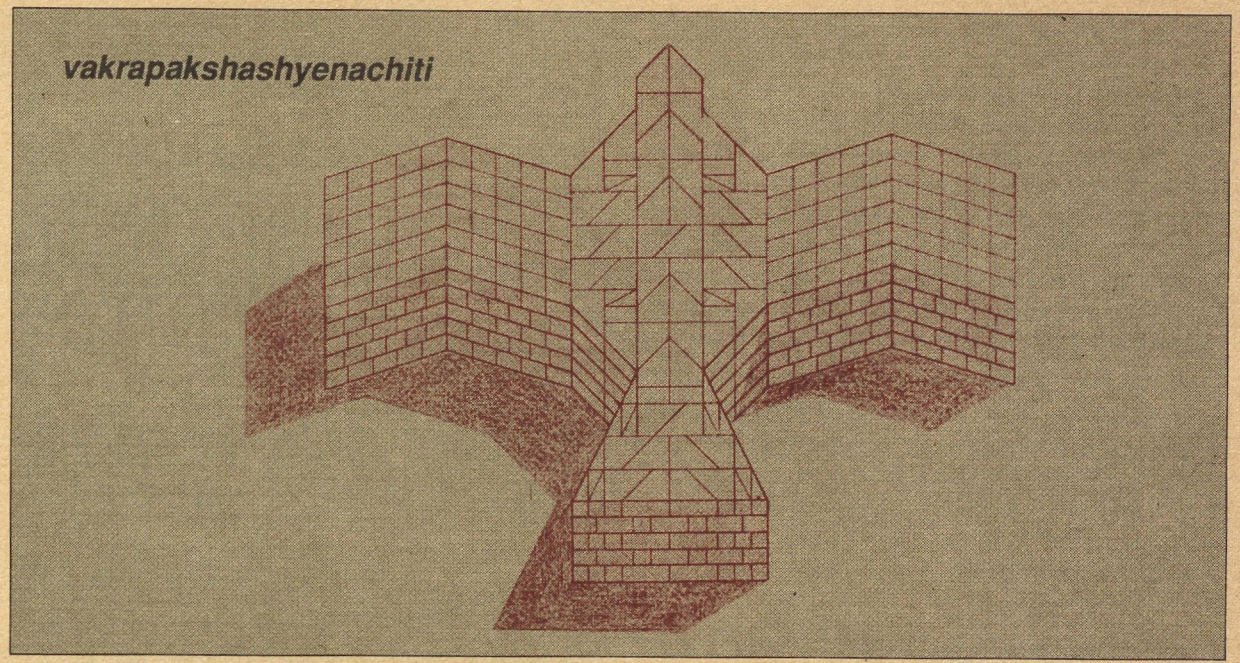
$d^2 = 2e^2$

As argued earlier, since d^2 is the square of an integer and has 2 as a factor, 2 must also be a factor of d.

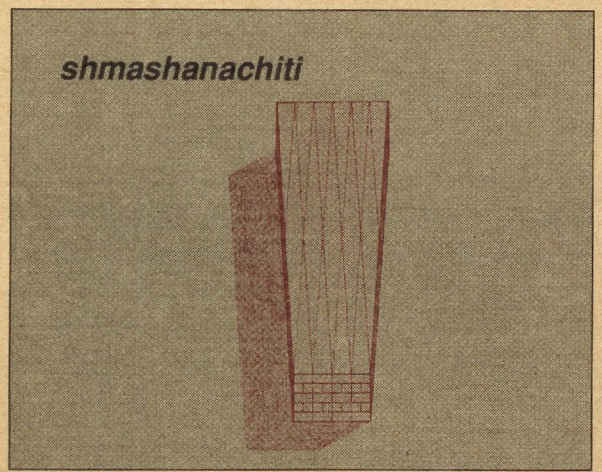
So we find that c and d have a common factor 2

But we had assumed that c and d do not have a common factor.

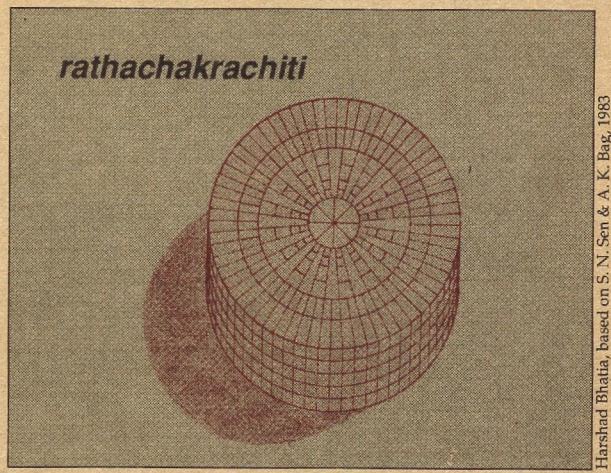
So our initial assumption that $\sqrt{2}$ can be represented by a ratio of two integers must be wrong.



The vakrapakshashyenachiti, *or falcon-shaped fire altar, was meant for those who aspired to heaven*



The shmashanachiti *or pyre-shaped fire altar, was built for the purpose of attaining the abode of one's ancestors*



The rathachakrachiti *or chariot-wheel-shaped fire altar, was constructed in order to gain control of a desired region, as in war*

Harshad Bhatia, based on S. N. Sen & A. K. Bag, 1983

Pythagoras was as much a mystic as a mathematician. He virtually worshipped the natural numbers or, to use the more popular but slightly inaccurate equivalent, the integers. For him, integers represented perfection and excellence. Since mathematics was the quintessence of perfection and it dealt in numbers, he also believed that all numbers could be expressed in the form of a relationship, a ratio, between these integers. Such was his reverence for the integers that he believed that everything essential in nature could be represented by the integers and their properties.

Let us look at numbers. Any number will either be a whole number or it will not, so went the argument. If it is not, we may still represent it as a ratio of two whole numbers (for example, 1.4 may be represented as 7/5, and 0.1072 as 67/625). The task is simply that of finding the right integers. Once this is accepted in principle, mathematics based on integers thereby, also attains perfection.

But things have never been that simple. What decisively proved them to be otherwise happened to be the theorem named after Pythagoras himself. If we take a right angled triangle whose base and height are one unit each, then the hypotenuse is $\sqrt{1^2+1^2} = \sqrt{2}$ units, that is the square root of two. This is a number that cannot be represented as a ratio of two integers. (Those interested may read the accompanying box, the rest will have to take my word for it!) There are not one, but innumerable numbers of this type— in fact, their number is an entire order of magnitude greater than that of the integers. But that meant the fall of the integers and with them, of perfection!

The Pythagorean sect met clandestinely and transacted its business in great secrecy. It is said that they tried hard to keep this discovery a secret. Eventually, the sect died out. This discovery may not have been the main reason for its decline, but Pythagoras' theorem did, by implication, strike at the very roots of Pythagorean beliefs.

Even today, we continue to call these numbers *irrational* numbers, even though there is nothing even remotely irrational about them. What is irrational is the old Pythagorean understanding of numbers. But then, history coins such terms and they become so much a part of the common, inherited conceptual baggage we unknowingly carry, that it is almost impossible to change them.

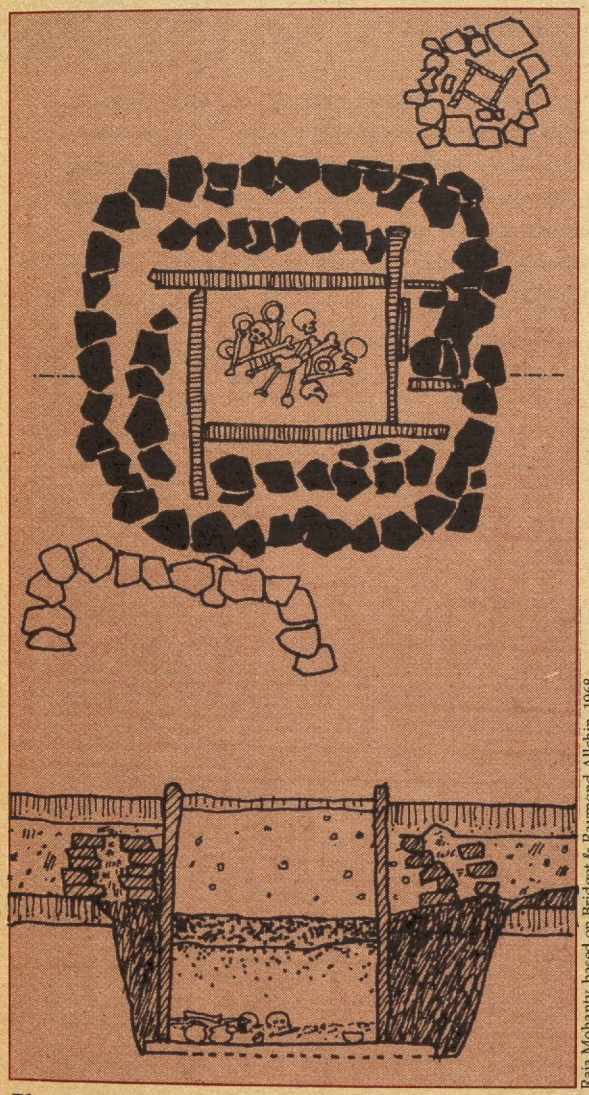
Let us return to the Indian subcontinent. Here, too, irrational numbers were used, but they never posed this kind of problem. Why not?

I think one reason lies in the nature of the mathematics of the Shulbasutras. In many ways, their attitude towards numbers was an extremely practical one. One example is that there is mention, but no discussion of rituals and their reasons; the aim is to find practical solutions to the geometric problems posed by the details specified by the rituals. For example, the square root of 2 becomes the Shulbasutra's *dwikarani*— roughly, "that (length) which makes two (square units)." It simply meant a length, such that, if you took a square with a side of that length, its area would be two square units. Each number is, similarly, placed in the context of an operation, an operation performed with the *shulba* or cord. From this point of view all numbers— integers, fractions, irrational numbers— belong to the same class, namely, definite lengths that give rise to definite areas. Operations received priority over classification. This attitude also brought with it its own limitations— for example, we never evolved a geometry as logically knit into a single system as Euclid's geometry. But there were also advantages, such as our strong tradition of algebra, especially its algorithms.

All of this points to an ironic paradox: Greece, which is supposed to be the cradle of ancient science, including experimental science, produced Pythagoras who treated numbers as mystical symbols; the Indian subcontinent, which is supposed to be the home of the most spiritual and mystical of traditions, produced the Shulbasutras which look at numbers in the most practical way.

amrita

The megaliths: a parallel stream



Raja Mohanty, based on Bridget & Raymond Allchin, 1968

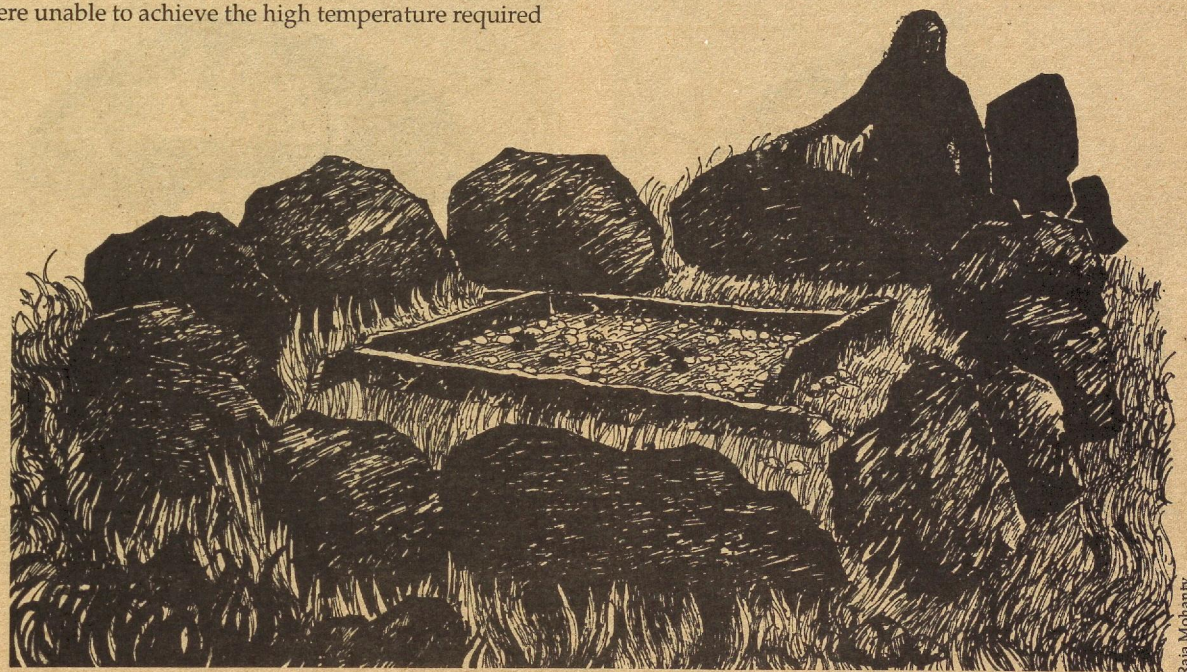
Plan and cross section of megalithic stone cist grave

I had not realised it, but at some point in time while working on these films, I had begun to stop and reflect more often. I became aware of this when I saw the remains of the megalithic cultures. What struck me particularly was those people's imagination of an afterlife.

After death, what? We are familiar with the answers that religion provides. And at the other end, we are trying to determine today, at what precise stage, life may be said to begin in the womb. We humans have travelled a long way indeed! Perhaps the search for answers to such questions began with the megalithic people.

My thoughts also touched upon another aspect of these cultures. We get a glimpse of their practical approach from their techniques of iron smelting. They were unable to achieve the high temperature required to melt iron, so they learnt to melt down the impurities at lower, more attainable temperatures instead. How simple the logic seems, but it must have taken much experimentation to arrive at this solution.

One question had puzzled me earlier. Was there no civilisation on this subcontinent between that of the Harappans and that of the Indo-Aryan speakers? It is believed that this was when the megalithic cultures, amongst others, flourished.

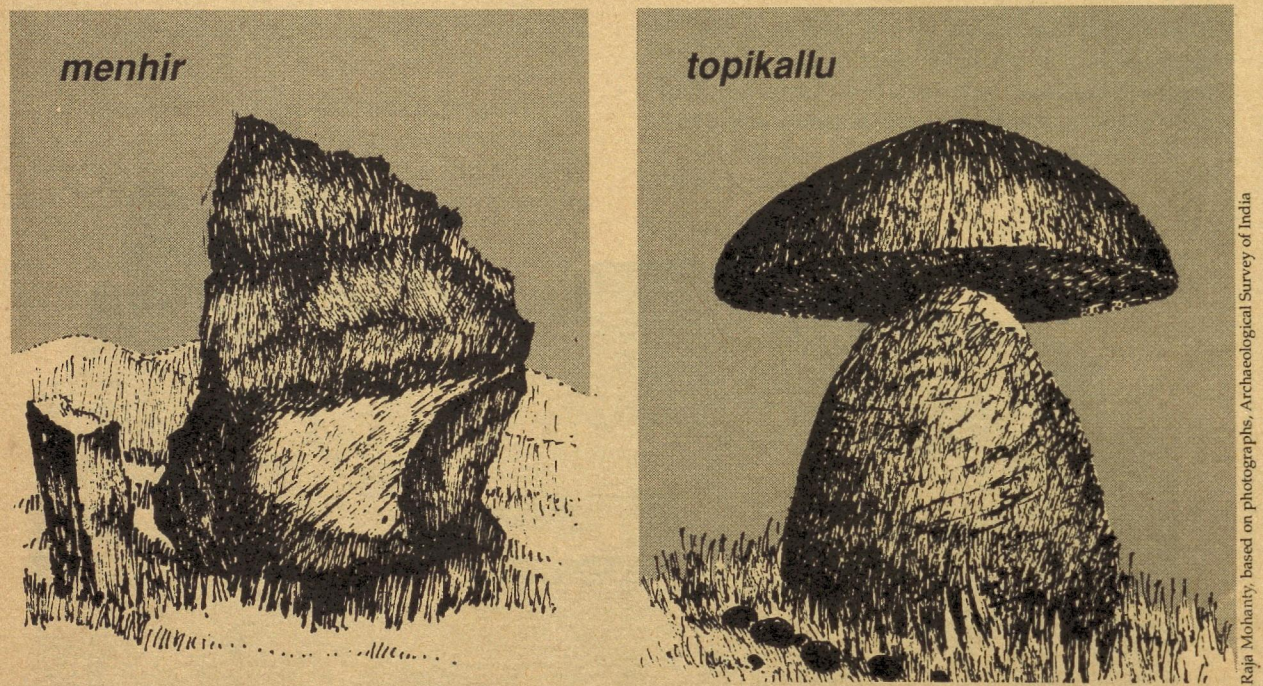


Raja Mohanty

Megaliths are found all over India, but I am speaking now of only those in the south. There are several hypotheses about them — some even say that these were cultures from other lands, that these people (like the Indo-Aryan speakers) came from elsewhere. Perhaps some people of Mediterranean origin came to the west coast around 500 BC and made their home in the vicinity of stone age settlements. Megalithic sites are mainly found in the regions where Dravidian languages are spoken, so perhaps their inhabitants were Dravidian speakers too. However, some archaeological evidence refutes the theory that these megalithic people merged with the earlier Dravidian settlers. The Indian megaliths do in some respects resemble Caucasian megaliths, but no firm conclusion can be drawn from this.

Some peninsular customs seem to derive from these old burial practices, like the burial of infants and special individuals. (In Islam and Christianity of course, all the dead are buried.) But we also come across other possible surviving stone age traditions as well. In the excavations at Inamgaon, a doll in a shoebox-sized container was found. This recalls a practice still seen in the area around Pune— after a miscarriage, it is customary to float a doll in a box down the river.

All these thoughts make me restless. It is not easy to correlate hypothesis and archaeological evidence at every step. Perhaps all I can finally say is that the Indo-Aryan speakers came here bringing with them what was special to their cultures, but when they arrived, there were already other settlements here with their own unique features. Do the megalithic cultures have any other significance? We do not know, but when we journey through the past, they awaken our curiosity. We know so little about them, we are not even sure what role they played in our history, but these very riddles provoke us to continue our search.



Raja Mohanty, based on photographs, Archaeological Survey of India

There are several types of megaliths found all over India. Among them are the **menhir**-*type megaliths which occur in many places from Kashmir to the peninsula, and the* **topikallu** *(hat stone) megaliths which are restricted to Kerala*

THE AGE OF CODIFICATION
500 B.C. to 300 A.D.

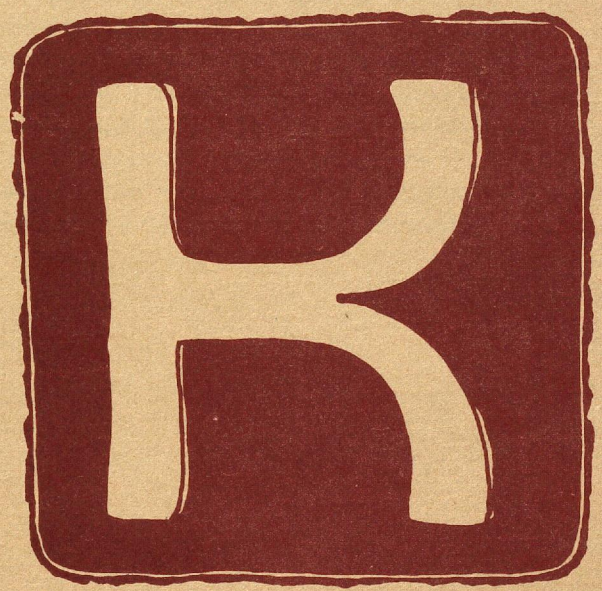
5

A visit to Sarnath and a song enaction of a Jataka story evoke the ethos of Buddhism, its teachings against oppression, and encouragement of trade.

In the melting pot of the new culture, many dialects of *Bhasha*, the early form of Sanskrit, could be heard. The grammarian Panini attempted to systematise the rules inherent in language. His work, a masterly achievement of logic, analysis and classification, is also of interest to computer scientists today. He made impressive use of the classical *sutra* style— deriving a large number of rules from brief, easily memorised formulae.

At the site of an ancient port, in Pondicherry, the trade with Rome is recalled. Cities and ports in the south developed during this period because of excellent irrigation systems. We take a look at a progression of these: the simple *etram* or water lever, the temple tank, and the Grand Anaicut on the Kaveri River.

The Saraswati Mahal Library, Thanjavur, is a storehouse of many manuscripts of works first compiled during this period, which saw an almost universal codification of social, religious, aesthetic and philosophic thought. Among these was the *Manusmriti*, which reflects the growing rigidity of the social order, and also the denial of basic rights to women and the lower castes. Two secular exceptions stand out from among the mainly religious corpus of literature. One of them is Kautilya's *Arthashastra* and the others are the ayurvedic compilations of Charaka and Sushruta, to be discussed in the next episode.





An age of codification

The period between the sixth century B.C. and the fourth century A.D. is an important one in our history of the subcontinent. It starts with the rise of the first cities in the Ganga basin and ends with the cities of the Gupta empire in the same region.

Along with the growth of these cities, many diverse currents of thought had emerged rapidly. By then, the vedic tradition had evolved into six broad philosophies. Buddhism and Jainism too, had put forth their own philosophies. Also, art and craft skills were developing into specialisations and were being systematised, and viewpoints embracing them were also evolving.

In this almost thousand-year period, we see all these thought currents emerging and taking definite and firm shape. Special systems were devised to codify these viewpoints. One especially— the *sutrapaddhati* of the vedic tradition— needs to be discussed here. A *sutra* is simply the encoding of thoughts into word-capsules or formulae which were often set to metre. The founding works of most of these philosophies have been rendered in this codified, or *sutrabaddha* form.

The sutra style of codification calls for compactness and density in expression. One gets some idea of this on reading the works of Panini or Aryabhat. The need for this compactness grew in the first instance out of the need to organise one's thoughts in the form of a theory. This drive has an obvious relation to science.

This style had many other effects. One was that the dense and compact sutra on its own was difficult to understand fully by itself. The student needed an expert intermediary— a teacher, the guru— who would simplify, give examples and explain the sutras. This, in combination with the oral tradition, further strengthened the importance of the guru.

Knowledge written down on leaves or printed on paper and the knowledge wielded by gurus are different in one basic way. The knowledge in the guru's possession can be received only by those to whom the guru wishes to give it. What portion is received, and how, also depends entirely on the guru. As we shall shortly see, the codification of knowledge into sutras increased the impact of the oral tradition.

When written down, knowledge can be accessible to anyone who can read or write. The importance of an individual guru is diminished and knowledge acquires a greater potential in the democratisation of the intellect. The sutrapaddhati by contrast, strengthened the tradition of knowledge as an area to which access was reserved for the few.

We see some difference between the vedic and the Buddhist traditions in this regard. At least in the initial stages, the Buddhist tradition gave much more importance to the sanghas,and later the universities, which even had huge manuscript collections. The vedic tradition continued to rely mainly on individual gurus and oral learning.

The emphasis on individual teachers was a limitation when it came to the dissemination of knowledge. As there was no intrinsic mechanism for pooling knowledge or for give-and-take, knowledge remained essentially an individual's accomplishment. Later, of course, the sutra style— along with the Sanskrit language— began to be adopted by the Buddhist tradition as well. The universities began to receive less sanction and support, and began to decline. The method of teaching also became more and more brahminical and elaborate. The Buddhist universities, which earlier used the *Prakrits* (languages that people spoke in their daily lives), slowly replaced them with Sanskrit. As a result of all this, the universities became increasingly alienated from society at large.

In my opinion, when this system of codification was joined to the caste system which was gaining strength, the effect in the long run was adverse. Theoretical sciences— and their medium, Sanskrit— remained in the clutches of the brahmins. The experts and the gurus were obviously brahmins, and to decipher codified knowledge, the guru was essential. In effect, codification also enhanced the power of the brahmins. This is a contradiction that we observe again and again: things which are important for the expansion of science at one level prevent the realisation of that very potential, and at another level, strengthen the existing monopolies of knowledge.

Shivasutra

अइउण् ऋऌक् एओङ् ऐऔच्

हयवरट् लण् ञमङणनम् झभञ्

घढ़धष् जबगड़दश् खफछठथचटतव्

कपय् शषसर् हल्

Panini's **Shivasutra** *which organised the* **varnamala** *(roughly the alphabet) into a unique sequence of groups. The consonant stops shown in red are end markers for the groups.*

अच्
अइउण् ऋऌक् एओङ् ऐऔच्
अ इ उ ऋ ऌ ए ओ ऐ औ

यण्
यवरट् लण्
य व र ल

अक्
अइउण् ऋऌक्
अ इ उ ऋ ऌ

इक्
इउण् ऋऌक्
इ उ ऋ ऌ

Examples of code words based on the **Shivasutra** *with their expansions into* **akshara** *(roughly letter) groups. Such words are used in Panini's rules of grammar. Note that the consonant stop markers are not included in the groups.*

इकोयणचि = **इक्** becomes **यण्** on meeting **अच्**

Ikoyanachi *— a rule or* **sutra,** *of* **sandhi** *or combination.*

Three code words based on the Shivasutra are used to denote relevant akshara groups.

इ + अ *or* (~~इ~~ उ ऋ ऌ ए ओ ऐ औ) = य् + अ *or* (~~इ~~ उ ऋ ऌ ए ओ ऐ औ)

उ + अ *or* (इ ~~उ~~ ऋ ऌ ए ओ ऐ औ) = व् + अ *or* (इ ~~उ~~ ऋ ऌ ए ओ ऐ औ)

ऋ + अ *or* (इ उ ~~ऋ~~ ऌ ए ओ ऐ औ) = र् + अ *or* (इ उ ~~ऋ~~ ऌ ए ओ ऐ औ)

ऌ + अ *or* (इ उ ऋ ~~ऌ~~ ए ओ ऐ औ) = ल् + अ *or* (इ उ ऋ ~~ऌ~~ ए ओ ऐ औ)

The transformations defined by ikoyanachi. Note that the rule does not apply to the crossed out aksharas.

अति + अन्त = अत् (~~इ~~ + अ) न्त
= अत् (य् + अ) न्त
= अत् (य) न्त
= अत्यन्त

A sandhi based on ikoyanachi.

अकःसवर्णे दीर्घः = **अक्** becomes **दीर्घ** (its own long form) on meeting **सवर्ण** (its own long or short form)

Akaha savarne dirghaha— *an exception sutra which modifies ikoyanachi.*

अ + अ *or* (आ) = आ

इ + इ *or* (ई) = ई

उ + उ *or* (ऊ) = ऊ

ऋ + ऋ *or* (ॠ) = ॠ

ऌ + ऌ *or* (ॡ) = ॡ

The transformations defined by akaha savarne dirghaha. It is because of this rule that ikoyanachi does not apply to this akshara group

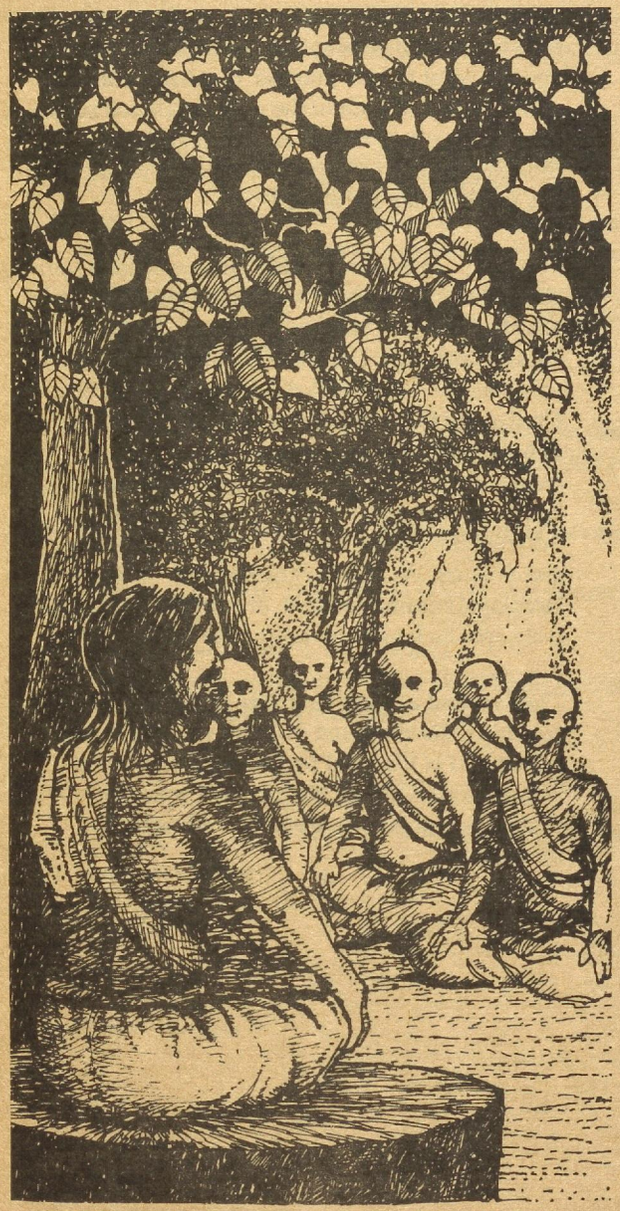
अति + इन्द्रिय = अत् (इ + इ) न्द्रिय
= अत् (ई) न्द्रिय
= अतीन्द्रिय

A sandhi based on akaha savarne dirghaha.

Sudeep Dasgupta

amrita

How the word spread



Sudeep Dasgupta

I had had an exposure to the tradition of ancient Sanskrit literature, particularly the vedas, in my university days, but my view of them had been exclusively literary then.

Once I started working on the subject of oral traditions for these films, it is as if a whole new world opened before me. I could see the texts linking up with the archaeological finds, the history, and the scientific achievements of their time. Without these contexts, how superficial my literary approach had been! These insights came out of my interaction with the experts— both in person and through their writing, as well as my colleagues.

When looking at ancient Sanskrit literature we must remember a key aspect: it was an oral tradition. The text was composed, and passed down the generations without the existence of a written record until much later. The fact of their being oral, determined the very manner in which they were composed, and their strengths and limitations. Whether it is the formidable achievements in grammar, or the limits of development in mathematics, or the idea of the magic power of *mantras*, or the monopolisation of learning by the brahmins— we find that the oral nature of these intellectual efforts shaped their very outcome.

The Indo-Aryan speakers brought their oral literature to the subcontinent with them, but they had no monopoly over the oral form. Tribal communities all over the world transmit their knowledge and ideas by this means even today. One can understand why pre-literate societies depend on oral forms. But here on the subcontinent, even centuries after writing was firmly established, we see the oral tradition continuing to act as the main medium of instruction and intellectual communication. This is especially true of those areas reserved exclusively for the brahmins.

Historians and linguists think, that by the time the compilation of the *Rigveda* was completed, society resolved to transmit this and later works down the generations in an exact word-to-word form. This decision was to have far-reaching effects. This was not merely a matter of recording knowledge in people's memories. All later learning was to show the imprint of this insistence on faithful duplication.

The requirement of exact copying also had its basis in the belief that the words of the Vedas had magical powers. This notion of *mantrashakti* was closely related to the verse form of these works.

Prose and poetry both use words, but their use is different in both. When one reads a poem one can hardly separate its subject from its words, their sound and their internal rhythms. Read prose, and its content is what one retains. One certainly also remembers what a poem was about, but inseparably from all its other aspects. That is why it is as difficult to write a good poem, as it is easy to memorise one.

The recitation of a good poem, whether in a community or in private, exerts a certain influence over its audience. The events and emotions evoked become real, and even if the the subject is familiar, it is as if the events unfold before us, in all their freshness. It is as if the word itself had a power over us, reconfirming the concept of mantrashakti.

When a poet is at work, and the poem forms in his or her mind, it is almost as if someone were reciting it to him or her from within. Who speaks the words? In today's individualistic world, it would be the poet's unconscious speeking. We accept this readily today, but in another time this may not have made sense at all. It would be natural to assert then that it was a supernatural power that spoke the words, using the poet as its medium.

This belief underlies the elevation of the Vedas to *shruti* status. If a relation had been established with the supernatural during the composition of a poem, it would be wise to maintain it by repeating the power-loaded words again and again. Exact reiteration also created its own requirements. It was not merely a matter of passing on words, but also their pronunciation, intonation, rhythm and pace, that is their performance aspect. It meant correlating the recitatives of different tribes of Indo-Aryan speakers and fusing a new tradition out of these.

Rules for pronunciation emerged, intonation was studied, the articulation of joint consonants was fixed, the exact count of complex rhythm cycles was established. Ultimately, this would lead to the study of words and sentence structures, grammar, and the creation of works like Panini's *Ashtadhyayi*.

A significant outcome of these studies is the identification of the basic unit of pronunciation: the *akshara* or the smallest pronounceable phonetic unit. The akshara is made up of a *swara* (i.e. vowel), or a combination of *vyanjanas* (i.e. consonant stops) modulated by a swara. This analysis was made long before writing came into its own in the subontinent.

The fact that all our scripts are phonetic precisely reflects this understanding. We have symbols for the basic consonant stops and the vowels, and a modulating symbol for each vowel modulating a consonant stop or a group of them. This could be done only on the basis of the understanding contained in the formulation of the akshara. Indian scripts are thus connected with their phonetic equivalents in a much more straightforward way than the scripts of languages such as English.

There was another outcome of these investigations into language, which we should not miss. This is the practice of setting up frameworks of rules and the arrangements of these into sequences. These were formulated in the sutra form to enable memorisation. To give a sense of how it was done: a simple rule would be stated first, then its exceptions would be noted , and this would finally conclude with irregular forms which would fit neither the rule nor the exceptions.

Recently, some scholars have related these traditions to the way mathematics grew on the subcontinent. Theoreticians like Euclid would search for certain basic laws or theorems which would then serve as a key to solving a range of similar problems. This was based on a confidence that there would be no exceptions to the rule. In contrast, here even the most general sutra would be expected to have an exception.

Well, whatever its effect on mathematics, the exception sutra had a very real reason for its existence in grammar. The living language of people, the *bhasha* as Sanskrit was known in Panini's time, was certainly not under the control of grammarians. It would keep changing as people used it, and they would break the rules as it suited them. The exception sutras covered just these modifications in the making, keeping up with an evolving entity.

The grammarian Patanjali has said, *'prayogsharanam vaiyakaranam'*, meaning that grammarians have to defer to what people practise. In other words grammar springs out of the way people use language, not the other way round. And he had also said, that though people go to a potter for pots, they do not go to a grammarian for words!

I began to see Sanskrit a little differently after learning about the grammarians' tradition. Panini had never heard of 'Sanskrit', to him it was just *bhasha*, the spoken language. The other variant he recognised was *chhandasi*, the metric language of the shrutis. Until about the first century A.D., *bhasha* still appears to have been a living language. Later its status changed and it was frozen, becoming an esoteric language of the brahmins, especially pandits. It deserted the people's courtyard for the royal courts and favours. What was earlier *bhasha*, the spoken language, became Sanskrit, or cultured, stamping the truly spoken languages as uncultured.

Thus we had a living language frozen into a formal construct, disconnected from the rich and living experience of life. And by that very act it became suitable for becoming the exclusive preserve of the brahmins, safeguarding and extending their monopoly.

The order and the divisons of the alphabet as we learn it today, are based on the practices of the ancient oral traditions, as is seen from the table below. Here, the division between vowels and consonants is dealt with first.

It is possible to pronounce vowels like अ आ इ completely in themselves. But consonant stops like क् ख् ग् (not क ख ग but क् ख् ग्) cannot be pronounced independently. These can be pronounced *only* in combination with a vowel or another letter.

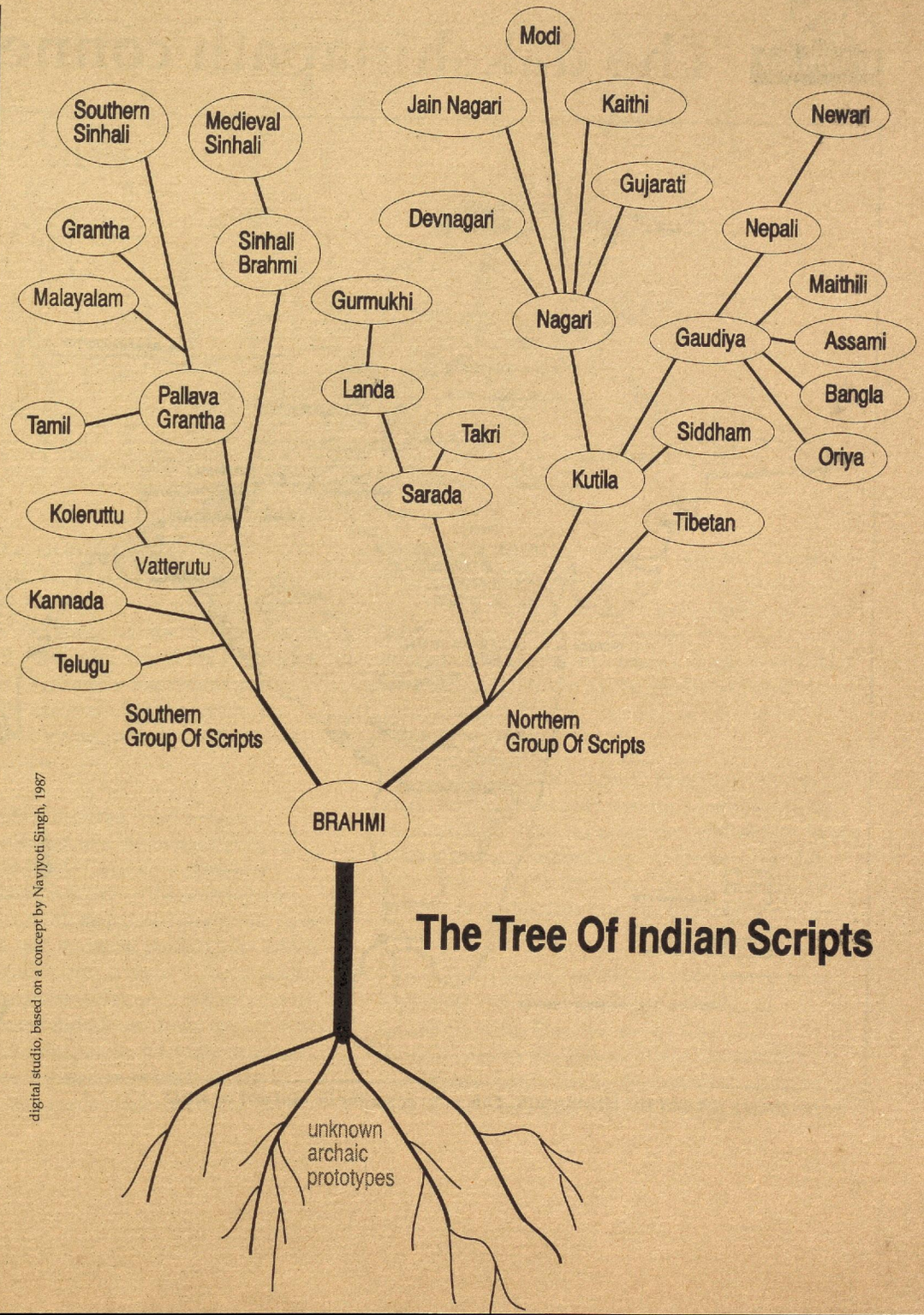
For instance, क् cannot be pronounced by itself. However क् + अ = क, or क् + ई = की, or क् + र = क्र, or प + क् = पक् can be pronounced clearly.

Vowels and consonants also have their own built–in order. This becomes clear from the classification of the 25 consonants under क, च, ट, त, प as shown in the table below.

The identity of these consonants in Indian phonetics depends upon :

- the part of the mouth involved in the pronunciation of the consonant
- whether the consonant is vibrant or not
- whether heat can be felt by placing one's hand in front of mouth when articulating the consonant

	non-vibrant		vibrant		nasal
	no heat	with heat	no heat	with heat	no heat
from the root of the tongue	क	ख	ग	घ	ङ
from the lower palate:	च	छ	ज	झ	ञ
from the upper palate	ट	ठ	ड	ढ	ण
from the roots of the teeth	त	थ	द	ध	न
from the lips	प	फ	ब	भ	म

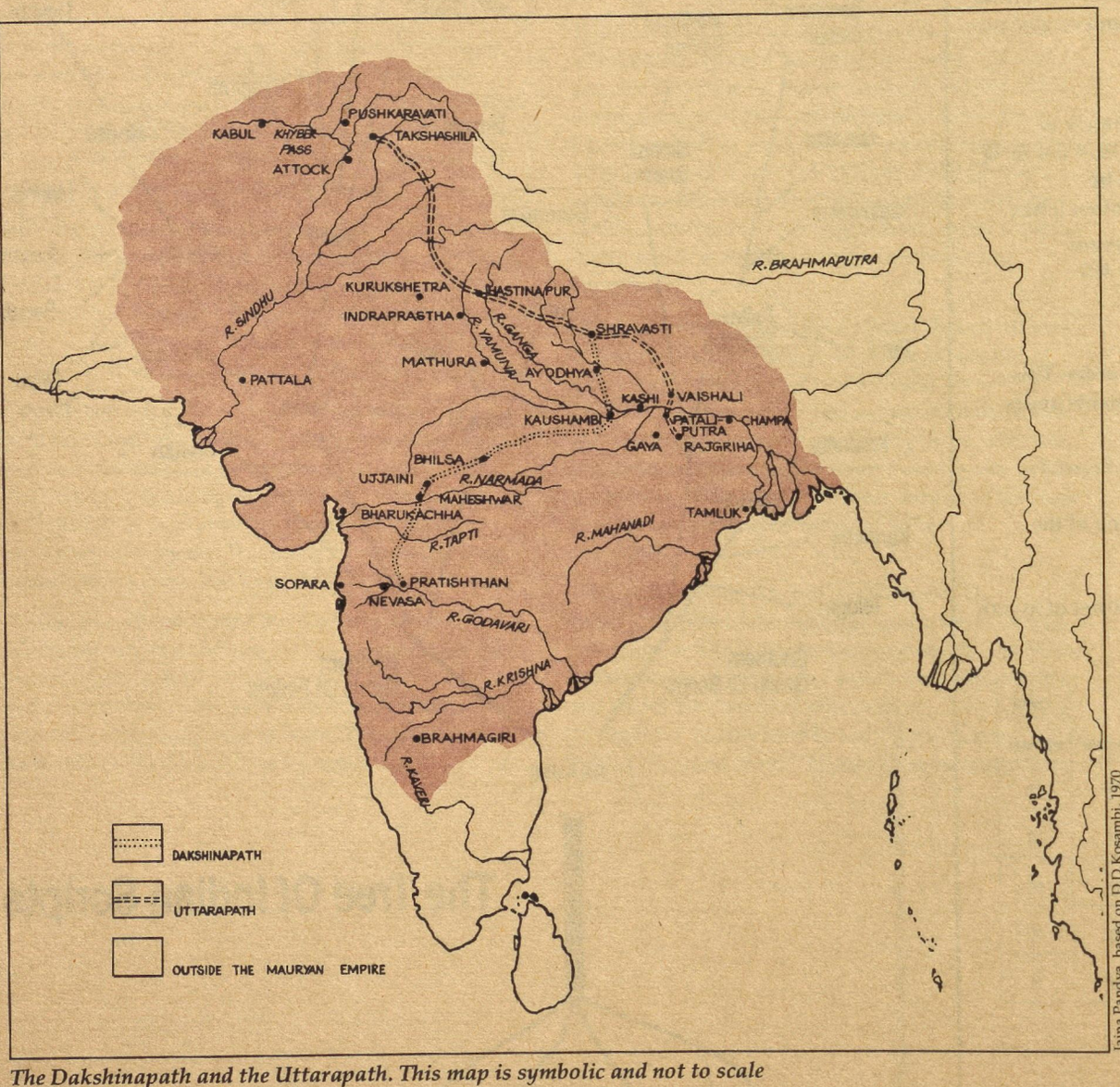


The Tree Of Indian Scripts

digital studio, based on a concept by Navjyoti Singh, 1987



The dakshinapath connection



Jaina Pandya, based on D.D. Kosambi, 1970

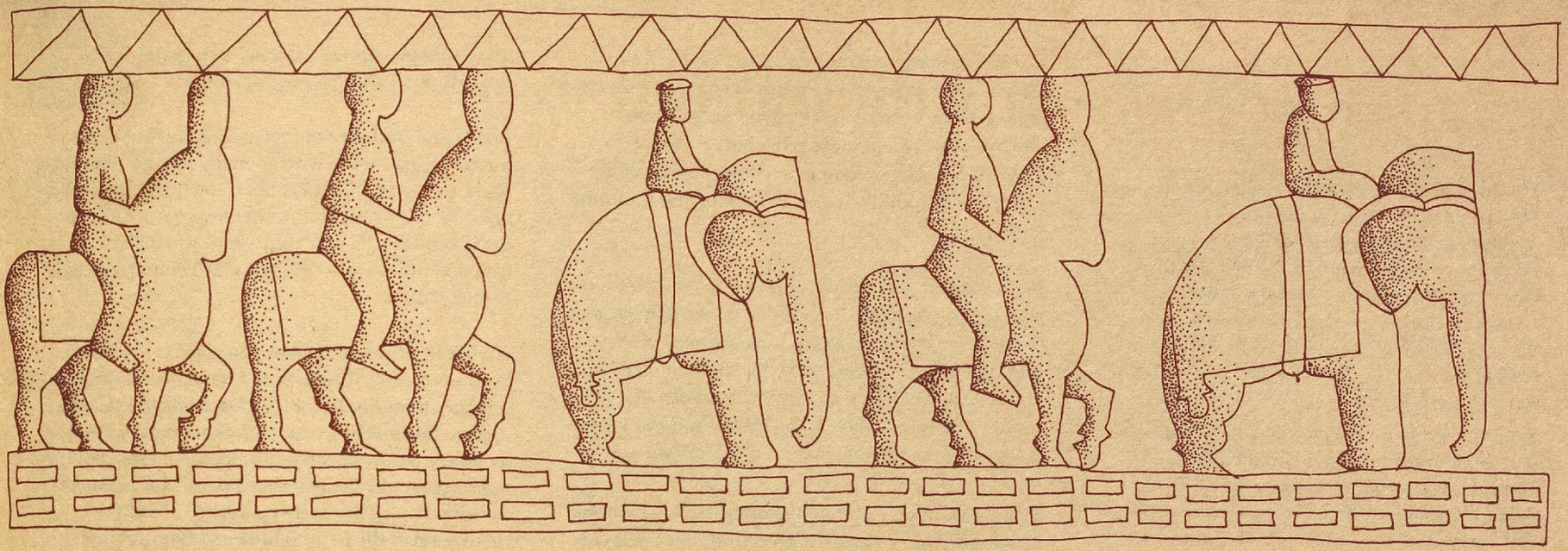
The Dakshinapath and the Uttarapath. This map is symbolic and not to scale

A friend of mine met an adivasi woman from Tamilnadu at the National Women's Conference in Calicut. To reach the conference, this woman had walked some forty kilometres through forests before she could get any vehicular transport. She belongs to a remote tribal community, which lives in houses on trees and includes reptiles in its regular diet. I was struck once again by the diversity in this country. So many varied cultures staying together, joined by a thread— the geo-political unity of the subcontinent. The same diversity that we had seen building up through the films, still thriving and strong.

What defines a nation or a country? If we even begin to answer this question seriously, we face a number of hurdles. India, we have been taught from childhood, is the land that stretches from Kashmir to Kanyakumari, *aasetuhimachal* is Bharat. Even in the Harappan period, the Himalayas were surely there, and so also Kanyakumari, but of the thread connecting them to form one 'nation', of the thread connecting 'India', we see little sign. What then, is this connecting thread? When was it formed and how?

While making the films, we took India as a geographic entity and, on its basis, we sought to trace Indianness, India's *chhap* on us. At the same time, we also searched for confirmation of those threads which bind us together. We see one such strand being formed around the sixth century B.C., and its formation is related to the Magadhan empire, to the expansion of Jain and Buddhist religions, and to a road.

After the nomadic tribes of Indo-Aryan speakers settled here, they obviously interacted with pre-existing cultures in the subcontinent. Agriculture spread, becoming the mainstay of civilisation.



Uttam Ghosh

Around the sixth century B.C., cities came up again, this time in the Ganga basin and along its tributaries. Artisans settled in the cities and industry flourished. These artisans provided the village and city dwellers with the everyday objects they required for their use. Trade grew rapidly and a flourishing trade has always necessitated the exploration of new markets and expansion into new territories, which leads to a greater interaction between different regions.

Along with the spread of trade, social structures too were evolving. Kings and kingdoms, the rulers and the ruled — new equations were being formed. The king had begun to acquire a right over the produce from the land, and power was becoming concentrated in his hands. To increase the area of their kingdoms and thereby their power, was the main occupation of these kings; to graduate from a king to an emperor their sole ambition. Wars inevitably followed. By Ashoka's time, Magadha had established its right to empire for a few centuries to come.

Society had also begun to be stratified into hierarchical groups. The brahmins, a category long established among the Indo-Aryan speakers had a high status, as did the king. And the kshatriyas — the warriors and their clans, who helped the king in his exploits — had to be granted a high status as well. There remained the artisans and the farmers, the actual producers, who were slotted in at the lowest levels of the hierarchy.

An ideology based on material wealth and its enjoyment, the evolution of a hierarchical society replacing the basis of clans, and the oppressive character of incessant warfare — the search for an alternative to all this also developed alongside. From it evolved the Jain and Buddhist philosophies which emphasised peace and ahimsa (non-violence), and questioned the hierarchy developing within society. All this was, however, initially confined to the Ganga basin and its surrounding areas. Dividing India into north and south even today, from Maharashtra to Orissa there stretches a broad belt covered with forests, and range after range of hills and mountains. This belt has always been the dwelling place of adivasis. Around the time the Ganga basin cities came up,these two parts were following their own, parallel courses of development, almost independently. But now the north, driven by the need of political conquest and of trade, extended an arm in the southern direction.

By Ashoka's time, this belt dividing the country geographically had been penetrated and a safe road built across it. This was called the *dakshinapath*. In the Jataka tales we find mention of safe travel on this route. For example, the *Suttanipat* tale of a brahmin disciple of the Buddha gives us a description of this road.

However,the dakshinapath was not simply a road. Over time it was to be an important link of communication. This link was formed and strengthened by the itinerant Buddhist and Jain monks, and was indissolubly connected with the *viharas* and *muths* they built. Along the dakshinapath

The Koshalan brahmin Bavari had left the capital, Savatthi, to go down the dakshinapath. He settled with a few young disciples at the junction of the Mula and Godavari rivers, in the territory of the Assakas (who were to be later known as the Satavahanas). There they lived by gathering wild grain and nuts from plants, and tubers or roots from the earth.

Eventually a large village came into being in the neighbourhood. Bavari gathered the surplus of this village and arranged a performance of a major Vedic yajna sacrifice. The ceremony was upset by a brahmin who turned up late, and he inflicted a curse on Bavari for not having anything more to give by the way of gifts. The anxious Bavari sent sixteen of his Brahmin acolytes north to question the Buddha, whose fame had travelled down the trade route, and who seemed to be the only person who might enable the curse to be foiled.

The pupils first went to Paithan, the terminus of the dakshinapath trade route, then presumably with some trade caravan past Aurangabad to Maheshvar on the Narmada; Ujjain, Gonaddha, Bhilsa, Koshambi, Saket, Savatthi. There they joined the uttarapath (the northern trade route) to go to Setavya, Kapilavastu, Kushinara, Pava, Bhognagar, Vaishali and then Rajgir.

There they found the Buddha at the stone chaitya outside the city, and were enlightened.

Adapted from D.D.Kosambi,1970

and its branches into the peninsular south, we find viharas and monks' settlements at almost all its nodal points. These constructions existed long before temples came up. In uniting the Indian peninsula from the Himalayan ranges to Kanyakumari in the south, the first credit goes to these Jain and Buddhist monks.

Buddhist and especially Jain philosophies, took root in many trader and artisan sections, perhaps because ahimsa was more consistent with the need of these groups and it was possible to practise it in their daily life as well. Another reason may have been that they could not improve their social status, and bring it to the level of the brahmins and the kshatriyas.

In any case, a new uniting thread began to be formed. Muths and universities developed, students started travelling. Buddhism, in particular, spread not only to the southern peninsula but all over Asia. The reason for this spread can be attributed to an openness and the readiness to live with and accept variations that both philosophies had. The same attitude was adopted by Ashoka's empire. In his edicts and inscriptions carved on rocks and pillars , there is no exaggerated self- praise, no enumeration or celebration of victories, no lists of kings vanquished and slain. Without submerging existing diversity,they appeal to ideals which could form a common bond. These inscriptions and edicts were erected all over India, from the Himalayan ranges to almost, though not quite, upto Kanyakumari.

The dakshinapath was a bridge fostering all these developments. Roads are an important link. They allow more people to communicate with each other and, in that sense, democratise communication. Roads help in assimilation of cultures, and increase the possibility of mutual give-and-take between cultures. They help widen access to the outside world, and facilitate exposure to new trends and the opportunity to learn and absorb them.

Roads and trade are not the only links. The Indian peninsula had trade with so many regions; Buddhism spread all over the world but these things alone did not give rise to a nation. Other important links are also necessary. Finally, the overall equation of power also determines what geographical boundaries will form a nation.

And, if links can unite they can also tie you down, become chains of subjection. I remember a struggle by adivasis from Maharashtra's Dhule district, who were against the building of a road. Superficially, it seems as if they were opposing development itself, but they were essentially questioning a particular notion of development. They were concerned about the disruption of the natural flora and fauna of their forests, and of their lifestyle, once the road established access to the outside world. It is important, then, that links between two cultures be on an equal footing, not on the basis that one dominate the other. Otherwise the links can turn into oppressive bonds.

The dakshinapath did not solve this problem either. Today in India we attempt to recognise diversity through states based on language. Yet, at some level, the north dominates the scene. Often in newspapers and history books, when India is spoken of, the entity meant is only its northern part. Sometimes I feel that I too am not free of this. Aren't the struggles that erupt against the declaration of Hindi as a national language also an outcome of this kind of unwarranted assumption and behaviour?

In the face of regional, religious or caste divisions, a spontaneous reaction is to ask, what is a nation? Aren't we a nation? Perhaps the question too, is wrong. A nation perhaps cannot just 'be', perhaps it is a notion that has to be created, held on to, and constantly recreated.



The sun, the moon and the extra month

As we returned from Wakeshwar, a full moon was rising. Enthralled, I asked myself whether pre-historic man had also watched it in the same way. Within a few days I was to get an unexpected and surprising answer to my question.

We had the opportunity to see a film serial made by the famous archaeologist, Richard Leakey, on the subject of human evolution. In one of the episodes he discussed a piece of bone, over twenty thousand years old, excavated from a European prehistoric site. On it was a series of marks which had initially seemed to be only decorative. Only on magnification and closer study do the markings reveal their secret.

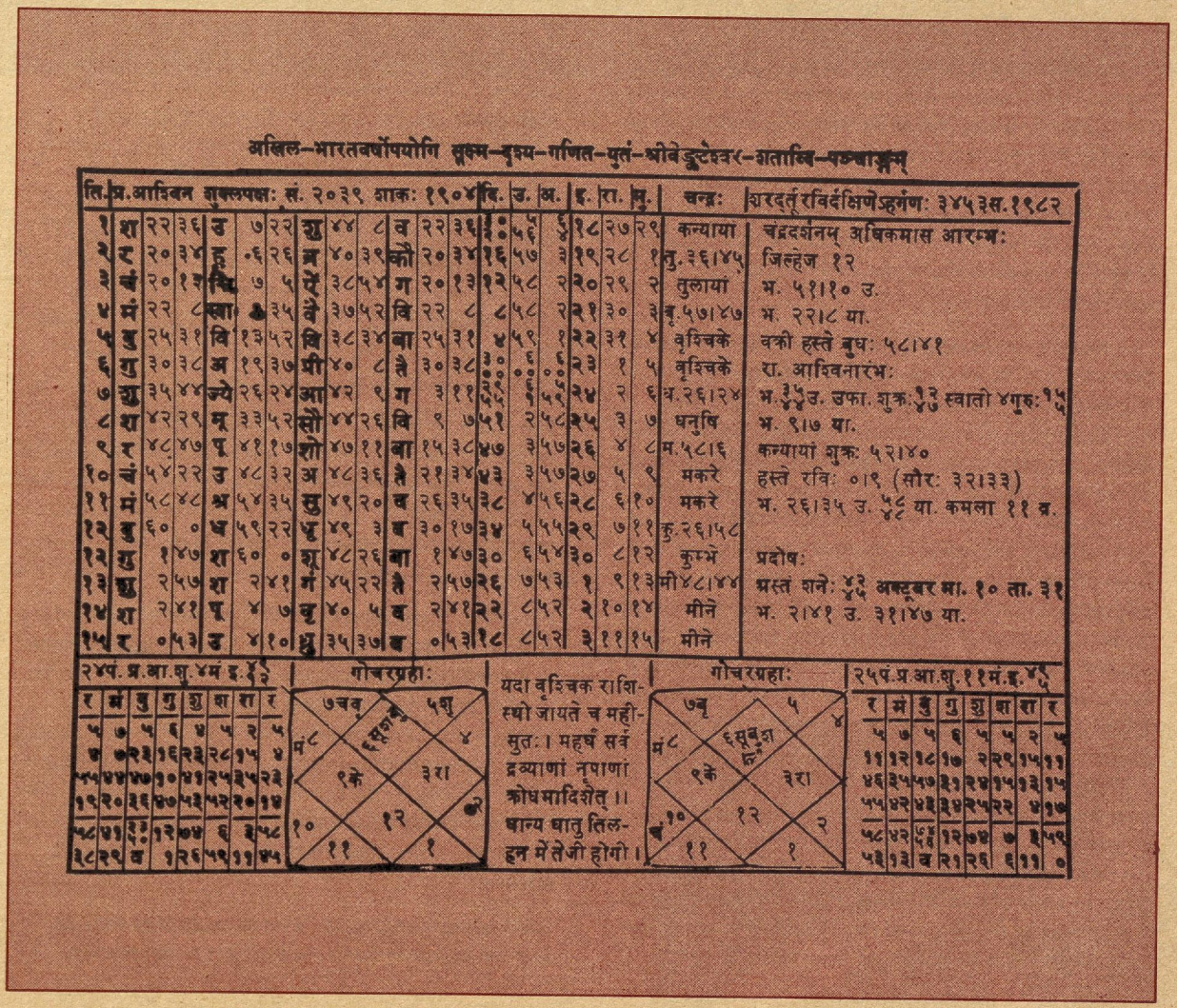
They are actually a record of the phases of the moon. Different marks had been used for the new moon, the half moon, the full moon, and so on. These symbols for the waxing and waning of the moon had formed a decorative pattern. As I watched, I said to myself, "So pre-historic man had watched the moon this way too!"

In a sense, astronomy starts with the moon— with an attempt to decipher its motion and to understand its cyclical rhythms.

Humans are a species with a deep sense of the flow of time, of events in time, and so, of history. For this they need to measure time, and the various repetitive cyclical rhythms in nature provide them with a basis.

The first and most obvious cycle of this kind is that of day and night, which together roughly match the sleeping-waking or the circadian rhythm of the human body. A longer natural rhythm is most certainly that of the moon— gradually waxing, then waning slowly after the full moon to disappear at new moon, to start waxing once again.

All over the world the natural unit greater than the day is the month, a word that is itself derived almost


अखिल-भारतवर्षोपयोगि सूक्ष्म-दृश्य-गणित-युतं-श्रीवेङ्कटेश्वर-शताब्दि-पञ्चाङ्गम्

Shri Venkateshwar Press, 1986

A page from a contemporary **panchang** *showing the* **adhik** *months of Ashwin and Phalgun. In 1982, or Vikram Samvat 2031, these were added, and half of Paush and Magh were deleted from that year's calendar. This led to controversies about festival dates: according to some, Diwali was on November 15th while others felt October 16th to be more appropriate*

everywhere from the word for the moon. In the Indian subcontinent we see textual evidence of astronomy in the *Jyotisha Vedanga*, composed around 1000 to 600 B.C. Here, the basis for the larger unit of time is based on the cyclical rhythm of the moon.

I have also come to recognise that this cycle of the moon corresponds roughly to another cyclical rhythm of the human body. Just as the sleeping-waking cycle roughly matches the day and night cycle, women's menstrual cycles roughly match the cycle of the moon. Perhaps it was a woman who, intrigued by this correspondence, tried to record on that piece of bone the phases of the moon, in an attempt to decipher its secret.

The moon's movement across the sky charts a broad, definite path. In vedic period astronomy, this path is divided into 27 *nakshatras* (at places into 28). This division seems to be common to ancient Asia. We find that around the same time, this path was divided into 27 parts called *hsui* in China. And in West Asia the Arabs called them *manazils*. Vedic period astronomy also includes a solution to another problem, this time brought up by the sun. The climate, the rains, the migration of birds and animals— all these are related to the revolution of the earth around the sun or, as the ancient view had it, of the sun around the earth. The basic unit of this cycle is the year. The problem arises when we try to match the two rhythms— of the sun and the moon. The average period of the monthly cycle of the moon is about 29.5 days, while that of the yearly cycle of the sun— as the ancients perceived it— is about 365.25 days. They do not match well. Twelve months make 354 days and 11 days are left over. In view of this difficulty, people in some places threw out the moon-based month, retaining only the solar year; and for a while, in areas like West Asia, people have just ignored the solar year (possibly because the annual solar climate cycle made little difference in the desert). Vedic period astronomy, however, tried to retain both.

This was done by periodically including an *adhik maas*, literally an extra month. Whenever the lunar calendar differed by more than 29.5 days from the solar year— that is, by more than a lunar month— a thirteenth lunar month was added to that calendar year. In other words, every three years or so, that calendar year was treated as if it contained 13 lunar months. Thus the lunar and solar calendars would again begin to roughly coincide with each other. In this way, every 100 years they would have added about 38 extra lunar months. This continues till today, though of course calendars these days are based on modern astronomical results.

The characteristic features of the astronomy of the vedic and following period were the determination of the solar year and the division of the moon's path into the 27 nakshatras. Of course there were other currents of astronomical thought— like Jain astronomy, a unique system in itself.

However, from around 600 B.C. to the second century A.D., we do not find any major changes taking place in astronomy in the subcontinent. This period can be likened to the period when a sown field soaks up water, which seeps into its every pore; the seeds begin to germinate, micro-organisms flourish, and yet for a while nothing is obvious to the eye. In this period the field was being irrigated with new questions, new problems— an irrigation that is very important for science.

After understanding the overall motion of the sun and the moon, it was now the turn of the planets. Understanding their motion was an altogether different kind of problem. They looked like stars, but unlike them, did not remain fixed in their proper positions in the sky. They roamed about, it seemed, as they fancied. In the literature we find occasional mention of planets and of astronomers devoting themselves to the study of the motion of particular planets.

We get a foretaste of what was to bring about a change in astronomy from the trade of that period. Trade is, of course, a matter of the exchange of goods and money, but here we are also concerned with another trade— the exchange of ideas. Throughout this period marked by the dominance of Buddhism and Jainism, we find an openness to new things in society. This continued for a while, even as these philosophies became less influential. Then the openness slowly declined. Trade too, especially that carried on abroad by Indian merchants, decreased.

The exchange of ideas, however, differs in important ways from the exchange of goods and money. Ideas, when they do travel, travel much faster and much further. And, once absorbed, they prove more durable too.

Two Greek ideas were travelling and being absorbed during this period, both of which were to show their influence, for better or worse, in their impact on astronomy in the Indian subcontinent. One was the foretelling of the future from the positions of stars and planets which was to change the very meaning of Jyotisha from astronomy to astrology. The second was the concept of the epicycle which was transformed and assimilated by Aryabhat in his own way. Later this thoroughly changed the calculation of planetary positions in the subcontinent. But these were things still to come.

AYURVEDA & ASTRONOMY
300 A.D. to 700 A.D.

6

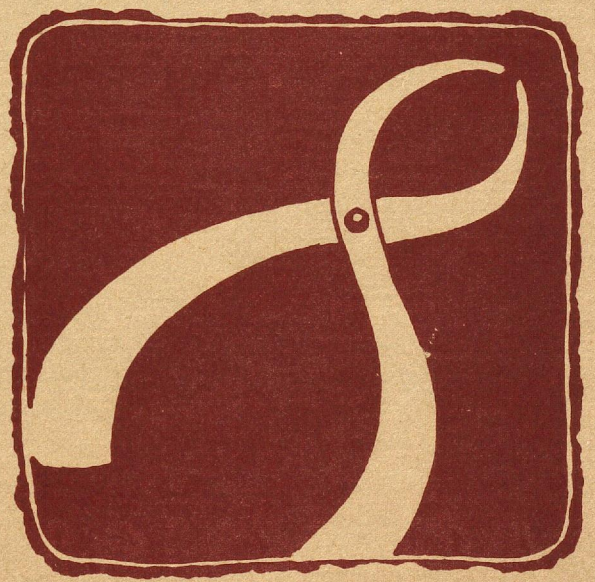
A fable about Jivaka the physician and a discussion with an ayurvedic doctor introduce us to the basic principles of ayurveda. A visit to the ayurvedic university in Jamnagar helps us realise how the Charaka and Sushruta texts are remarkable not only for their pharmacopoeia and surgical knowledge, but also for their empirical-rational basis, scientific method and materialist outlook. No wonder this science was suppressed by an increasingly orthodox society in later times.

Urbanism had already reached its zenith in the Kushana cities of the early centuries A.D. We admire the red sandstone sculptures in the Mathura Museum and visit the Kushana site of Sonkh. We also explore the remains of an immense 2500 year-old complex of tanks — used to capture, filter and store drinking water from the monsoon floods — at Shringaverpur near Allahabad.

The growing debate between idealism and materialism, with the commonsensical Lokayat intervening, is dramatically recreated at the old university site of Nalanda. The Chinese traveller Yuan Chwang came here and the astronomer Aryabhat may have taught here.

Aryabhat's achievements are impressive: his hypothesis of the earth's rotation and the calculation of its period; the value of pi; and his sound explanation of eclipses as a phenomenon of shadows. Mathematics is seen as an essential component of astronomy.

Aryabhat is wholly rational, but it was an age of increasing orthodoxy and superstition in which he was an exception. The works of his successors have more to do with astrology than with astronomy.



The 'golden age'

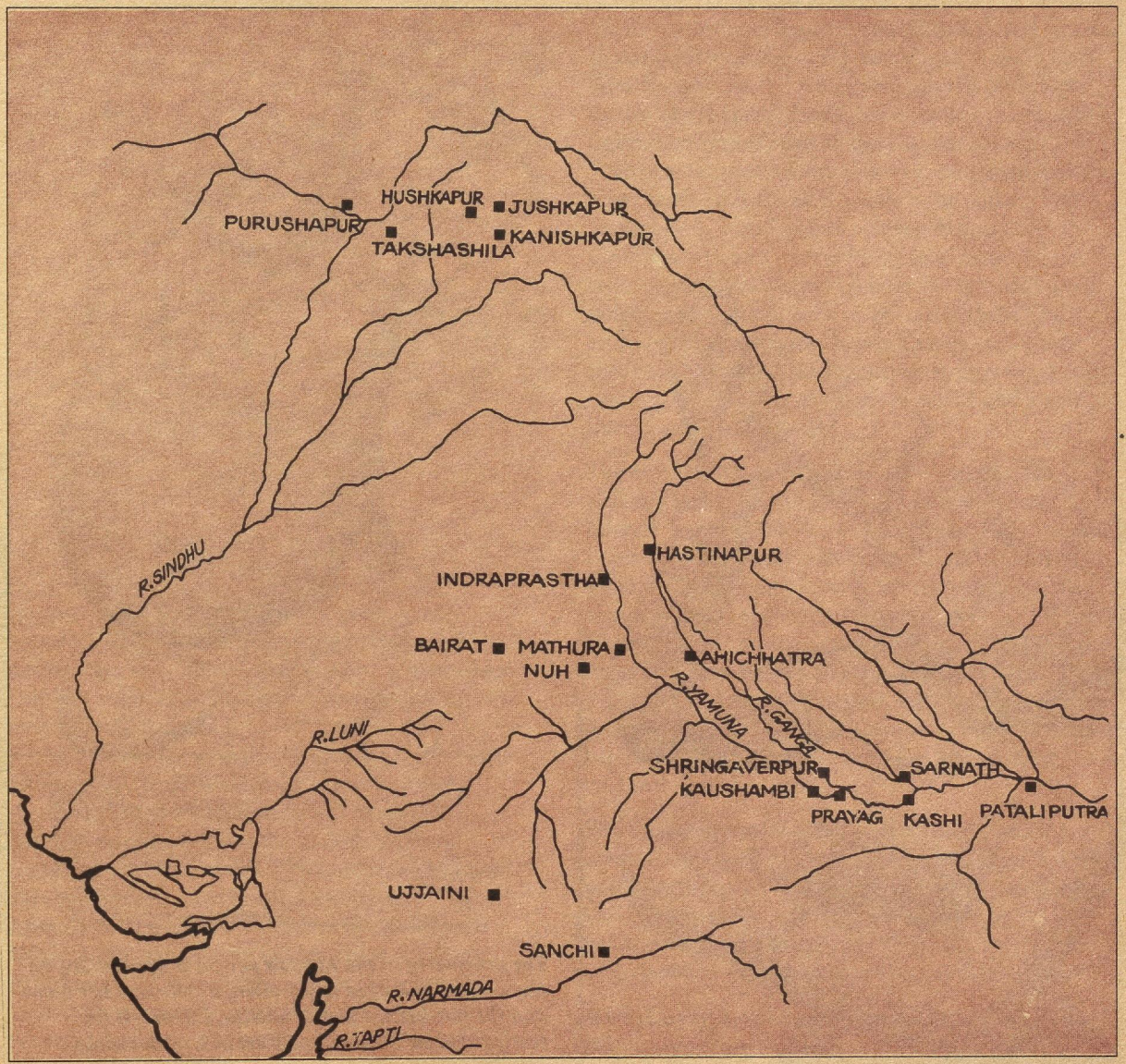
In my school history textbook, the period from the fourth to sixth centuries, used to be called "the golden age of the Guptas". What makes a golden age? I would like to explore the special features which mark this period.

By this time, all over the peninsula, the first common context of cultural identity had been established by the Buddhist and Jain monks travelling along the dakshinapath and other trade routes, spreading their faiths. However, these religions could not strike roots extensively in all the social layers of the subcontinent.

By the Gupta period we see the beginning of the social transformation of the village— from a structure based mainly on vedic traditions and rites, to one based on a polyglot caste structure. Broadly, we can call this the formative period of the Hindu religion as well. The caste system bound various groups together through the obligations it imposed, and formed the village into a relatively autonomous unit embracing all social layers. The expansion of the Gupta empire in some ways also reflects the expansion of this new emerging system and its search for roots and social sanction.

The other important feature of the Gupta empire, in contrast to the earlier Mauryan empire, is that the local lords and kings and village chiefs were not subordinate to the larger empire; they maintained a certain degree of autonomy. In short, imperial power was not as centralised; under the rubric of a single empire, other power spheres were provided.

One can see this empire as a federal structure that rested on an emerging village-based social system. This federal structure gave the north a period of some stability, but it did not extend into the south to any significant degree. Significantly, the impact of these two features travels down history, well beyond the Gupta period. Thus, the expansion of the Gupta empire reflects the formation and spread of a new social system all over the peninsula.



Jaina Pandya, based on Kameshwar Prasad, 1984

Important Kushan centres in India. This map is symbolic and not to scale



Uttam Ghosh, based on Sanghol sculpture, National Museum, New Delhi



Uttam Ghosh, based on Mathura sculpture, National Museum, New Delhi

The prosperity of the Kushan period is symbolised by the woman bedecked in jewellery as she sips her wine, and the pot-bellied god of wealth, Kubera. Both testify also to the sculptor's art in Kushan times

However, when we turn to those 'golden' features for which the Gupta age is famed — the prosperity of the people, the flourishing literature, art and sculpture, — I am left somewhat puzzled. Because I see all this happening, and reaching considerable heights, even in the earlier Kushan empire (first to fourth centuries). The archaeological evidence is certainly much stronger for the Kushan cities. It is also during the Kushan period that we have well-struck uniform gold coins coming into currency, and these have been found to reach as far as Rome, indicating a much more extensive trade.

These developments continued into the Gupta period. The rule of the relatively autonomous Gupta feudatories in their own right was also considerable. And we find that these developments continued in many places well beyond the Gupta period. Why, then, is the Gupta period singled out as a golden age? For any period to be marked out in this way from its historical context, there has to be a reason. The speculation is that the Kushans were left out because they were pagans, later converts to Buddhism. Though their empire extended right upto Kashi and they had been here for centuries, the Kushans were still considered *mlechhas*, unclean foreigners because of their origins beyond the Northwestern mountain passes (others with a similar address, the so-called Aryans, did not, of course, have to suffer this disability). The Guptas, by contrast were self-proclaimed protectors of brahmins and cows and worshippers of Shiva and Vishnu.

The awarding of such titles thus has little to do with history and more to do with the prejudices of the present. There are other such examples — Renaissance Europe, seeing its origins in ancient Greece, labelled it a golden age.

Today when I see the revivalism raging around us, I am disturbed at how such unwitting prejudices may affect our perceptions. Instead of busying ourselves in colouring the past with terms like 'golden age' or 'bloody era', we ought to take a hint from D.D. Kosambi's remark that "the golden age, if any, exists in the future, and not in the past."

The many streams of philosophy

While on the subject of science and technology, it is important to talk about philosophy. For example, you may have heard about 'Eastern science' which is often praised by present-day philosophers of science. This is based mainly on the Chinese philosophy, which sees everything as made up of the interplay of two opposite principles — the *yin* and the *yang*. When we are talking about science in the Indian subcontinent, it is fitting that we should explore what was happening in Indian philosophy. In the film, we have been able to convey the essence of some of the many differing philosophies of nature and life in the subcontinent, but I thought we should discuss it some more here.

So far as science is concerned, the philosophy of living is important because it is capable of influencing the direction science takes. As an example, we shall have a glimpse later of how a particular philosophical outlook determined the progress of astronomy, the questions it took up, as well as the ways in which it found answers to them.

Philosophy is a general perspective on life, usually a complex system of interconnected ideas. In the film we dramatised a debate between three philosophies. Presenting such complicated concepts in a simple way was something of a challenge for us. We confined ourselves to relevant essential principles. Of the three, two — the *mayavadi* and the *bhautikvadi* — are not names by which any philosophy in the subcontinent is known. They only represent two broad trends. The third— *lokayat*— was actually known by this name, and it has been applied to a philosophy that is quite different from the other two. Lokayat, however, does not come down to us in any authorised or written composition of that school.

Before we could begin, we had to study the general trends in Indian philosophy and we were quite



Sudeep Dasgupta

impressed by its richness. It is interesting that Vedanta, which is often presumed to be *the* Indian philosophy, was but one among many philosophies that had emerged in the subcontinent by the sixth century A.D. Vedanta is actually part of the *shad-darshan* or six schools of philosophy — Nyaya, Vaisheshika, Yoga, Sankhya, Mimamsa (strictly speaking, Purva-mimamsa) and Vedanta (or Uttar-mimamsa). Besides these, there were the Buddhist, the Jain and the Ajivika schools; nihilistic currents like those of Purana Kassapa or Ajita Keshkambali; and the distinctively different Lokayat. We are not even talking about the many branches and sub-branches of these that existed. Vedanta became really important later, only after it acquired a proponent like Shankara around the turn of the millennium.

We have classified these diverse philosophical schools in three different ways, in order to gain an overview. First, the idealist and materialist schools of thought. I would like to clarify that these words have a special technical meaning here. In the popular sense, 'idealism' means an attitude which considers ideals as important and material pursuits as secondary, while 'materialism' stands for its reverse. In short, an idealist is seen as a person living in a dream world, refusing practical reality, whereas the materialist is a vulgar pursuer of riches and power. In the stricter, philosophical sense, idealism is a school of thought that treats ideas and consciousness as important and primary, while materialism gives nature and material objects a similar status.

The second classification has to do with how the philosophies concerned relate to monopolies of interest inscribed into the social structure. On the one hand, are the schools of thought that uphold these monopolies, and on the other are those that do not accept them. In respect of the evolving hierarchy in Hinduism, this means drawing a distinction between those who supported and sought to extend the hierarchy, and those who rejected it. The former group believed in the *shrutis* and the *smritis*, and have been termed *aastik* by tradition; the latter did not, and tradition calls them *nastik*.

The third classification is that of the theist and atheist schools of thought: those that believed in god, and in god being all-powerful, and those that opposed this view. Today the word nastik has come to be synonymous with atheist, but in the strict philosophical sense they are not equivalent terms.

If we classify the philosophies in this way, we find that many of the popularly accepted beliefs about Indian tradition are without basis. Take for example the view that most of the ancient philosophies in the

subcontinent were idealist, and by extension, non-worldly in outlook. We find that Vedanta is the only major philosophical school that was a truly idealist school. All the other schools accepted the reality of the external world; they did not treat the world as illusory (*maya*), and each school is quite explicit about this.

In this sense, both Nyaya and Vaisheshika were materialist schools of thought. Nyaya specialised in the analysis of logical forms and categories, and Vaisheshika had an atomist viewpoint about nature. Their thinking was clearer and more accessible than Vedanta. Both also gave consciousness an independent status.

Sankhya and Yoga were also materialist in this sense. Both treated *prakriti* or nature as *pradhan* or primary, and accepted its independent existence and importance. At the same time, both incorporated consciousness as a separate principle. Yoga was concerned with knowing and controlling one's body. Many scholars connect these two philosophies with the concepts of ayurveda, and of Lokayat too. However, both philosophies could be said to have had a large component of magical beliefs.

The Buddhist and Jain philosophical schools gave central importance to incessant change and causality. At the same time, especially in Buddhism, there was a streak of nihilism that was also to become the basis of its later assimilation and transformation.

Among all these, Lokayat stands out for its thorough-going materialist viewpoint. According to Lokayat, even consciousness arises out of the balance of physical elements. All processes and events are caused by the *sva-bhav* or the self-nature of physical principles or phenomena; in other words by their properties.

I feel that this way of looking at consciousness was an important and distinctive element of Lokayat. I think that is why, after the eleventh century or so, when Vedanta began to become the dominant philosophy and the materialist element in all other philosophies began to decline, Lokayat appears to have stood its ground.

On the basis of the second type of classification, we see that out of the Buddhist and Jain schools and Lokayat, none accepted the hierarchies of the vedic tradition, at least as far as the status of men versus men was concerned. (Women had been given a more-or-less subordinate status by all the schools). Nor did they accept the brahminical monopoly over learning.

In this respect the shad-darshan fall into one group. Each one, in some way, accepted the authority and traditions of the vedas. Those that were materialist later had to face internal contradictions because of this. Once the vedic tradition had been accepted, they also had to slowly accept all that flowed from the logical extension of its principles. We see the consequences of this clearly in the Nyaya and Vaisheshika schools.

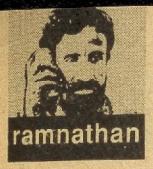
Another example of these compulsions can be seen with respect to theism. In the beginning, except for Vedanta, none of the schools accepted an all-powerful personal god. In fact the heaviest castigation of theism comes from a severely aastik school — Vedanta's twin — the Purva- mimamsa. The Purva-mimamsaks treated only the Vedas as valid, not the upanishads which came later, and which are essential to the Vedanta (hence Ved*anta*, that which comes at the end of the Vedas). They treated the *chhandas* of the Vedas strictly as *mantras*, phonetic strings whose verbal meaning, in the strictest sense, was secondary. By contrast, Vedanta based itself on the authority of the Vedas as well as of the Upanishads, and believed that the Vedas could only be interpreted on the basis of the Upanishads. That is why Vedanta is called Uttar(later)-mimamsa and Mimamsa is called Purva(early)-mimamsa.

Even the Buddhist and Jain philosophies did not believe in a personal, all-powerful god. Buddha's much quoted remark sums up their attitude: "I do not know what lies beyond the river, all I am concerned with is crossing it."

This brings me to Lokayat, whose name itself is connected with the non-acceptance of god. It is called Lokayat because it believes only in the *lok* (this world) and not in the *parlok* (the world beyond). It does not admit to any force from outside of this world.

What does one gather from this bird's eye view? On the one side we find Vedanta — idealist, aastik, and upholding the belief in god. On the other side stands Lokayat — materialist, nastik and atheist. And in between stand all the other schools, which were originally materialist and atheist in the main. In time, as the caste system took hold in society and the feudal systems based on it evolved, the other schools were slowly drawn towards idealism and theism. Present-day versions of the different currents of Indian philosophy all incorporate these effects of Vedanta in one way or the other. Because of this, it is widely believed that the ancient philosophies of the subcontinent have always been opposed to science and this-worldliness, that they have always been idealistic and have upheld the caste system, and have been inseparable from spiritualism and theism.

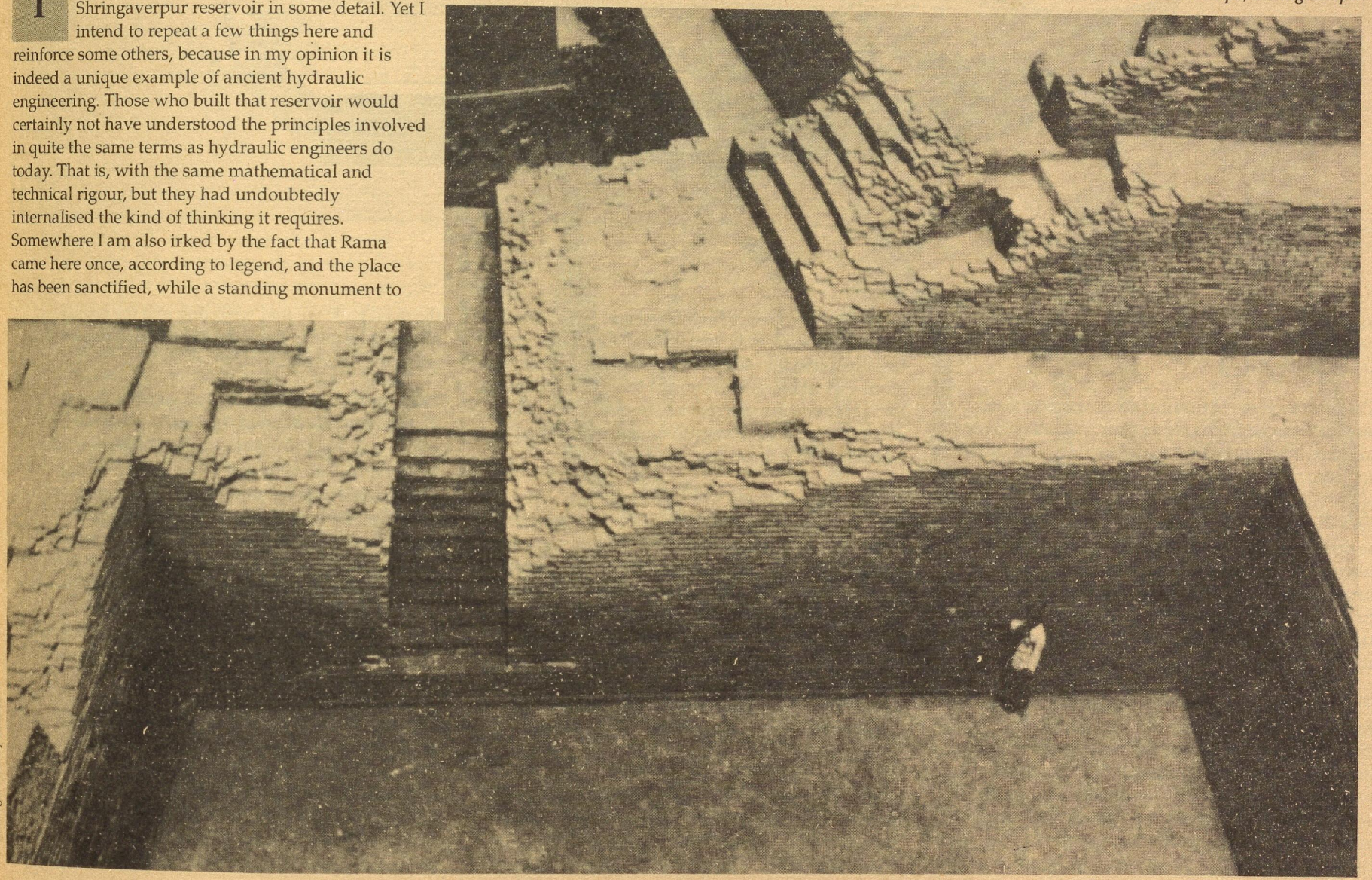
And when, during British rule, we needed to rediscover our self-respect, this fallacious viewpoint was eagerly accepted and became the final word on the subject.This other-worldliness presumably set us apart as a special people, and also explained our colonial condition. We need to put aside these tinted spectacles of the present. If we look afresh at the philosophies in the subcontinent we shall find that our ancient tradition is not just one of spiritualism, but of science too. That not only theism, but atheism too, is as ancient an Indian tradition as any other; as is the nastik tradition and the refusal to acknowledge caste. And this is why we have made separate and special mention of Lokayat, for it is the clearest expression of this alternative tradition.



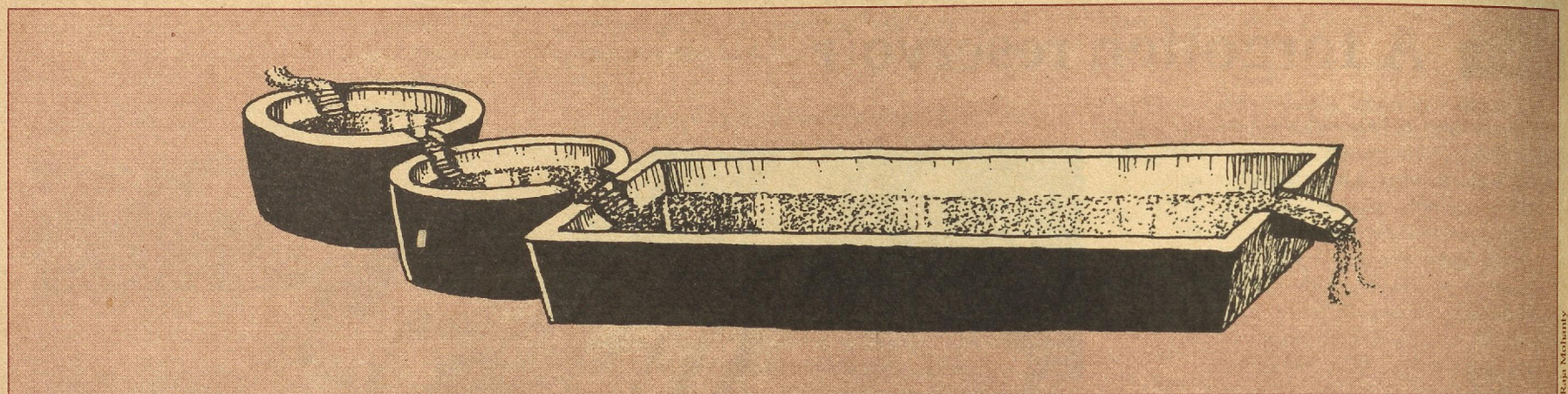
A forgotten reservoir

In the film we have described the Shringaverpur reservoir in some detail. Yet I intend to repeat a few things here and reinforce some others, because in my opinion it is indeed a unique example of ancient hydraulic engineering. Those who built that reservoir would certainly not have understood the principles involved in quite the same terms as hydraulic engineers do today. That is, with the same mathematical and technical rigour, but they had undoubtedly internalised the kind of thinking it requires. Somewhere I am also irked by the fact that Rama came here once, according to legend, and the place has been sanctified, while a standing monument to

Tank and steps, Shringaverpur



Archaeological Survey of India



Raja Mohanty

Schematic view of Shringaverpur reservoir system

human effort — into which the thinking, knowledge and labour of so many people must have gone — stands neglected.

The most impressive feature of this reservoir is its size. Its main tank is as big as three football fields put together. To have realised the ambition of designing something that could meet the water needs of an entire city is, by itself, impressive. To utilise the river's back-flow up a *nallah* during the monsoon floods and to drain it in the required direction without disturbing the river's course or endangering the town, was another piece of technical ingenuity. And finally to achieve the settling of sediment in a series of tanks in order to get clean drinking water the year round — that crowns it all.

The underlying principles are mainly those of hydraulics. If such a body of water were to keep flowing during the floods, the current itself would be enough to carry the sediment along with it; there would be no question of the sediment settling. The settling was made possible by systematically and progressively breaking the water velocity as it flowed through the system of interconnected tanks that formed the reservoir system. The tanks were so built that when the water flowed through the first two tanks and into the third one, it passed through curved channels that broke its force, and then it flowed into the bigger tanks over a series of steps that formed what we would call energy dissipation structures, which slowed it down further.

However, the thinking which went into the construction did not end there. In profile the bigger tanks have a narrow base and a wider top; also, they are constricted where the water entered and broader towards the exit; and instead of continuous walls in the final largest tank, there were gradually wider sections. Each section had an outward inclination, since calculated to be roughly between 11 and 13 degrees. The result was that as the water flowed through the system and its level rose, it slowed down considerably, giving enough time for the sediment to settle.

Finally, the fact that the system depended entirely on flood water meant there could be shortages in certain years. Thought seems to have been given to such problems too, and provisions made. In the middle of the main tank, we find wells dug into the tank floor, allowing people to draw the stored groundwater when the reservoir ran dry.

The supply of drinking water must have been the main aim of this reservoir system. The final tank had steps going right to the bottom, so that there would be access to clean drinking water as the level fell. There are also indications that the tank may have been used for religious purposes, because many terracotta figurines of gods and goddesses were found on its floor during the excavation. Just as the human-made objects found at Burzahom were a clue to identifying it as a neolithic site, the date of the reservoir is estimated on the basis of these figurines. The combined evidence puts the date approximately at the beginning of the Christian era.

The site was excavated because of its legendary association with the god Rama, who is supposed to have spent some time here during his exile. The excavations, however, told us something else. They told us of human skills and human capabilities — and of a monument to them — which history seems to prefer to forget.

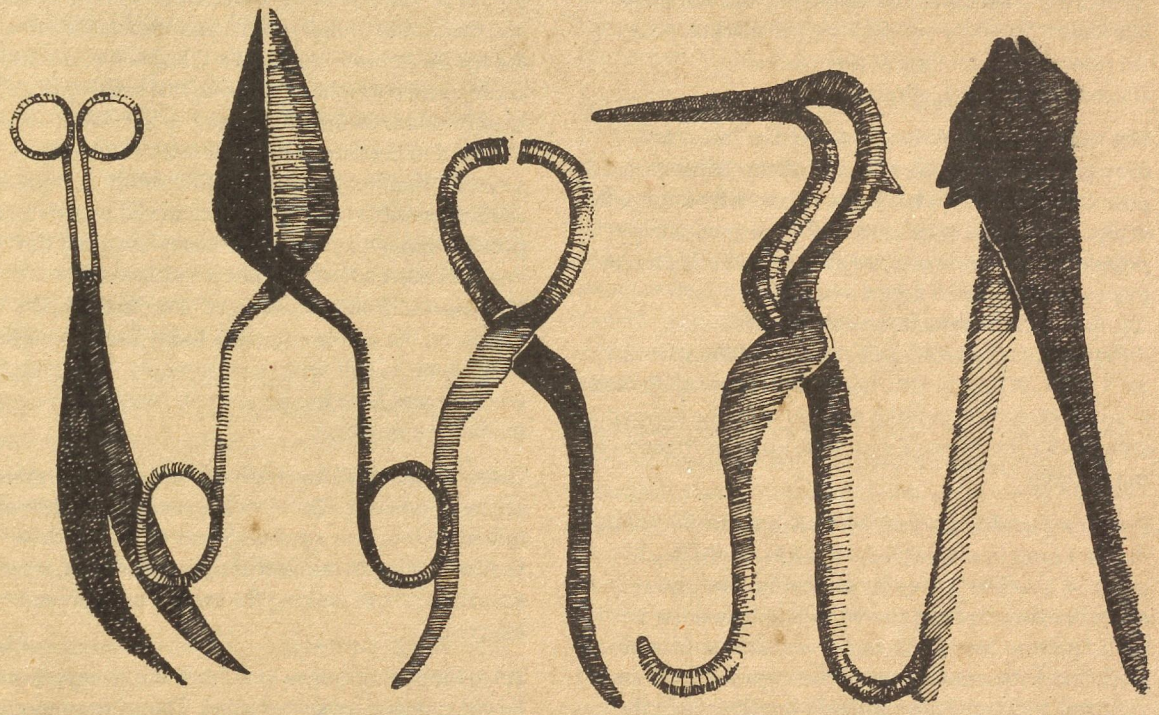


Ayurveda in the present

As I came to know more and more about the *Charaka Samhita*, the *Sushruta Samhita* and the herbal medicine practised by the Bastar adivasis, one thing perplexed me. It was an advertisement for a capsule called 'Select' — an ayurvedic medicine supposedly to be used to select the sex of a fetus. It may be taken after conception and can, it is claimed, select for a male child. A companion product, 'Select Plus', selects for a female child. It goes without saying that hardly anyone would feel the need to take 'Select Plus' in our "highly developed" society. Allopathy, of course, already offers a technique to test the amniotic fluid— a technique that is used openly and widely by people to determine the sex and then abort female fetuses.

To me, finding such ayurvedic products was quite surprising. Reading about ayurveda, I had a strong impression that it is mainly an extensive codification of knowledge accumulated by people through their experience. Was even this collectively-emerging knowledge influenced by the need to discover such techniques of prenatal sex selection? Why is a need felt to develop a medicine to select a male child? Is today's society responsible for this? Or is it the system of medicine — a system based on a market economy and market-oriented social structure? Is it that if ayurvedic medicines are to survive, they must include all those medicines which are 'needed' by the market and society?

And how are the actual needs themselves addressed? We may not be able to guarantee a full and wholesome meal for all; but yes, we can provide them with health tonics. We may not control pollution and we may not want to change our lifestyle; but yes, we can always provide a syrup for the cough that may develop. Women's status in this society may be definitely subordinate and we may not even talk of



Raja Mohanty, based on models in Birla Industrial & Technological Museum, Calcutta

Surgical instruments described in the **Sushruta Samhita**

changing it; but yes, we can provide medicines and conduct research on techniques which prevent the birth of a girl-child. And ayurveda has not lagged behind in all this. Market forces have determined its course too. So it has come about that we have 'ayurvedic' medicines and cosmetics and remedies like Select, all easily available on the market. And we are now used to looking at them as benign alternatives to harsh allopathy.

The medical system existing today has its own drawbacks: it is partial, and side effects of treatments pose a big problem. That is the reason why ayurvedic drugs, seen as harmless, are becoming increasingly popular. After reading more about ayurveda and its theory, one begins to doubt whether two such different health systems, based on such totally different perspectives, can be seen as alternatives to each other. Where health, body and life are all looked at so differently, providing medicines in the allopathic style under the name of ayurveda appears to me to be misleading.

Preparing medicines from herbs is but one part of the medical system of ayurveda. Such knowledge of plants is also being used by allopathy. Simply to extract chemicals from plants for medicinal use is nothing more than replacing an artificial source of medicine with a natural one. The outcome of all such practices is that the accumulated knowledge of the centuries is captured by the multinationals, who after all, have a keener sense of the market. All the basic manuscripts, even the plants, are being taken over by them, so that much of the information about ayurvedic medicines has disappeared from the public domain today.

It is to an extent natural that ayurveda should be so used, given the fact that marketable products are more important than production methods today. Ayurveda, properly speaking, is not just medicine, but an entire health care system. Medicines are only part of it. The other important aspects of the system are: the nature of individuals and their environment, the health care services, and a wholesome, carefully chosen and controlled diet — in this sense, a distinct kind of relationship with nature. Is it possible for such a system to become part of our lives and lifestyles? Is a system that treats persons and individual traits as central, possible in today's mechanised world? Is it possible today to change our lifestyles to suit the needs of our bodies? It is not possible to do so because the choice is no longer in an individual's hands. So the whole emphasis today is on changing individuals to suit their environments. Changing the environment is no longer even an issue in day-to-day medicine any longer.

Given all this, making ayurveda effective as a system seems impossible. The system evolved in a different milieu, and unless we change our milieu, with a radical change in our attitudes to life as well, it seems absurd to talk of making the system of ayurveda effective.

An analogy that comes to mind is the woman from Bastar carrying a plastic basket. Things from modern society — whether plastic bags, watches, or transistor sets — are available in tribal areas. These things have become available in the name of development, disregarding the tribals' own perspective on life. In the same way, based on the knowledge of ayurveda, we may extract chemicals from plants, use them in a patently allopathic manner and still think that we are practising ayurvedic medicine. For me, it remains a mismatch.

Besides all this, there is another thing that keeps surfacing. That is our complacent attitude about so many ancient things. For example, saying that our ancestors (this of course includes only those who came before the thirteenth century!) were so developed, had such comprehensive knowledge, that they could easily have won contests against the modern health care system. This type of claim is heard ever so often: the birth of test tube babies in Mahabharat times, or perhaps of modern deep surgery being performed by Sushruta, and so on.

I think there is something definitely wrong here, because the texts indicate that Sushruta's surgery was confined to the peripheral rather than the vital tissues. Deep surgery on vital organs may have been tried but had certainly not become replicable. But why look so far? Take the present-day example of the 'Select' capsule. How is a change of sex possible after conception? If ayurveda claims to have truly developed such a technique, this needs to be explored and evaluated. It is essential, in fact, to evaluate all the knowledge in ayurveda with the help of modern techniques. The system does have a potential that is worth examining. But to adopt it unconditionally as a system — a system that could not develop beyond a certain point because of its own limitations — and while doing so to proclaim it as the highest pinnacle of medical knowledge, shows nothing but the narrowness of our own perspective.



Aryabhat: putting Rahu-Ketu in the shade

The fifth to the seventh century was a period when astronomy in the Indian subcontinent was undergoing a sea-change. Change on this scale is always exciting but also full of contradictions. We have already seen something of it in the film but I cannot resist dwelling on it again, because the matter seems important to me.

The *Aryabhatiya* of Aryabhat (born 476 A.D.) is the work that attracts me most. His other work, the *Aryabhat-sidhhanta*, is also famous but not extant. We know parts of it from later commentaries and cited references. The Aryabhatiya is his only complete work that we have today.

One of the Aryabhatiya's special characteristics is its compactness. This book that set astronomy on a new path in the Indian subcontinent has only 121 couplets. Most of the compactness is due to the sutra style, one example of which we have already seen in Panini's *Ashtadhyayi*. For the Indian subcontinent, in some ways the Aryabhatiya has in astronomy the same place as the Ashtadhyayi in grammar.

The first thirteen couplets of the Aryabhatiya are known as the *dashgitika*. Leaving aside the opening and closing couplets which contain invocations, and another couplet which includes a sine table, the remaining couplets give all the parameters necessary for calendrical calculations.

The first couplet describes a unique phonetic notation system for numbers. Just as we combine a numeral with a place value to denote different values, we have here a system in which the consonants define a simple numeral value and a vowel the place value; and because in Indian phonetics an *akshara* is made of a combination of consonant and vowel, an akshara becomes capable of representing a value. In short, we have here a parallel phonetic numeral and notation system.

The couplets that follow give the values (in this compact phonetic notation) of the parameters that form the basis of all calendrical calculations. These include the number of revolutions in a *yuga* for the different planets; the different units of time and their interconversions; the orbits of the different planets; their linear diameters; inclinations of the orbits from the ecliptic; and the different epicycles and their parameters. All this in just nine couplets! This degree of compaction is made possible in the first instance by the sutra style, but much more so by this unique system of phonetic representation of numbers described in the first couplet.

The rest of the couplets are treated together as a separate work that follows the learning and the recitation of the dashgitika. It is often called the *Aryashtashata*, and is itself divided into three sections: the first treats the necessary mathematics; the second is concerned with time, its measurement and related processes; the third and last describes the celestial sphere.

Aryabhat makes no mention whatsoever of *Rahu* and *Ketu* in this work , nor are they considered when eclipses are analysed. I find this as important as his determination of the value of π or his belief in the rotation of the earth, because it is striking in the face of the received wisdom of the *smritis* and tradition. Even when Aryabhat's conclusions do agree with the smritis, or more accurately, do not contradict them, at no point does he try to invoke their authority in support of his results.

In that sense, the smritis, for Aryabhat, are not the basis of truth and its demonstration. His responsibility is to observe celestial events and make sense out of observed events, and he does not flinch from this task even when it goes against received wisdom. In fact he takes this method so much for granted that even when his, or anyone else's, results do contradict received wisdom, he hardly ever goes out of his way to mention this or to make it a focus of discussion.

Another characteristic of the Aryabhatiya is intimately connected with this attitude. As Ranjan has mentioned elsewhere, the term *jyotisha* has today come to stand for astrology, not astronomy. In the Aryabhatiya we find little astrology; it is, quite remarkably, a purely astronomical work. Remarkable because for the astronomers who follow him, including the famous Varahamihira (died 587 AD) and Brahmagupta (around 628 AD), astronomy and astrology go hand in hand.

Brahmagupta is another extremely interesting figure of those times. He has a love-hate relationship with Aryabhat that is quite illuminating. He wrote his first work, the *Brahma Sphuta Sidhhanta*, at the age of thirty. In this work he criticises Aryabhat heavily, almost totally dismissing his work. On some of the astronomical and mathematical points his criticism is quite justified. What is not justified is his method, a far cry from Aryabhat's. The arguments are too complicated to discuss here in any detail, but one's basic disappointment is to often find that his final reason for rejecting or accepting many hypotheses is simply this — that it is, or is not, in conformity with the smritis.

Towards the end of his life, at the age of 66, Brahmagupta composed his other famous work, the *Khanda-Khadyaka*. He comes across as much more mature here; he also recognises the importance of Aryabhat's work. In fact, he calls the first portion of his work essentially a summarised recapitulation of Aryabhat's work. He goes on to say that as the observed planetary positions no longer correspond well with the positions worked out by Aryabhat's

Underlying the compactness of the Aryabhatiya is a unique phonetic number notation system. It is not too difficult to understand. In the Indian subcontinent, the unit of produced sound is the akshara, which is formed by a combination of vowels and consonants. What Aryabhat did was to give the consonants a numerical value and the vowels a place value each — and that was all.

The values of the varga consonants

क्	ख्	ग्	घ्	ङ्
1	2	3	4	5
च्	छ्	ज्	झ्	ञ्
6	7	8	9	10
ट्	ठ्	ड्	ढ्	ण्
11	12	13	14	15
त्	थ्	द्	ध्	न्
16	17	18	19	20
प्	फ्	ब्	भ्	म्
21	22	23	24	25

The values of the a-varga consonants

य्	र्	ल्	व्
30	40	50	60
श्	ष्	स्	ह्
70	80	90	100

The place values of the vowels

–	ऌ	–	ॠ	–	उ	–	इ	-	अ
–	ॡ	–	ॠ	–	ऊ	–	ई	-	आ
0	0	0	0	0	0	0	0	0	0

hundreds of millions | millions | tens of thousands | hundreds | units

When you encounter a 'word' that denotes a value, all you have to do is to add the values represented by each akshara (that is, the sum of the values denoted by the consonants in that akshara multiplied by the place value of the vowel that modulates them), and you have the value the 'word' represents.

For example, one of the sutras gives the number of rotations of the earth as— **ङि शि बु णॡ ष्खृ**

It may be seen that this means—

ङि	शि	बु	णॡ	ष्खृ
(ङ्+इ)	+ (श्+इ)	+ (ब्+उ)	+ (ण्+ऌ)	+ (ष+ख) + (ॠ)
= 5×10^2	+ 70×10^2	+ 23×10^4	+ 15×10^8	+ $(80+2)\times10^6$

= 1, 58, 22, 37, 500

If we had represented the same value as it is normally done, namely as (in English), one billion five hundred eighty two million two hundred thirty seven thousand five hundred, it would have contained as many as 34 aksharas by Indian phonetic reckoning.

By contrast, **ङि शि बु णॡ ष्खृ** using only 6 aksharas, is extremely compact. The need for this compactness arises out of the oral tradition. There has to be as little as possible to be learnt by heart.

Of course, for us it is difficult to even begin to pronounce something like **ङि शि बु णॡ ष्खृ** leave alone learning it by heart. But then, the first lesson of the oral tradition was to be able to learn and recite sounds phonetically, quite independently of their meanings.

For the same reason, the relevance of this phonetic number notation system remains confined to the oral tradition.

method, he is suggesting modifications. A long distance indeed from his younger self!

My curiosity was aroused — what prompted this change and what does it show? Nissim tends to believe that when Brahmagupta wrote at the age of thirty, he did not have a very deep understading of astronomy. Even if he did not, I think his *method* of argument remains to be explained. As I see it, it has to do with the social milieu then. After all, as Ranjan points out, scientists and science are both part of society too. This changeover from Aryabhat's approach to Brahmagupta's, gives us, I think, a sense of the change that was taking place in the social milieu . A milieu in which ritual was becoming more important, ongoing practices were becoming hard traditions, and the infallibility granted to received wisdom was becoming an obstacle to science. Aryabhat, too, composed his first work at a very young age, and yet his work is free of such dogma. By Brahmagupta's time, orthodoxy had to be struggled against and a way around it gradually found.

Aryabhat and Brahmagupta were not only astronomers but mathematicians as well. Except for isolated exceptions, all mathematicians in the subcontinent were invariably astronomers. The last in this series of great astronomer-mathematicians was Bhaskaracharya the second, in the eleventh century, no less in stature than Aryabhat.

What was the consequence of this close correspondence between astronomy and mathematics? Did it serve as an engine of development or as a brake on it? That is a different story, one that I will have to take up later.

MATHEMATICS & TEMPLE ARCHITECTURE
700 to 1200

7

This is an age of cultural and scientific exchange, in which the Arabs play a major role. The learning of India, China and the Arabic world is brought closer together, and this learning later travels to Europe.

In this period, a strange paradox is noted. India is ahead of many regions in several scientific and technological respects; but we see that almost invariably an impasse is reached here, while elsewhere these accomplishments became the basis of something new. Thus the mathematics of our earlier astronomers and of the mathmetician Bhaskara reaches a dead end, its threads to be taken up centuries later in Europe. Alchemy arises in India, China and West Asia out of a quest for immortality and gold, but it is in Europe that it gives birth to modern chemistry. The social reasons for this phenomenon are examined.

The subcontinent makes a significant contribution to the world with the zero and the place value notation system using the ten numerals (0 through 9).

The sophisticated technology of zinc distillation is explored. At Hindustan Zinc Ltd. in Zawar, and at the MS University in Baroda, the technical aspects and social consequences of zinc-making are recreated.

Metallurgy reaches artistic heights in the superb Chola bronzes. The image in worship links up with the growth of Hindu temples. At a number of temple sites we trace the features of trabeate architecture and see how, once the essential forms ceased to develop, architecture became more and more decorative. Another impasse.

However, the winds of change are imminent: new forms of architecture, new scientific ideas, new mechanisms, are on their way from West and Central Asia.





Is it already the medieval period?

This seventh episode of the serial covers a long period, stretching from the seventh to the twelfth century. In our opinion, it is the first phase of the medieval period in India. I deliberately say 'in our opinion' because we had a discussion and an argument about this. The argument took place because I had not realised that the English historian Mill had shaped my thinking even though I had never read his work.

When we began our discussions about this episode, Nissim, Maitreyi and Shehnaaz spoke of it as the medieval period in the subcontinent.

I found myself thinking that temple architecture, Sanskrit, *rasashastra* and the developments in mathematics somehow did not fit well into the medieval period. They seemed to belong to the ancient period. I also vaguely recollected that the medieval period was supposed to start somewhere around the thirteenth century. Amrita too had the same problem. So we stopped Nissim and aired our doubts.

I still remember how all conversation ceased for a moment and I felt I had said something off-key. Nissim, Maitreyi and Shehnaaz exchanged knowing looks, and Nissim smiled and said, "I have been waiting for someone to raise this question."

Irritated, I said, "If you expected us to have these doubts, why did you not explain the matter right in the beginning?"

Nissim kept smiling and replied, "Because I wanted you to raise it and I wanted to ask you a simple question — why? That is, why does the medieval period start from the thirteenth century?"

Thoroughly irritated by now, I said, "So now I have to sit for a history exam all over again!"

"No, no," Nissim replied, "Believe me, I am not making fun of you. Well, I'll tell you what I think about it too. But do look into your own mind before you accept what I say." And that was how I came to realise how Mill had influenced me.

Mill had divided the history of the Indian subcontinent into three periods — the Hindu, the Muslim and the Modern periods. After independence the boundaries of these periods have not really changed, only the names have — we now call them the ancient, the medieval and the modern periods. What was making me uneasy was that in temples, rasashastra and the developments in mathematics I could hardly find anything explicitly Islamic — how could it be the medieval period then?

The point is that all classification needs a criterion. For Mill the criterion is clear — it is religion. But if we do not believe that this is a relevant criterion, what is the other alternative that we offer? There is an ambiguity here, even an absence, in respect of such a criterion. In such a situation, the effective criterion that operates implicitly, and that makes matters more serious, is still that of religion. After all, the time boundaries coincide. So even if we try to move away from a religious periodisation by using the terms ancient, medieval and modern, we nevertheless indirectly accept the religious periodisation.

If we look at the rest of the world and try to see what constitutes a basis for the medieval period, I think it is quite clear — the fall of the centralised Roman empire and its replacement by a localised, feudal state and society. With this criterion in mind, I believe that the medieval period should be taken to start if not with the Gupta empire then definitely from its decline. Not all historians would agree with this, and, apart from Nissim, none of us is a historian. Yet, we find the matter important — important enough to put it before you for consideration.

Loyalty to the feudal lord on earth — *swamibhakti*, and loyalty to the lord of the other world — *bhakti*, are both aspects of this feudal viewpoint. Both establish themselves during this period. Wars and battles also change their character at this time. Wars between clans and tribes decline; those between local lords based on the multiclass, multicaste village system or *grama-vyavastha* — become much more important. The consolidation of Hinduism based on the caste system, and its final legitimisation through the far-flung *muths* established by Shankara also belong to this same period. For many such reasons the medieval period should, in our opinion, start from about the sixth century.

There are other reasons for rejecting Mill's division. If we accept it, and uncritically at that, we club all the different sections who came here (rulers, their families, servants, warriors, merchants) for different purposes (to plunder and return, to trade, to settle and rule, to earn their livelihood) from widely differing regions and traditions (Turks, Turanis, Iranis, Afghans, Mongols) into a single category — a homogenous mass of Muslims.

In fact, by the time the first of these many people came, society in the subcontinent had already split into vertical and horizontal sections with the top feudal layers jostling each other for dominance. The coming of the so-called Muslims added to these layers without essentially changing the nature of the ongoing conflict.

Clubbing them together also presents the conflict of that period, not as the struggle between the various feudal layers among themselves, but as a conflict of Hindus versus Muslims. Once this happens, we end up with all those popular (and some purportedly

serious) histories in which Muslims fighting for their 'Hindu' lords are seen as loyal, while Hindus fighting for their 'Muslim' lords are seen as traitors — or vice versa, depending on the 'historian's' religious affiliation. The fundamentalists of any variety are unanimous in wanting us to look at history in exactly this way.

That this drawing of lines on the basis of religion does not work, is amply borne out by events like the Iran-Iraq war which took place despite a common reverence for Mecca, Medina and the Kaaba. There is in our subcontinent another peculiarly local belief that calls attention to itself in this respect — the belief that religious allegiance to places outside the nation is contrary to patriotism. This belief is extremely widespread, and I think it is related to a lack of a certain experience in the history of the subcontinent.

I am reminded here of a scholar and philosopher who had said that individuals owe allegiance to three kinds of country: their *janmabhoomi* — the land of their birth or more exactly, the land where they grow up; their *karmabhoomi* — the land where they spend their working life; and their *dharmabhoomi* — the land to which their religious faith is linked.

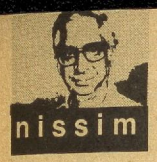
He also added that the people of this subcontinent do not realise their great fortune and their culture's exceptional nature in this respect. For the majority, the three lands have been identical. Most of the world's people, however, are less happily situated. Even if their janmabhoomi and karmabhoomi are the same, for many their dharmabhoomi has been different . In fact, all three may be different for much of the substantial itinerant population of the world — the Jewish people, the Palestinians, even the non-resident Indians. To live thus, experiencing the pulls between these three allegiances, seems to be fairly common outside India.

I recognise the tolerance of Hinduism. But I have come to think that the lack of these three sepearte allegiances is quite important in shaping our identity in the modern period. In fact here, one all-embracing three-fold allegiance is routinely but implicitly demanded of everyone. No one seems to realise that this unexpressed bias translates itself into expectations that people in most countries would find impossible to fulfil. We urgently need to realise how exceptional the coincidence of these three bhoomis is . If we do not, I am afraid the 'tolerance' on which we pride ourselves will turn into a prison, bound by its own limitations.

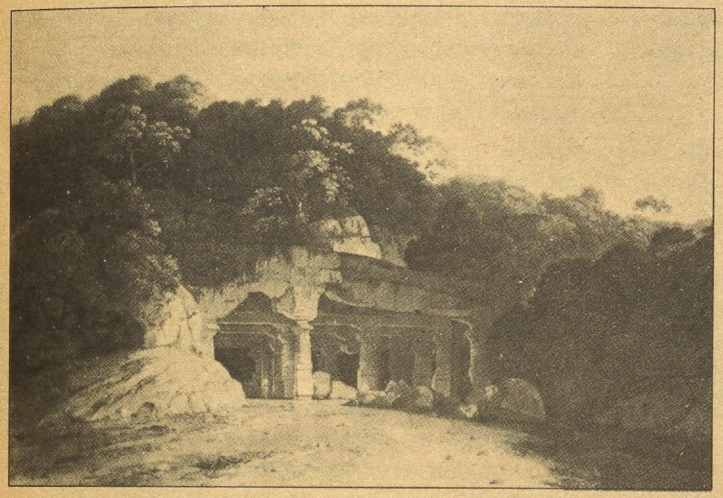
Bhakti was often an extreme form of loyalty — to the Lord as well as the feudal lord. In south Indian bhakti literature, the legend is that, one day, Kannappan, a tribal, noticed that the eye of the Shivalinga he worshipped was bleeding, and he plucked out his own eye and offered it to the Lord. In this Chola bronze, Kannappan is depicted holding the plucked eyeball in the palm of his hand



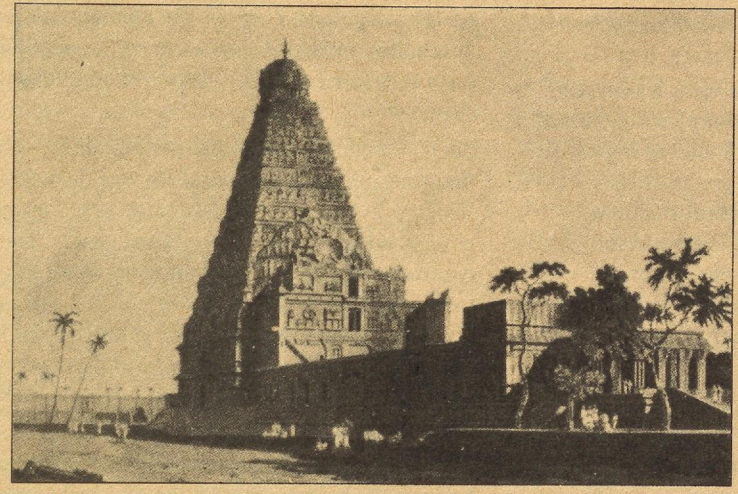
Thomas & William Daniel, 1799



Bhakti: the emerging alternative



Thomas & William Daniel, 1799



As temples moved from mountain caves into the midst of human settlements, the distance between humans and their gods increased: more boundary walls, more rituals, more intermediaries

As religion struck deeper roots in society, the relationship of human beings with nature also underwent a change. Magical chants invoking the forces of nature began to give way to faith in an all-powerful god, and to appeasement through elaborate rituals and offerings. At the same time, a new kind of social structure emerged, with a similar basis, investing an earthly lord with power over life . Today we tend to see the individual as the focus of the relationship between god and human beings, and we strive to restrict religion to an individual's private life. But in the course of its evolution, religion has been an integral part of society's structures.

Religion is also a concept, an idea. In this sense, as far as the Hindu religion is considered, the individual does not occupy a central place. In this respect, Hinduism also differs from other religions like Christianity, Islam, Buddhism and Jainism. All give definite models of behaviour to their *individual* followers. And these guidelines are often found in holy scriptures like the *Kuran* and the *Bible*.

By contrast, the Hindu religion has no such *universal* code of conduct that applies to all Hindu individuals. Dr. Ambedkar had always maintained that there was no clear precept as to what the duties and responsibilities of a Hindu person should be. Maybe at best, one hears an ambiguous exhortation like, "do your duty without any expectation of returns", which still leaves the 'duty' crucially undefined. In fact, declaring oneself to be a Hindu, in itself is not enough. One has to further specify one's *varna, jati, gotra,* for one's duties and obligations to begin to be defined.

This aspect is important, especially in talking of *bhakti*. Bhakti was a sect, a thought, an attitude and a reform movement too. In the Hindu religion, outside the bhakti sect, the only way of establishing a relationship with god was, and still is, through a mediator— the brahmin. Ordinary people, especially those from the lower castes, were prohibited any direct contact with god.

It is certain that even by the late Vedic period, the right to perform rites and rituals had begun to be concentrated in the hands of the brahmins. But what should be the relationship with this supernatural power and what would be the best place for its enaction? With this question begins a chain of events that finally leads us to the construction of what we today recognise as temples. If we look at religion as a relationship between humans and god, and at

temples as houses of god, then we see a clear connection. Perhaps it is because of this present-day perspective on things, that we see in the cave paintings at Bhimbaitka or in some Harappan artefacts, an effort at establishing a relationship with god.

From Buddhist stupas and caves, to temples carved out of sheer rock, to free-standing temples built stone upon stone — it is a long road that leads us to present day temples. At every step in this long process, religion became more and more institutionalised. Temples were always symbols of this power and institutionalisation and with time, their hold gradually became more consolidated. In the same process, the distance between human beings and god kept on increasing.

In the cave, it was probably possible to build a direct individual relationship with god. From there we finally reach a stage where a cave-like *garbha-griha*, an outer room, another outer room, a *parikrama-path*, and a host of mediating brahmin priests and pandits, all stand between the individual and the object of worship. In our efforts to house god amidst us, we had managed to move him further away, to a point where the relationship was now totally controlled by institutionalised religion.

It is interesting to note that this institutionalisation was strongest in the south, although the south was the last to be absorbed into the Vedic tradition. But then resistance to this growing distance, in the form of the bhakti movement, also began from here. For centuries it reverberated among the rural and urban people, from the southern Nayanars and Alwars, right up to the time of Kabir and Nanak in the north.

After the institutionalisation of religion, the bhakti movement is the first time that ordinary people could build a direct relationship with god. Within its ambit it was no longer necessary that a Hindu man of a specific caste and varna be the mediator. Regardless of religion, caste or varna, and gender, anyone could form this bond of bhakti, bonds of emotional closeness to god.

Such close bonds needed a medium of expression. At that time, all religious literature was in Sanskrit, no longer a living, people's language as in Panini's period, when it was simply called *bhasha*. The common people did not even have those linguistic tools with which they could establish a dialogue with god and express their religious emotions. So they had no direct contact with god, nor did they have the rights or the means to establish this contact. What then, could serve as this instrument?

The regional languages evolving from the Prakrits became the instrument. All the regional languages have been influenced by this wave of the bhakti movement and all of them in turn strengthened and enriched the movement. Trapped in the courtly circle of brahmins and kings, Sanskrit could only become more ornate. But in the bhakti movement, without any great adornment, the ease, simplicity and the power with which the regional languages gave expression to bhakti, emphasised and highlighted the inner beauty of the simple, living regional languages.

When bhakti accepted people's spoken dialects and languages, there was an inevitable transformation in its content. Forms such as the *doha, choupai, abhanga* provided a platform where individuals developed their personalities. They expressed their relationship to god in an amazing variety of ways. They addressed god as friend, as mother, as a naughty child, as a lover — and gave an intense personal expression to their feeling of closeness, a feeling that is a distinctive character of the bhakti movement. A sense of belonging, a bond of affection joined god and devotee. It allowed conversation with god on topics related to this life, its sorrows, and its philosophies.

Yet, one thing disturbs me. There is an unanswered question that surfaces through its absence. Science lover that I am, I cannot refrain from asking why, in spite of all this, regional languages could not become media for conveying and sharing of *knowledge*. The only exception to some extent is Tamil, with about twelve hundred manuscripts on *rasashastra*, but then that is all.

There is also the glimpse of an answer which I can see in the Hindu religion. It accommodated bhakti in its fold, in spite of its strict norms, but this acceptance was conditional. There were now two paths to salvation — one was the path of devotion, the *bhakti-marg* and the other the path of knowledge, *jnyana-marg*. There was no question of barring the bhakti-marg from the common people; it was from them that it had arisen, it already belonged to them. But the acceptance of bhakti into Hindu religion could be made possible on condition that the path of knowledge, jnyana-marg, be restricted to a chosen few from among the brahmins. This was but another way of safeguarding the monopoly of knowledge and thereby power. And so, the regional languages and the bhakti-marg possibly represent two sides of a single coin that did not allow the regional languages to become a medium of knowledge.



Progress and stagnation in mathematics

At the turn of the twelfth century, in the West Italian city of Pisa, there lived a merchant, Leonardo Fibonacci, who was also a very good mathematician. As a merchant he had travelled extensively, especially in the Arab kingdoms of West Asia, and had absorbed much of the mathematics that thrived there. His name is today permanently linked to the now-famous Fibonacci series, and a quarterly journal devoted exclusively to its mathematics is regularly published as a sizeable volume.

In 1202, the same Leonardo wrote a book that in the opinion of many scholars, marks the beginning of the renaissance in European mathematics. In it, Leonardo warned Europe that, unless it adopted the convenient numeral and notation system used by the Arabs, it would scarcely be able to make progress in mathematics. This was the same numeral and notation system that had evolved in the Indian subcontinent, travelled to West Asia and which became so common there as to be called the Arab numeral system by Europe which received it last.

This is but one indicator of the distance that separated the mathematics in the subcontinent (and in China and West Asia) from that in Europe at the beginning of the thirteenth century. Leonardo wrote his book less than a century after the birth of the mathematician Bhaskaracharya the second. This means that while Europe was still struggling to acquire and use a well-knit numeral and notation system, mathematics in the Indian subcontinent was already at its highest point of development. One example of this is the work of Bhaskaracharya himself. As important an example is the tradition of the so-called *patiganit*.

Patiganit comprised in itself an entire curriculum. As was usual, it was in Sanskrit, and therefore accessible only to the brahmins. But what is characteristic and important about it, is that it is not a compilation of any extraordinary mathematical genius, but rather a basic, routine syllabus for mathematics. Even the *Lilavati* section of Bhaskaracharya's *Siddhanta-Shiromani* itself is essentially a patiganit.

It was probably in the period after Aryabhat that the broad features of the patiganit syllabus were fixed. Included in it are some 30 kinds of calculation, often called *parikramas*. They include the addition, subtraction, multiplication, division, square, square root, cube and cube root of integers and fractions respectively; and the rules for finding missing terms in ratios for three, five, seven and nine terms. Along with this was usually included a separate section, on what we may roughly call mensuration, these operations being generally called *vyavaharas*. These included the determination of mixtures, of series, of areas, of volumes of excavations, of heaps of grain and bricks and the determination of shadows.

Bhaskaracharya seems to stand head and shoulders above his contemporaries. His work reflects a completeness unique to him. The appearance that his work has of being mainly a compilation of his predecessors' works is quite deceptive. For, each of them has been carefully scrutinised, discrepancies removed, errors corrected and the whole made virtually faultless. Thus, for example Aryabhat's faulty result for the surface of a sphere has been weeded out, as are Brahmagupta's confusions over division by zero. It is this unique ambience of the faultless and the immaculate in Bhaskaracharya which also troubles me.

Compared to Bhaskaracharya's work, the mathematics of Aryabhat and others appears incomplete. Yet their work also displays a strong spirit of curiosity and discovery. They are like pioneers who know they are journeying into uncharted territories, and their work carries this mark along with an understandable element of pride and self-praise. By contrast, Bhaskaracharya's work expresses a calmness, a contentedness that is a striking contrast to the vibrant eagerness of his predecessors' work. Bhaskaracharya's work conveys the feeling of already having reached one's goal, of calmly going over old ground again. As if everyhing has, in the main, been completed, and all that remains are small refinements.

Today, with the benefit of hindsight, and of knowing about all that happened in mathematics later, it is this contentedness that makes me uneasy. For much remained to be done, many new territories were yet to be opened up. This was indeed done — not in this subcontinent, but in Europe. In fact, by the seventeenth century, the same kind of distance still separated the mathematics in the subcontinent from that in Europe, but the positions were now reversed.

Actually, the question regarding the further development of mathematics in the subcontinent concerned a shift to a different level of mathematical problems. At the given level, a plateau had been reached and as much, perhaps, as could be done had truly been done, so that Bhaskaracharya was not all that unjustified in his attitude. What was needed, was a jump over a threshold — one that Bhaskaracharya had reached with his inklings of differential calculus. That threshold was not crossed; it required a leap and, perhaps, a push as well.

The question this constantly raises and has to be faced at some point, is this: why this arrested development? Why could the threshold not be crossed? We meet these sorts of questions in different ways, in different periods, sometimes in the context of Europe, sometimes with respect to the subcontinent. And even if we do not ask them, the very pace and extent of

change is such that the contrast by itself begs for an answer!

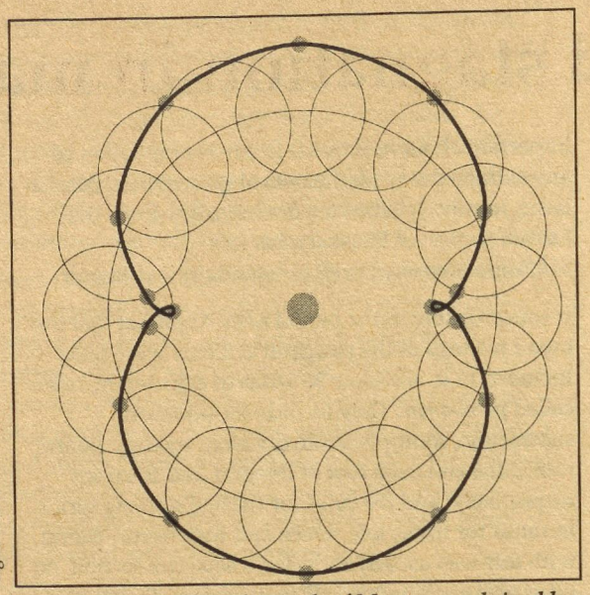
Directly or indirectly, many scholars have tried to explore these questions. I deliberately do not say 'answer' these questions, because the chain of developments that began with modern science is so all-sided and all-pervading in its range, that scholars are somewhat in the position of the blind men in the fable who try to make sense of an elephant.

I too, am trying to make my own sense of it, and indeed all of us today, whether we are scholars or not, need to make our own sense of the rapid pace of developments around us. All the more so, if we take into account the fact that scholars themselves are extremely divided over most issues.

Some scholars find the solution in an intrinsic superiority of European or Greek culture and thought. Others mirror this and say that if Europe or Greece were intrinsically superior in science, the subcontinent is intrinsically superior in spiritual matters. Besides these, other scholars can be divided into two broad streams. One stream believes that the answer lies in the social or 'external' context of science, while the other believes that it is to be found more in the 'internal' make-up of scientific theories and practice.

In the face of such diverse opinion, novices like myself cannot but resort to that age-old maxim — "listen to everyone, but decide for yourself." I am putting before you my thoughts in the same spirit, and expect you to receive them in the same way.

What appears to be most important to me, in this respect, is the intimate link between astronomy and mathematics in the subcontinent. As mentioned earlier, almost all our mathematicians have also been astronomers. Frontier work in mathematics here had always been fuelled by problems faced in astronomy. Examples are: trigonometry; to some extent, spherical geometry; even indeterminate equations. I think when astronomy here reached a plateau (and not only here, but in China and West Asia as well), mathematics too reached its own plateau.



digital studio

The apparently irregular path of Mars as explained by the epicycle model

Of course, this immediately raises the question — why did astronomy reach a stage of stagnation? Here, however, I do see a few possible reasons — reasons both 'internal' and 'external' to it.

The internal reasons are linked to the special make-up of astronomy in the subcontinent. Most astronomical algorithms have been of a *bija* or seed type. Studies have shown that with a given bija, the discrepancy between calculated and actual positions rises systematically with time. Small in the beginning, after around a century or so, the discrepancy becomes significant. At such times a new bija based on observed positions can be devised, and it would be good for another hundred-odd years. And of course there was scope for some refinement in the details of computational methods as well.

Our computational methods also differed in another way. Greek astronomy was based on a detailed physical picture of the celestial sphere — a crystal sphere to which the planets were fixed. An epicycle was another sphere inserted into this sphere. Each change in computation had also to be supported by corresponding changes in the underlying physical model. The physical picture thus began to get more and more cluttered and complicated, creating further problems.

By contrast, in the subcontinent, very little physical detail went with any computational method. For example, in Aryabhat there are two epicycles, the *manda* and the *shighra*, but there is little physical detail connected with either of them. They are simply algorithms, means of arriving at a calculation of the planetary positions. So long as they could do this with a fair degree of accuracy, there were no serious questions raised about what physical picture they represented.

The degree of accuracy brings us to the 'external' reasons. For, what was finally the social function of astronomy in the subcontinent? Basically the determination of the *panchangas* and of auspicious and inauspicious *muhurtas*. A certain degree of accuracy had already been reached in this respect: when discrepancies became significant over a period of a century or so, the algorithms were reset. There was no social need that demanded a greater degree of accuracy from astronomy.

In Western Europe on the other hand, as we shall see later, sailing the high seas was to demand much greater accuracy from astronomical observations and also from timekeeping. At the same time, the subcontinent was entering a period in which crossing the seas was being increasingly forbidden and could even be a reason for excommunication. I think this too, is as important as anything else because, finally, science cannot rise too far above its assigned social function.

amrita

The twilight language

I was first attracted to *rasashastra* because of its language which has a beautiful name — *sandhya bhasha*, literally, the twilight language. Rasashastra developed here in association with tantricism, and its language reflects this.

In this language, everything has both a surface meaning and a hidden meaning. An example would be the expression "the mating of Shiva and Parvati" which seems obvious enough. In rasashastra's arcane terminology, however, mercury is Shiva and sulphur is Parvati. The 'mating' of these leads to the formation of *sindoor* or *kajari (kajjali)*, i.e., red or the black sulphides of mercury. Twilight is ambiguous, neither day nor night, yet in a sense both. Hence, the name of the language, sandhya bhasha.

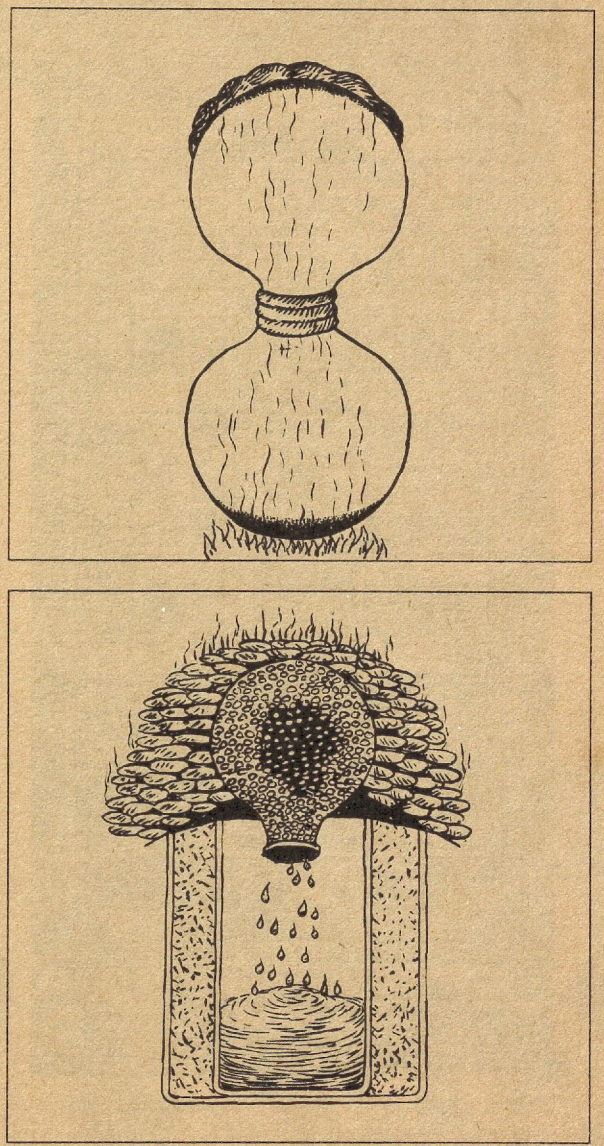
Rasashastra was part of the evolving worldwide discipline of alchemy. It is considered to have first arisen in China and from there to have reached the Arabs. In fact,during this period, West Asia had become a centre where the world's knowledge was pooled, and from where it was redistributed, reshaped by its cross-cultural travels. Alchemy was one such discipline, which spread across over the old world and in the process, reached the Indian peninsula . Later, in Greece and in England, alchemy was to evolve into the modern science of chemistry. In this subcontinent, however, such a change could not take place.

As we have said in the film, alchemy had a twofold aim: the search for the elixir of life and the transmutation of base metals into gold. Achieving eternal life had long been a quest of ayurveda and other systems of medicine too. Alchemy saw gold as the perfect substance, rare and virtually corrosion-free. It believed that if gold could be consumed in the form of a medicine, it could grant humans a perfect body, or immortality. But gold is not plentiful, and extremely valuable. So, a twin aim became the mastery of a process which would transform base metals into gold. This overriding aim of transmutation encouraged a variety of experiments, but at the same time proved to be a hindrance in the development of alchemy. The experimenters limited the context of their analysis and observation only to the end product, the 'result' of the experiment. It so happened that in Europe, Paracelsus was able to break from this overriding aim. He succeeded in establishing the experiments themselves as being independently significant, thus paving the way for the discipline of chemistry. Nothing like that could happen here, and unable to achieve its impossible aims, alchemy itself lost its vitality.

Rasashastra saw all natural phenomena as an interaction between their constituent male and female elements. It is significant that neither was considered superior to the other. This idea of rasashastra resembles and probably evolved from the *yin-yang* concepts in Chinese thought.

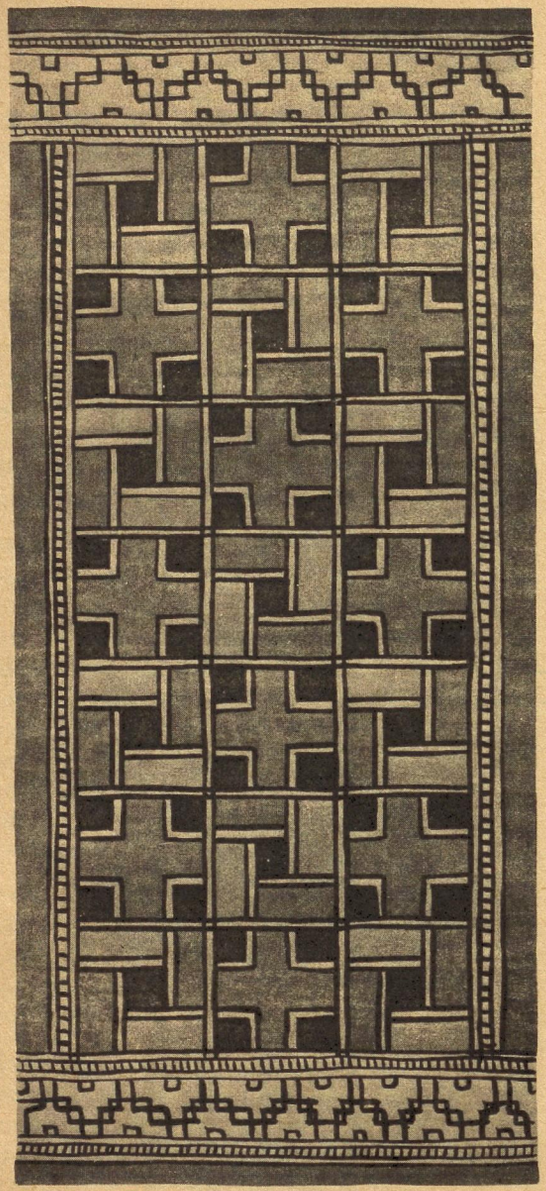
In the Indian subcontinent, these concepts were assimilated in a very different way. There is mention of such male-female dualism in the sankhya, yoga, tantra texts and also in many tribal rites and rituals, but none of these were a significant part of mainstream thinking. In any case, how could mainstream thinking in a caste-ridden feudal society accept the equality of male and female elements?

So it was natural that the discipline of rasashastra was kept outside the pale of medieval society, as were tantric rituals. The tantrics gave importance to physical interactions: music and dance, sexual intercourse, feasting, magic, and *rasavidya*. For them, all these were in a sense, means of study and research and not indulgences. Because of fear of persecution,



V. J. Mohan

Rasashastra intruments



Uttam Ghosh

Tantric yantra used for time computation and projection of mantras in series

tantric rites were performed in secret, as mysterious acts.

Today, many knowledgeable people find tantric rites extreme and perverse. In fact, they would find it strange to include tantricism in a discussion on science. Yet one cannot ignore their contribution. Tantric structures, and the beautiful geometric patterns of tantric art, have inspired and influenced many modern artists and architects.
Tantra-Yoga-Sankhya have always been connected with health-related practices. Before the evolution of rasashastra, medicine depended mostly on herbs and plants. Rasashastra helped to bring inorganic substances into common medical usage. In fact, the Siddha schools of medicine in the south are almost entirely based on rasavidya. Today, practices like kundalini, yoga, and ayurveda, are becoming popular in the western world too, though in a form divorced from their philosophical tenets.

I find a strange kind of beauty in both rasashastra and the tantric disciplines. This does not sit well with the modern 'rational' judgment of their being extreme and perverse. But if one tries to look at the tantric disciplines in the emerging social context of the medieval period, things seem to get clearer. One can begin to understand why they were labelled in such a manner and continue to be seen as vaguely anti-social even now.

The things to which the tantrics had given an extreme importance make up a pattern directly opposed to mainstream thinking. For example, the place of man-woman relationships. Even while celebrating the sensuous, medieval society never saw sexual relations as a source of pleasure between equals. It considered the male element as supreme and the female element as its slave. Salvation of women and persons from the lower castes were topics beyond discussion. Tantric practices represent an inversion of these beliefs: the equal importance of male-female elements; and the freedom to seek salvation irrespective of caste or sex.

In this light — the secretive, mysterious meetings, the extreme viewpoints and their strange beauty — all fall in place. Tantricism then, may be seen as an attempt to break out of the suffocating norms and practices of medieval society. In all periods, such attempts are often inverse images of the existing norms of society. I have seen this in literature, and I see it now in history too. The inverse of an extreme is also extreme. In modern times, an example of this was the hippy trend of the '60s— a reaction of spontaneity to the rigid norms of Western society. An extreme inverse of an extreme norm.

Tantric rites were not just illogical, extreme reactions. In the context of their time, they were also a demand for freedom. If certain aspects of tantricism are becoming popular today , maybe the same causes are at work. What we need to remember, however, is the lesson of the sandhya bhasha, namely, that something quite different may be implied than what is apparently being said. If rasashastra and tantricism put forward an extreme viewpoint, maybe what it implies is deeper than that — it may be a matter of going beyond both extremes.

SYNTHESIS & GROWTH
1200 to 1600

8

A scene at the Qutb complex in Delhi describes society prior to the Turk and Afghan migrations into the Indian subcontinent. In the Sultanate period and later, feudalism became more deeply entrenched. The eleventh century traveller Al-Biruni had commented on how insular and how unwilling the orthodox learned men were to share or improve their knowledge. However we find the peasants and artisans were open to technological innovation. A wide range of crops were grown and new technologies came into common use. The Persian wheel adopted from Iran was described in detail by Babar, newly arrived in the country.

By the early sixteenth century, the Portuguese founded their trading posts, and 'Golden Goa' rivalled the opulence of the Indian courts. The missionaries carried out botanical studies and introduced the printing press to India. In the South there flourished the kingdom of Vijayanagar. The excavations at Hampi reveal, along with an impressive layout of temples and statuary, a network of water tanks and aqueducts.

Under Akbar the emerging cultural synthesis reached new heights. There was an explosion of crafts—exquisite products made by the most laborious means for consumption by an increasingly decadent nobility. Our reporters travel around Fatehpur Sikri with a guide. They listen to a *qawwali* at Salim Chishti's tomb, visit the ruins of craft workshops and comment on the exorbitant amounts collected in taxes, mainly from agriculture.

The work of historian Abul Fazl and inventor Fatullah Shirazi are discussed.

The nobility encouraged horticulture and introduced many exotic fruits. Jehangir made an extensive study of plants and animals.

India was renowned for its painted and printed textiles. A visit to Machhilipatnam traces the still-surviving art of *kalamkari*. This was one of the prime commodities that attracted European traders to India in times to come.





Some thoughts on identity

In the context of growing Hindu fundamentalism, one often has to listen to statements about the ruin of India brought on by the Muslims. Even the history textbooks we studied as children have left the same kind of impression on me: that the Muslims came to India, looted and plundered, spread Islam, formed an empire and reigned in opulence as Sultans. On the other side of the divide are Muslim fundamentalists, who say that it was a period of victory, of jehad, that it was the highest point in India's development — a golden age. Considering my Muslim identity, both the statements — or perhaps I should say both versions, for they are of the same type — make me unhappy. One has had enough of the medieval period being made out to be a dark age as well as a golden age.

Who were these Muslims, and why were they considered to be outsiders and foreigners? I feel it is important to address such questions, because the issues arising out of them often caused me pain. It is painful, to be treated as a stranger by one's neighbours, to feel isolated in day-to-day life, and to have to keep asserting that one belongs.

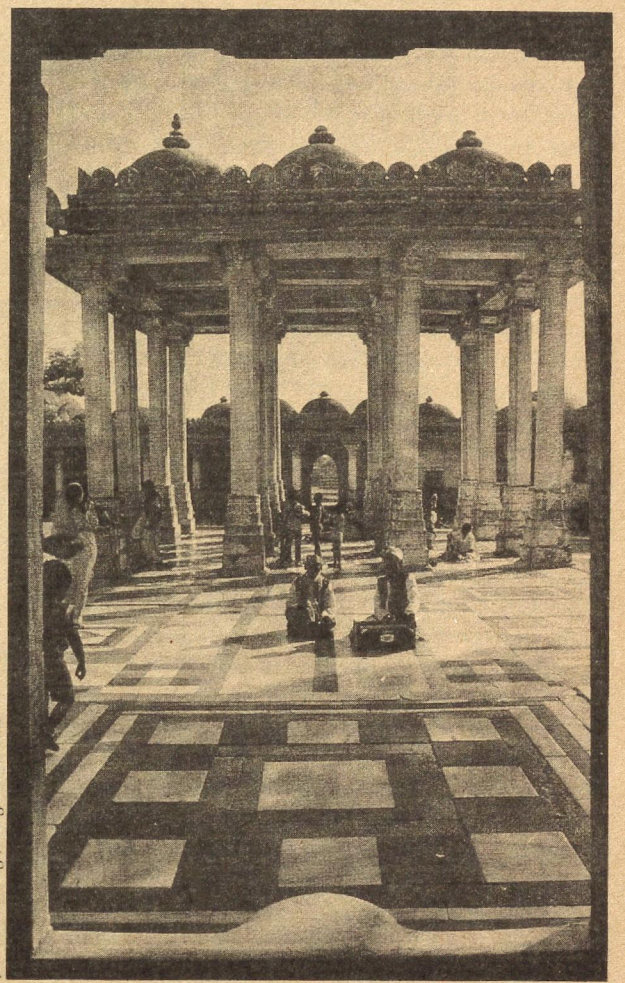
And so it becomes necessary to repeat as question what I so often hear as statement. Had these migrants only come to spread Islam? Where *did* they come from? Where did Islam itself originate? Were all these newcomers generically raiders and invaders? What is the difference between their coming and that of the earlier newcomers, the Indo-Aryan speakers?

Though I have raised a series of questions, it does not mean that I consider valid the *reasons* for which they are generally asked. Whatever may be the distant past of my community, I have been born and brought up in this society and this land. No one has the right to snatch away this history from me. Yet today, I am forced to reconfirm my identity and its validity. I do not think it necessary to defend either those who came from other lands and settled here, or those already here who converted to Islam. In today's milieu of half-truth and falsehoods, however, even truth is in need of strong proof. And to those like me, it seems as if it has been made our responsibility to answer at least these questions.

Talking with a historian like Nissim comforts me somewhat. Only after discussions with him have I found proper answers to some of these questions. First, that those called Muslims have come at different times, from different lands, different cultures and communities; a variety of purposes brought them to India. That most of these people were Muslims, was the result of a historical coincidence. To understand this, one has to understand a little more about how Islam arose and how it spread.

The youngest of all major religions, the doctrine of Islam was first preached by Muhammad in the seventh century. He addressed mainly the Arab tribes who constantly fought amongst themselves. They had many irrational beliefs and customs, and the main emphasis in Muhammad's teachings was on eliminating these. Like all other religions, Islam originated in a period of despair and ferment and therefore, it had special relevance to the land and the period in which it originated. Islam at that time did not have any thought of spreading to the rest of the world.

The simple life Islam preached was welcomed by the Arab people. Those wielding power saw a threat in its growing strength. To get social sanction — even before Muhammad's death — Islam had to strike a compromise with at least some of the traditional beliefs of the Arabs, such as reverence for the *Kaaba*. Gradually all the warring Arab tribes embraced Islam. Some time after the death of Muhammad, the



John Burton-Page, Marg Publications

This pavilion at Sarkhej, Gujarat, built in the reign of Muhammad Shah in the 15th century, harmoniously combines older elements of Indian architecture with a series of domes

chiefs of the tribes united to conquer other empires. The purpose of these wars was not so much to spread Islam but to control resources. The Arab warriors, steeled in the harsh conditions of the desert, won many battles because of their superior skills and soon their kingdoms began to spread across Asia. The people of these lands had the right to practise their own religions, though when taxes were collected, non-Muslims had to pay higher taxes. Baghdad and its rulers, the *khalifas*, became the major centre of power, soon to be joined by the noble families from neighbouring kingdoms. This was not only a period of rapidly expanding trade and prosperity for the whole of West Asia, but also a period in which learning from all lands was absorbed.

The first Muslims to come to India were Arab traders around the time of the first khalifas. They came to the west coast and settled in a number of places. They believed in Islam, and would have probably influenced their associates and their families to convert to their religion. However, they had come to trade, and that remained their preoccupation, not religion.

All over the world, this was a period of wars-and invasions. Groups from West and Central Asia often came into conflict. Constant warfare forced them to new regions, often in flight from their conquerors, and this brought many to India too. One of the first among these was Mahmud, of Ghazni in Afghanistan. To get the finance needed for his military ventures, he found a source in the weakly defended treasuries of India. He never wanted to settle here, his purpose being to gather wealth. He attacked different centres in the North repeatedly, and successfully because he had a powerful army and superior military technology.

Two centuries after Mahmud of Ghazni came Muhammad Ghori. He wanted to extend the boundaries of his kingdom eastwards, to include as much of the subcontinent as he could. This meant he had to conquer the Rajput kingdoms which held these lands. After long campaigns he succeeded in reaching Delhi — and by then his homeland of Ghor, in Afghanistan, was as good as forgotten. To establish his supremacy, at first he did attack some temples which were symbols, and centres of the wealth and of the then-existing powers; but there is also evidence that after he settled here, he helped to rebuild them and to build new ones as well.

After a few generations, these Turko-Afghan kings and nobles became, so to speak, naturalised. Once again, processes of assimilation and the give-and-take of cultures took over. These newcomers learnt the local languages and adopted local customs. Their main aim was to rule, not to spread Islam. Thus they did not try to change society. They left caste and other traditions well alone, even when these were at odds with Islam.

The most significant such entry was that of the Mughal Babar with his army, on invitation from the Rajput kings. His aim was to rule Hindustan, as he says in his memoirs, from Delhi, which at that time was held by Ibrahim Lodhi. After a fierce battle, Babar won. Mughal rule was thus established. In a short time it was to spread all over the north and much of the south, forming once again, an over-arching empire in the subcontinent.

My main aim in recapitulating this history is to show that none of these West and Central Asian rulers had come here with the aim of spreading Islam. They may have been Muslims, but they were primarily kings on military expeditions, who came from different countries with different objectives. While some came for plunder like the earlier Huns, many came to settle here; to rule, surely, but equally to settle. They learnt the languages and respected the traditions of this country because they wanted to rule in peace. And even if they did have their origins in different countries, traditions and religious sects, once they settled here, they chose to become part of this region. I see it as one more phase of assimilation, as happened with the Kushans and the Shakas, or even earlier, when the nomadic tribes of Indo-Aryan speakers wandered into the subcontinent in search of new pastures. They must all have had to fight with local tribes, but once they settled here a culture based on mutual assimilation evolved. In a similar fashion, warriors who followed Islam came from West and Central Asia during medieval times, and finally settled here.

What then, is the difference? On what basis can we say that the Indo-Aryan speakers who came during the Vedic period (and their descendants) are the true inheritors of this land, while those who came later (and their descendants), are foreigners? Both groups in both times, left their home countries and came here, never to go back.Then why the discrimination?

These notes of mine perhaps represent the opinions of an individual who is not entirely free of preconceived notions. In the course of this journey into the history of science and technology in the subcontinent, I acquired the courage to express some of these thoughts. Even so, one thing continues to bother me, and that is the meaninglessness of the boundaries that circumscribe national, religious and cultural groupings. Human beings have always wandered about, settling in new places, adapting themselves, their cultures and their technologies to suit new environments. Then why this muddled terminology of 'ours', 'theirs', 'those who belong' and 'those who do not', as if these were self-sufficient categories? Does this tangled skein of words serve to define anything, or does it hide something else one is yet to understand, to dare to reveal?



Innovations, but little reward

As I learnt more about the medieval period in the subcontinent, one thing emerged very clearly. From Vijayanagar to Fatehpur Sikri, from the mansions of village landlords to imperial palaces, and from temples to fortresses — everything carried the unmistakable stamp of the opulent life style which the dominant sections of that society enjoyed. It was a living standard many times richer than any in the ancient world, and perhaps in medieval Europe, also.

Another striking feature was the large non-agricultural population: artisans, brahmins, village landlords and recordkeepers, merchants and officials, the service occupations and the salaried army. Even if it was a minority, it formed a significant proportion of society, significantly higher than in the ancient period or in medieval Europe.

Both these features are important because they challenge the view that society in the Indian subcontinent was static and unchanging. They indicate that in the medieval period there must have occurred a quantum jump in agricultural productivity. Without it, the non-agricultural population could not have become so broad, or enjoyed such a high living standard, in what was basically an agrarian society.

Agricultural production could attain such a level only by evolving an appropriate set of agricultural practices. Evidence of this is available from contemporary records, which mention not only agricultural practices, but also the development of improved species. As the historian Abul Fazal put it — if a single grain of each known variety of rice grown in the Indian subcontinent was collected, the resulting pile would fill a large *kalsi*. And while Kautilya's ancient *Arthashastra* mentioned the growing of seventeen main crops, this number had risen to forty by the sixteenth century . It is also during this period that many implements like the



National Museum, New Delhi

Right-angled gearing. Persian wheel being used to irrigate a garden, miniature painting, **Baburnama**, *16th century manuscript*

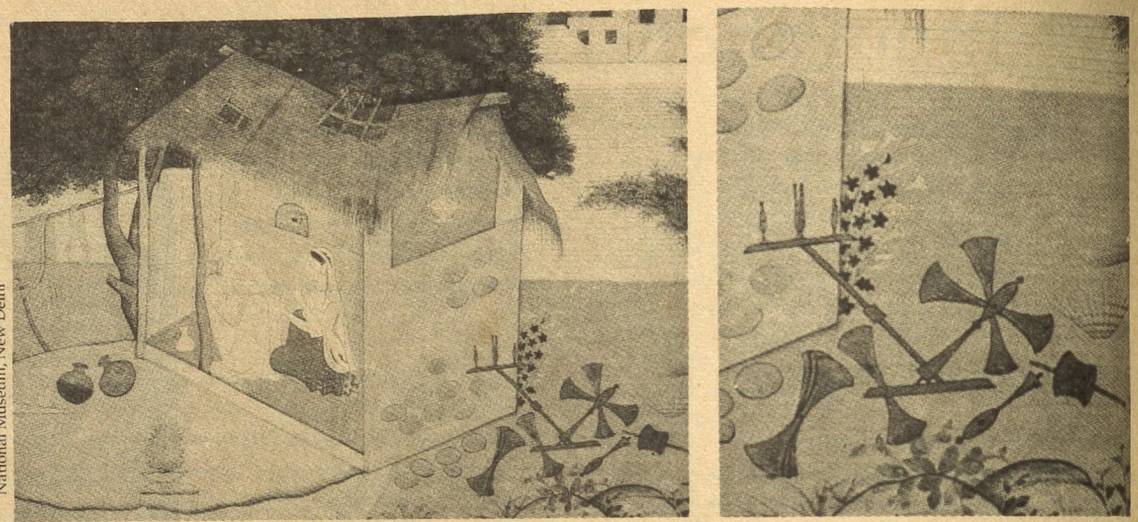
plough, the *bakhar* and the seed drill were developed and shaped to suit the different needs of various regions. Many of these tools were to continue in use in identical forms right up to the twentieth century.

Not much is found in the records about crop rotation or intercropping. But then, written records have their own limitations. Those who wrote them were not the peasants — at best, the record keepers may have talked to peasants. It is quite possible that the peasants would not mention details they thought too commonplace or too obvious to mention. There must be a great deal of this kind of information which may through light on many things. The existence of such innovative but little-known practices may often be learned from many old people in the village.

Agricultural practices like manure being applied raw, and only to selected crops, were also common. We find in this period increasing mention of irrigation, of efforts to develop it, in proclamations and grants by kings. It is also during this time that we first see the in use of right-angled gearing in the subcontinent.

All in all, the period is marked by a substantial degree of innovation by our peasants and craftsmen — provided of course we identify it properly. All too often, we tend to recognise innovation only in the context of a progression to machines and power-driven implements. This makes the peasant traditions of India appear non-innovative. My readings confirm my scepticism about this viewpoint. To me, innovation, like curiosity, is an integral part of people's lives. It may be limited to particular spheres in certain periods, but it is unlikely to disappear altogether.

I found that our peasants and craftsmen have accepted innovations from elsewhere, too, whenever they have found these convenient and having the potential to make a difference to their lives. The crafts provide many examples of such adoption of innovations from abroad. But even in our food habits, considered so resistant to change, there are many examples: the coconut came to the subcontinent around the first century A.D. and since then, it has acquired a central place in religious life and is grown



National Museum, New Delhi

Agricultural and craft implements, Pahari painting, 19th century

in much of the subcontinent. Or the green chilli without which Indian cuisine today is unimaginable, was imported by the Portuguese into the subcontinent from South America. The tomato, the potato and tobacco are also late entrants in our culture.

One reason for the higher agricultural productivity in the subcontinent, as compared to that of Europe, is of course the climate. The agricultural season in Europe is much briefer and the sun's light has a lower intensity per unit area than on the subcontinent. The climate was favourable to the Indian subcontinent even in the ancient period. Equally important to this contrast, then, is the innovative development and adaptation of crops, crop patterns, agricultural implements and the strategic use of limited irrigation in the medieval period by our peasantry.

This, however, does not mean that the peasants were much better off than before. They lived at the margin of subsistence, and a failure of the rains still brought famine in its wake. What I find strange, is the co-existence of innovation with life lived at the subsistence level. It would seem they were two sides of a coin — a curious mixture of freedom and bondage that characterised the feudal — if it may be called that — system in medieval India.

In Europe, peasants were clearly serfs. They had to put in a good portion of unpaid labour on the lords' lands, and there were restrictions on what they could grow on their own lands. It is a matter of debate whether such feudal relations existed in the Indian subcontinent, and if they did, in what form. It can, however, generally be said that peasants here had substantial control over the production process and resources, but had to give over a major portion of their crop as tribute and payment. So they did have the scope to innovate, but as they had to pay out such a large share of the produce, the innovations did not become instruments for raising their standard of living. Instead, they led to the broadening of the non-agricultural strata and increased opulence of the dominant sections. This, in fact, was the basis of the explosion of crafts in this period. We shall see the strange admixture of freedom and bondage in the crafts as well, because of which the crafts were to remain crafts and not become industries, as would happen elsewhere in the period to come.



Assimilating new techniques

Often, the urge to establish all achievements as those of our ancient culture, makes us lose sight of technological transformations that took place in the subcontinent during the medieval period. The latter period is often reduced in our minds to one of wars waged by foreign invaders. There certainly were battles, and many new people did come into the subcontinent, but there was also a process of give-and-take and of learning new techniques, that tend to be overlooked.

Many people from many countries were responsible for the transformations which took place in different fields. During the period when Ghazni repeatedly attacked the North, Ghori finally settled down there, and thereafter, many techniques came into the subcontinent from West and Central Asia. These had a profound impact on the arts and crafts. The new techniques were soon absorbed by urban craftsmen who had to satisfy the newcomers' demands and also to earn their living. In the process, a few techniques which served to satisfy the needs of common folk also spread through the subcontinent.

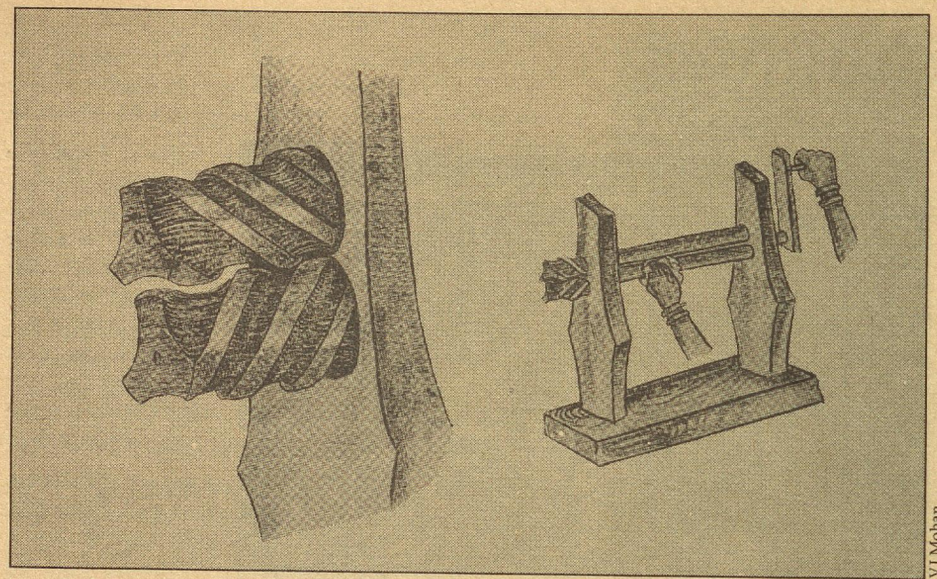
Some of these techniques have been described in the film, but I think it is appropriate to summarise the whole range here. The geared water-wheel greatly simplified the task of drawing water from deep wells, and raised the efficiency of animal power substantially. The water-wheel, in which a horizontal wheel turned by animal power in turn rotated a vertical wheel inside the well, was based on the principle of right- angled gearing. This type of gearing also found other applications, but why it was not more commonly used in everyday appliances is a question that bothers one.

Something that made a tremendous difference to the productivity of ordinary people was the belt-drive mechanism, which gave the familiar charkha its final



Khudabakhsh Oriental Public Library, Patna

Paper making, in a nobleman's manuscript atelier, miniature painting from Akhlakh-e-Nassim, *17th century manuscript*



V.J.Mohan

Parallel worm gear, commonly used in cotton gin and sugarcane press



National Museum, New Delhi

Blacksmith shoeing a horse, detail from Mughal miniature painting, 18th century

shape.The belt drive had been developed in China, but came to the subcontinent through West Asia and Iran. It greatly increased the quality and efficiency of spinning, and the added availability must have had a beneficial impact on cloth prices.

Besides these, the use of lime mortar in construction was a significant advance. So was paper-making, which travelled from China to Iran and then to the subcontinent. Within a short period, the use of paper had become common enough for a number of production centres to have come up.

A major reason for the successive defeats suffered by the local rulers in this period was poor military technology. The Iranian and the Turkish armies had better horses and superior cavalry. Other small innovations also made a significant difference, such as stirrups and horseshoes made of iron.The local stirrups were made of materials such as wood, cane or rope, which restricted the rider's reach compared to iron ones. Thus, a succession of innovations came into the subcontinent in the two centuries following Ghori. Though often grim companions of warfare, ultimately they enriched techniques in the subcontinent — especially in the sphere of crafts.

In that period innovative developments were also taking place in China. The direct trade relations West and Central Asia had with China led to many of these techniques being introduced to the subcontinent from the westward routes. Often, however, it is not possible to say with certainty whether a technique reached here directly, or from the northwest.

One such technique was that of making silk. The techniques of rearing silkworms and spinning silk yarn were initially kept secret by the Chinese. However,the know-how spread clandestinely all over the world. It arrived here around the fifteenth century, and was so quickly assimilated, that in less than two hundred years, Bengal had become one of the world's most important centres of silk weaving. Other techniques connected with yarn and cloth-making, which made a significant impact, were

the use of the treadle and the flying shuttle in the loom, and a systematic method of textile printing. These were all developed first in China, and then they came, either directly or indirectly into the subcontinent.

Techniques of warfare continued to develop. The use of gunpowder and ballistic weapons shows advances in this period. The knowledge of controlled explosions, which could propel stones, or other heavy materials such as the shrapnel in cannon balls, became widespread. Fireworks also became popular. We also find definite proof that this particular group of innovations came to India directly from China.

It becomes quite clear that there was a readiness to accept new techniques. Perhaps one reason for this was that there were no really stringent craft or guild restrictions in operation. Craftsmen felt free to devise new products, and adopt new techniques as the demand of the market changed. The ruling sections certainly encouraged the craftsmen, but did not give them any significant support for innovative experiments.

The result was that craftsmen did what they could do on their own, and only selected new techniques took root. The level of investment needed to develop them further was more than the individual craftsman could afford. The affluent could not see the value of such investments. The consequences of this lack of interest would be known later, when technical development in Europe would take off with unprecedented results.

Though there was exchange with Europe too in this period, there were many things our craftsmen were not able to learn. An interesting example of this is the screw, or rather its threads. The craftsmen needed lathes to make the threads, which they did not have. So they made ingenious copies of the screw. Instead of cutting a thread, they wound and stuck a wire around the stock of the 'screw', which then worked like the threads. But these false threads proved to be very weak. Many such potentially important mechanisms could not develop properly because of the lack of investment on any sizable scale.



Khudabakhsh Oriental Public Library, Patna

Belt-drive mechanism. Persian miniature of women at spinning wheel from* Shahnamah *of Firdausi, 16th century manuscript

The nature of the economy gives us a clue to this. On the one hand, there were the kings and the nobles who, on the basis of growing productivity in agriculture, were able to patronise the crafts. As long as agriculture did not suffer a setback, this could continue. On the other hand,there were the merchants, who prospered by catering to the existing needs of the affluent and therefore, had little desire to invest in risky and seemingly irrelevant things.

In Europe, big investments were soon to become a necessary part of technology. Craftsmen and their implements were to be replaced by workers and machines, which made labour more efficient and also increased the scale and pace of production. These new techniques were to be used to produce not only goods of leisure but also goods for daily consumption. It is this that made objects of common usage available at low costs. For such processes to get under way, it was not sufficient that craftsmen alone be innovative. Society as a whole would have to take the initiative in this direction. And that, it seems, was not to happen.

A bustling Mughal port

While talking about history, you sometimes wish you could travel back in time to that period and actually see what was happening. It is fun to speculate, but that cannot of course give you the whole picture. You can, however, dream. So let us journey to the port town of Surat during the Mughal period.

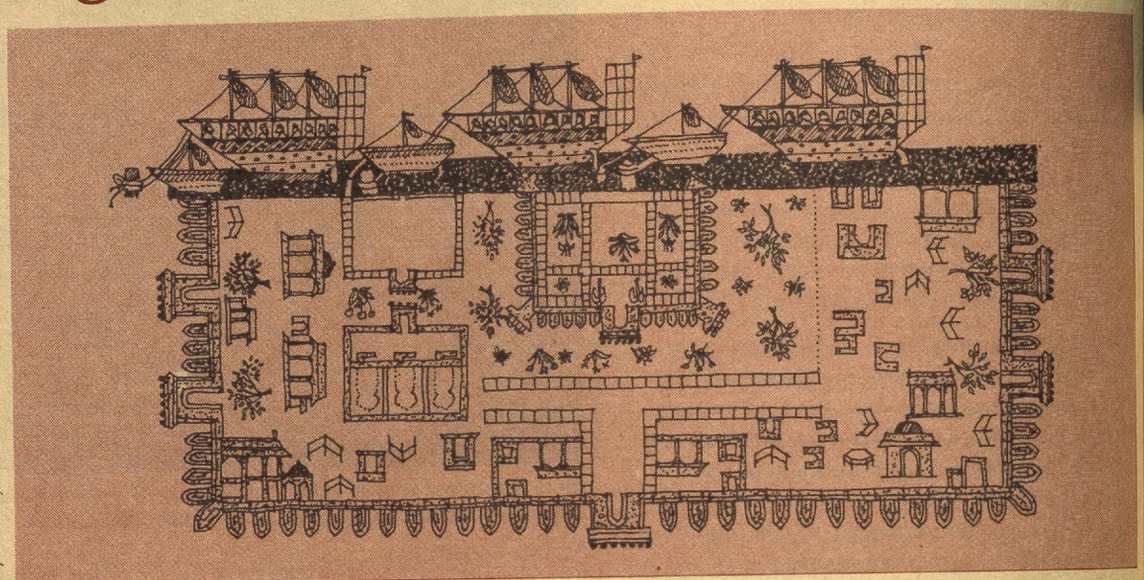
As our boat moves upstream, from where the Tapti river empties into the sea, we first encounter the villages of the fisherfolk along the banks. Then suddenly, we see huge ships. They belong to Mughal nobles, French and Dutch traders. They have come from Europe, Arabia, China, Indonesia. All have sails, and move by wind power.

From April to September, when the sea winds blow from west to east, these ships sail from Europe to India via Africa. During the same months, Arab ships sail across the Red Sea to reach India. They will be loaded with cargo from India and move on to Indonesia. In the winter, when the direction of the wind is reversed, all the ships will retrace their routes.

We move past the anchored ships, and are now faced with the toll office. All traders have to pay taxes on the goods they have brought. The Mughal emperor earns an impressive revenue by this means.

Opposite the toll office is the royal mint. The traders are exchanging gold and silver for Mughal currency. These coins will be used for buying and selling in the Indian market. We watch labourers unload the goods the merchants have brought to sell in the Surat market. And what will they take back with them? Silk and cotton cloth, indigo, sugar and spices — the demand for which is growing in the merchants' home countries.

Are all these things produced in Surat itself? Let us stroll through the market which is being set up in the open grounds here. A Gujarati merchant's cargo of indigo has just arrived by bullock cart from Bayana. The agent who brought it says that he could not get transport to Surat for ten days. A caravan from Lucknow did pass through Bayana, but its carts were overloaded. So he had to wait until some carts from Burhanpur finally agreed to take his goods. The merchant complains that had the agent sent a message earlier, he could have made a sale by this time.



Raja Mohanty, based on manuscript, Prince of Wales Museum, Bombay

Port of Surat, based on an illustration in **Anis-al-Haj,** *17th century manuscript*

In the market there are traders from Holland, England, Indonesia, Turkey and the Arab countries. Two Dutch businessmen are discussing how it is simpler to go to the villages and buy goods there, rather than in the town. Things would be cheaper, even after paying the taxes at the innumerable toll gates. Such expeditions are easier these days, they feel, because there are good, well-maintained roads and most of the *nallahs* have bridges over them. Night halts are necessary, but there are good inns along the road. Their main fear is of dacoits and wild animals.

Two Parsi traders seem to have anxieties of a slightly different nature. They are concerned about what will happen once they have paid the taxes, loaded the cargo and set out on their voyage. The Portuguese will have to be paid money too, or else they are likely to attack and loot defaulters. Every ship requires a pass from the Portuguese. It is not easy to escape from them, for they have control over all the routes on the Indian ocean. Their soldiers are present not only at the ports, but also on board their ships at sea.

This then, was the market scene at Surat. Toll office, mint, inns, port officials, traders from far and wide, labourers, the Portuguese navy — all these together make Surat an example of an international sea port of Mughal India .

STAGNATION & A CHANGING WORLD
1600 to 1800

9

At Banurgarh, one of the smaller of Shivaji's forts in Maharashtra, a *bhajan mandali* sings a Tukaram *abhang*. The *bhakti* and *sufi* movements were gathering force as the Mughal empire dissolved into small kingdoms. While the religious leaders emphasised ideas of equality, this democratic impetus did not realise its potential for a wider involvement with science. Alongside the high level of craft development, the theory-practice divide continued, and this was to prove a great limitation in this period, and in the time to come.

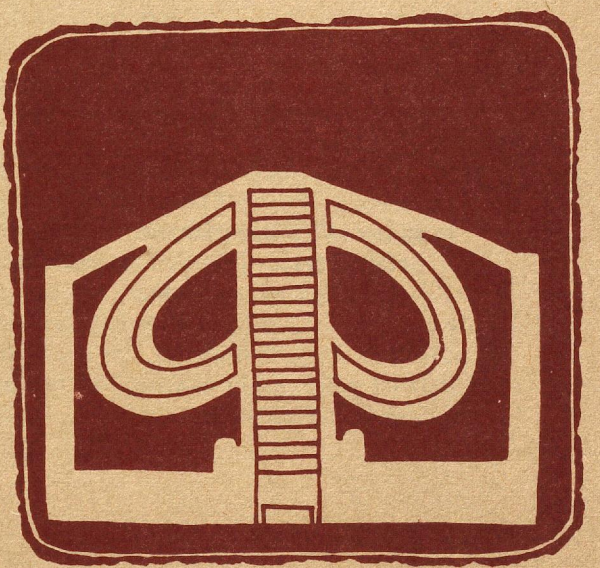
A visit to present-day Jamsalaya in Gujarat, where a wooden ship is under construction, provides an appropriate setting to discuss the technical strengths of Indian ship-building. Indian-built ships were much in demand by the Europeans. However, we lacked navigational technology — it was Europe and not the East that sailed the high seas and eventually ruled the world, helped of course, by the might of their military innovations.

The renaissance in Europe broke with the constraints of the medieval world-view and revolutionised both science and art. The new scientific knowledge and philosophy travelled to India as well. It was left to individual noblemen, however, to take an interest. Science therefore never acquired the dimensions of a social force.

Meanwhile, Jaisingh planned the city of Jaipur, reformed the calendar and built a number of astronomical observatories — the Jantar Mantars. His astronomy was calendrical, and pre-telescopic, though the telescope was known to him.

Tipu Sultan of Mysore had a more integrated approach to social and technological change, as his economic policies reveal. He attempted to acquire the latest military technology, and the steel rocket invented by his army was a singular achievement. Tipu was also fascinated by the French Revolution, and was unique in his early conviction that Indian forces must unite against the British. However, with Tipu's defeat, a major threat to colonialism was removed.

Meanwhile, the Scientific Revolution was taking place in Europe — a great leap forward in many theoretical fields that cut across social barriers and formed a prelude to the Industrial Revolution of the nineteenth century.





A little before company rule

In our school days we learnt that the English came to India to trade and ended up ruling us. How did this trade get established here? What were the relations between countries of the world then, especially those in Europe? How did trade metamorphose into imperial rule? These were questions and issues that have always fascinated me.

The British came to the Indian subcontinent in a period when a new world order was being established. This was the period when trade, science, industry — were all acquiring a new global character, when modern science and national policies evolved and began to be accepted. Today, when we are experiencing world-wide turmoil, related perhaps to the creation of another new order, we should look at this period more carefully.

The first to arrive from Europe were the Portuguese, at the end of the fifteenth century. Helped by the geographical position of their country, they had by then become expert sea voyagers and navigators. Avoiding the African and Arab countries surrounding them, they turned to the sea, found a new route around Africa and were the first Europeans to reach this subcontinent by sea. Having found the route, they wanted to make profits from the trade carried on through it. They established a strict monopoly over this new sea route, and every ship, especially those from other countries, had to pay heavy taxes to the Portuguese sealords. If the taxes were not paid, the Portuguese looted the ships with the help of their strong navy.

For some centuries, the old sea and land routes to India through Central and West Asia had been closed due to political reasons. This had forced the Portuguese and the Spanish to search for a new route through the unexplored high seas. A little before the Portuguese sailed around Africa, Columbus had set out to the west and discovered the Americas. The search for a route to a known land had taken Columbus to a new continent, with abundant natural resources, and what followed is another story.



Engraving by J.Shury, 1772

A view of Surat on the banks of the Tapti when controlled by the East India Company

The Portuguese monopoly on trade with Asia did not last very long. The Dutch navy and traders then took over the East Indies and the spice trade from the Portuguese. Slowly the British and the French trading companies also followed the Portuguese and the Dutch to this part of the world. Together, these European traders started a new chain of developments in the Indian subcontinent.

The strained condition of the Mughal empire's finances during this period helped these traders to come and establish themselves here. The wealth of the empire relied not only on good agricultural produce, but also a faithful and honest bureaucracy. With the expansion of the empire, this bureaucracy had increased in size. Income from trade with other countries had the possibility of supplying the state with the means to retain and stabilise the empire. It



F.Quilici

An Indian bullock caravan carrying grain from Balaghat in Madhya Pradesh to the Portuguese settlement in Goa



Bibliotheque Nationale, Paris

Street scene in Goa, at the end of the 16th century

must have seemed a good opportunity, and the European trading companies were encouraged to come and establish themselves here.

The companies, however, had come all this way for their own gain and had their own priorities. They cultivated the dissatisfied and disgruntled imperial officers. They offered the services of their small but powerful armies to the rebellious nobles. The fragile empire, held together by weak bonds, began to disintegrate into smaller kingdoms. The European companies reaped the benefits of this.

By the end of the seventeenth century, the main contending powers on the sub-continent were the British and the French. Their interests clashed with each other in many parts of the world — India was only one such region. Another was the newly colonised continent, North America. In the following period, their battles over the ruins of a disintegrating Mughal empire, were a continuation of this global war for supremacy. Wars fought and compromises made in lands far away from India and with little connection to the events here, affected the moves and balance of power in India.

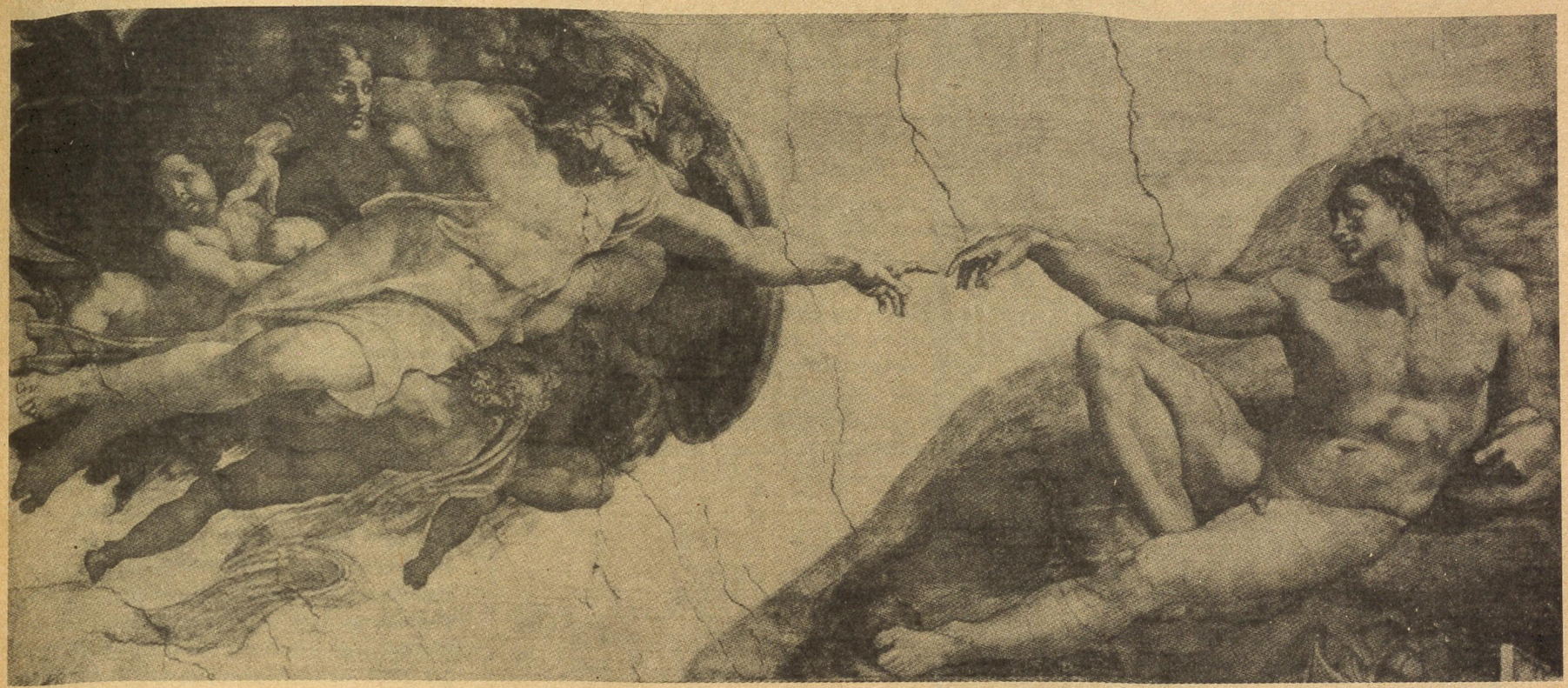
Finally the British won, and installed a 'raj' here. The subcontinent was again united into a political entity under their domination. However, these latest 'invaders', had come here to trade, not to settle like earlier migrants. They did not want to leave their native land and become assimilated into this culture. When it became necessary, they established a permanent base with a large bureaucracy to protect their huge profits from trade. But, Britain remained home, and thus India became a colony.

Earlier, the Europeans had been interested in Indian craft goods which had a great demand in their countries. These crafts were flourishing and their export brought in gold from Europe. With the setting up of machine factories in England, however, things were reversed. Cheap goods started being produced in large quantities there. Now, raw material had to be sent for them from India and machine-made goods were brought back for sale. Slowly, the dependence of the Indian market and industry on this arrangement increased. British industry and power controlled natural resources and trade. All aspects of life began to change in response to needs and demands defined in Britain.

Social connections were recast in a uniform manner and on a commercial basis. This new empire that replaced the old disintegrating one was erected on the explicit understanding that it would help sustain the growing and flourishing trade and industry in the West.

The world has changed a lot since then. But we are still not free of those practices of using trade and industry to expand empires and to gain control over natural resources of other nations . Along with a superior military technology, it has been the use of this new kind of power derived from the production of goods, that has decided the equations of power in this phase of world history.

Language and the renaissance



Michelangelo Buonarroti

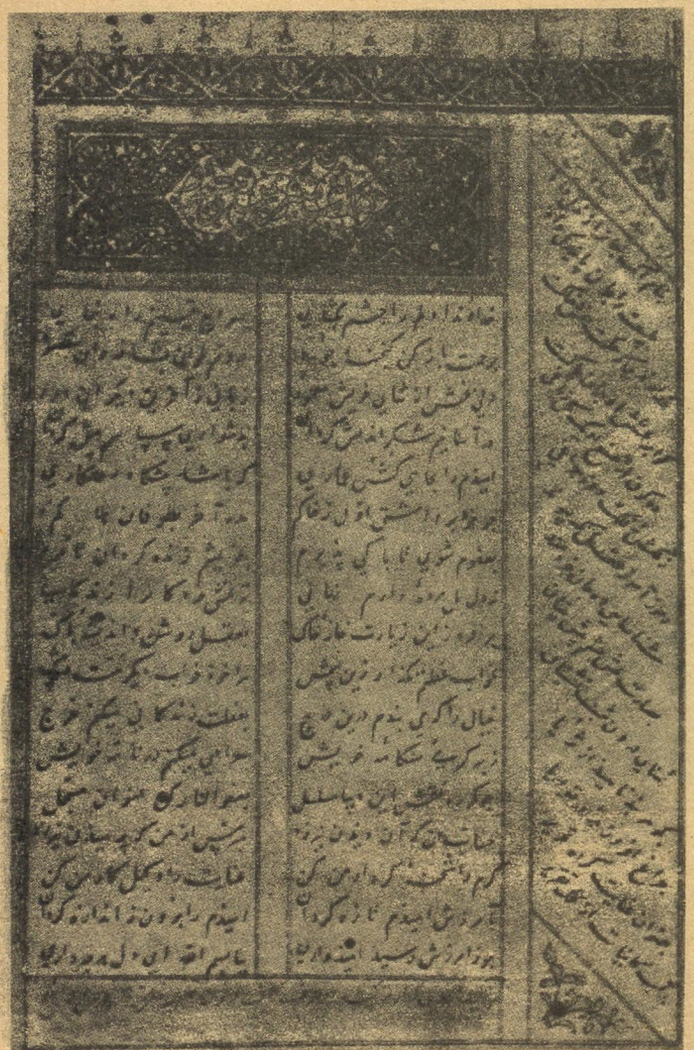
Creation of Adam, ***detail from Sistine Chapel***

Renaissance, rebirth. A new energy and new inspiration. I often wonder about the strange chemistry that manages to invest an entire age with a new energy which is able to pervade all its aspects. The renaissance in Europe had this strange quality, encompassing all its creations.

The name renaissance, of course, is derived from events that took place in the areas of art and literature. The period that followed it is called the reformation, and that name had its roots in events related to religion. It was followed by the period known as the enlightenment and it derives its name from philosophical and, to some extent, from political events. By then we are almost on the verge of the period of the scientific and then the industrial revolution. So, in a sense, the renaissance is the beginning of an entire chain of overwhelming events.

Before the renaissance, European arts and literature had become frozen, almost stagnant. 'Almost', because the arts never become completely frozen and stagnant in any age. They were hemmed in by the framework that medieval religions provided. If their paintings were beautiful, they were at the same time somewhat lifeless.

The renaissance is a major turning point. Religion and life-after-death are left behind. The arts begin to concern themselves with issues related to this life, this world. They shed the veil of hypocritical morality that so far covered their depictions, and images of Europe's daily life break through.



Kutub Khana Madarassa Mohammadi, Madras

First page from* Shirin-wa-Khusrau, *of Amir Khusrau manuscript dated to 1426

Literature entered a period of narrative tales. These were not parables with prescriptions of morality, but stories told for their own sake, dealing with incidents of everyday life. Though transcriptions changed the character of the stories, their roots still lay in the oral traditions of story-telling. With them began the long road that took us centuries later to the modern short story.

Similar trends are visible in the arts. In painting and sculpture, angels hover in the background, and humans and human-like figures take centre stage. The renaissance begins a movement away from the frozen, lifeless depictions of holy themes, to the fluent, vigorous experience of people's lives and relationships in this world. It is this energy that breaks through in the renaissance stories and so often saves them from being mere pedestrian accounts of daily affairs.

Of course, there is another thing that I almost forgot to mention: all this writing was in the local, regional languages. Europe too had a high language — Latin, which was restricted to the elite, like our Sanskrit. Renaissance literature, just as it broke through the bounds prescribed by religion, disowned Latin and adopted instead the local, native languages. Despite this, Latin continued for a long time as the language in matters related to knowledge and science. But the scope of regional languages kept on increasing, until finally, a few centuries later Newton had to print the second edition of his famous *Principia* in English.

Although the renaissance occurred outside the realm of science, it nevertheless had an important role to play in creating a backdrop for the scientific revolution. The renaissance had its own limitations and drawbacks. For instance, there was an undercurrent of racism; women were looked upon as objects of desire; and there was a newly emerging exploitative outlook towards nature too. Once one had freed oneself from the domination of god, nature no longer remained god's gift; like so many other

things, it became a form of property, to be owned, enjoyed and disposed of at will.

Finally the question that bothers us time and again — why do we not see similar developments in the Indian subcontinent? As we go along, we have been trying to answer this question, to the best of our individual understanding. Sometimes we come up with answers to one particular aspect. Perhaps the question does not admit of one, single comprehensive answer. After all, the answer also depends on who is asking the question and why.

I cannot believe that we did not have such literature in our local languages. In the visual arts there are numerous examples. But in literature there are very few examples outside the bhakti tradition. As I wonder why, I am reminded of Shehnaaz's adivasi friend. I think that what he has to say has something to do with how I understand the matter.

Shehnaaz's friend is himself a writer, and a lot of his writing has been widely published. It is most exciting to listen to him narrate his stories, or to see his plays, which contain many of his songs,performed by an adivasi troupe that get together on special occasions and festivals. Most of this 'literature' of his is not written. He tells us that there are many more like him, and that a lot of such literature disappears totally, because it is not retained in written form.

This, I think, is an important point, and it has to do with our oral tradition. In the oral tradition, only the things linked to a powerful institution or social tradition are preserved. Other creative expressions would be heard, seen and appreciated, but not preserved as accepted tradition. Thus, in written literature, we see very few instances of contemporary writing outside the bhakti tradition. One such example is the work of Amir Khusrau. However, bhakti is the primary *rasa* preserved in the written works. It is only in the nineteenth century that we come to a literature that begins to be concerned with life in this world.

I know that this is an incomplete answer to the question I have raised. There are many more complex issues involved here. Yet, today when I look around me, I think the aspect I just outlined acquires importance. I felt that many of our scientists are indifferent, often contemptuous of the world of literature. They are unaware of new literary happenings. They are even indifferent to popular science literature in their regional languages. In such a situation, I feel that this other aspect of the answer does become important. The question therefore is— without a vigorous literature in the regional languages, with a mainstream tradition in which it has been absent for so long, can there be a vigorous science rooted in the reality of its region and its people?



Expanding horizons, changing perspectives

The word renaissance at once brings to mind the paintings of the great masters. However, the effects of the renaissance went much beyond the world of art. It was a period when worldviews changed radically. There was a complete shift— a shift from a god-oriented to a 'man'-centred universe. Now human beings became the most important creatures on the earth. Gradually this led to the view that they were the ones who had the power and the will to change the course of everything. Nothing else, as a corollary, could function according to its own will.

Now, not only was every phenomenon merely to be understood, it was also necessary to be able to make predictions about its behaviour with certainty. Once man was considered supremely capable, there was no place for uncertainty or doubt. All events had to be explainable and predictable; every process had to be capable of being controlled and manoeuvered according to man's needs. A very deterministic picture of the world emerged.

Today, it is easy for us to see the implications of this change, because we are still living through its consequences. But what could have been its cause? And what was the exact nature of these changes? These questions often roll around in my head. While making the films it was obvious to all of us that something crucial had happened to the world over the last three or four centuries. It is clear that this was the era when science had acquired some kind of universal character; this was the time when scientific thought, as we understand it today, took root and began to thrive; this was the period when science also became an important part of our daily lives.

Tracing world history along with the specific history of science and technology also gave one a sense of continuity. It was not as if innovations in science and technology simply dropped from the skies. It obviously was not the birth of one Newton or one Descartes which changed an earlier way of looking at the world. While the contribution of these individuals cannot be denied, it was the entire milieu that led not only to the voicing, but also to the acceptance, of the ideas these scientists proposed.

If we juxtapose what was happening in the world outside with what was happening in science, we see certain connections. Although trade and the exchange of ideas had been happening for more than two thousand years, events in this period herald the forging together of the world under the power of those armed with the new knowledge. Knowledge was universalised, but also centralised; it concentrated power in the hands of those who controlled it, or contributed to its growth and sustenance. A kind of uniform culture and thought started to evolve around the world; leaving in the process hardly any space for indigenous ways of life and of thinking, though they continued nevertheless to exist on its margins. Looking back, I think that what happened was, from the beginning, implicit in the nature of the science that evolved.

The first major shake-up came with the discovery that the earth, far from being the centre of the universe, was a miniscule part of a whole galaxy. The second significant aspect was the rigid mathematical formulation of the laws of nature. Planetary motion had already been explained in mathematical terms. The symbols of mathematics epitomised the idea of an ultimate, objective truth. Thus, it was assumed that the language of mathematics could be used to explain the entire range of nature's behaviour.

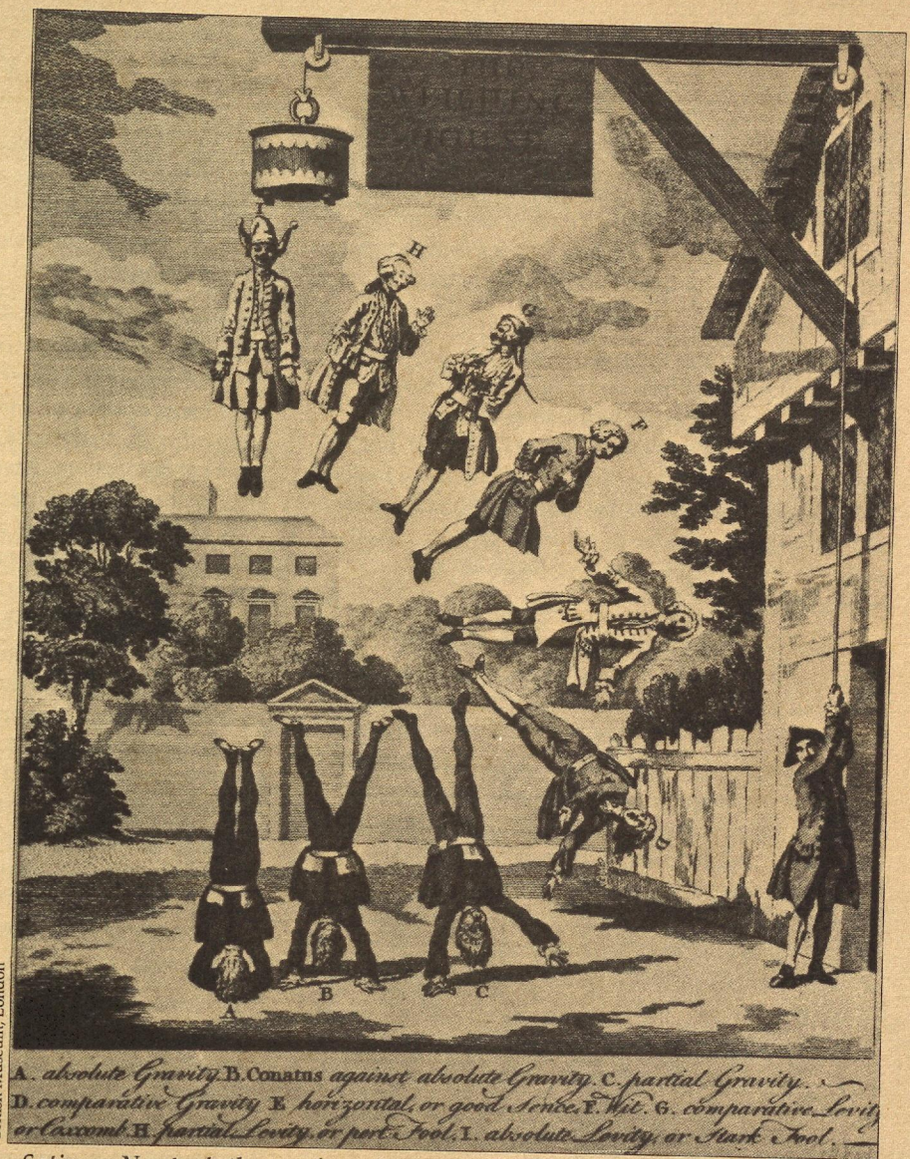
If I may speculate, it seems that earlier the way in which god, spirit and other supernatural elements were assumed to control life, led to superstitious beliefs and a dead-end of sorts. Perhaps at this time it was necessary to begin at the other extreme. Thus the world swung from the belief that everything on this earth functions according to an unknown will, to the belief that there is absolute certainty in the laws which govern every happening.

The stage was set for a scientific method that involved the statement of a theory, and its verification by actual, replicable experiments. The stress was on exact prediction. No room was left, in principle, for doubt, probability or any kind of indeterminacy. The attempt to understand the nature of things in a deterministic way also led to the quest for the smallest constituent particles, their nature and their behaviour. It was assumed that the basic laws governing the behaviour of these smallest particles would help in understanding the behaviour of the macroscopic body made of these constituent parts. The whole could be understood once the constituent particles were known, it was thought, because the same laws governed all of nature and applied to all particles, big or small, and to all phenomena in which these particles participated. The ideology was, to say the least, reductionist.

Thus began the search for the basic building blocks of matter and also for the unifying laws and theories which governed all matter, living and non-living, on this planet. This exact, mathematical, replicable method of science evolved by physicists, astronomers and mathematicians, began to be applied to all aspects of people's lives and surroundings. While the advances in knowledge that resulted are numerous, today we also sense the limitations of this kind of approach. We have come to understand the fallacy of the belief in an absolute truth. We have failed to find one, all-encompassing explanation of the world. All this is being realised not only at the level of everyday

life, but also within science itself; ironically, even in the discipline which spearheaded the earlier scientific revolution — physics. But more about this later.

To my mind what is significant is that rational thought and methods grew more important where earlier there had been a dominance of the irrational. It was an eventful period for science, vital to the body of knowledge that has since emerged. What is bothersome is its dogmatic and unidimensional approach to the world. Almost every day we encounter the rigid belief in *naseeb*, in *vidhilikhit*, a destiny that shapes our ends, and we have experienced how difficult it is to make even a dent in it. I am not sure how far replacing such a belief with a rational, exact, deterministic, 'man'-centred worldview, that is as rigid and fixed, would take us. Such unidimensionality has certainly led to much one-sided 'progress', but does this attitude not go against the basic principle of science: that of an openness to new and different ideas? In that sense, the scientific revolution had its limitations. It did not encourage a holistic approach to life and to knowledge.



British Museum, London

Satire on Newton's theory of gravitation by a cartoonist of his time



Spotlight on the individual

Whenever we talk about science, one important aspect stands out strikingly — that almost every invention, discovery or theory of importance in modern science is associated with the name of an individual. Is this intrinsic to science?

We have all read the story about how Newton saw an apple falling from a tree, and it led to his discovery of the law of gravity. A ripe fruit falling off a tree is a common event many people would have seen, but Newton saw in it the law of gravity. This was a major milestone in science — in the identification of theories about the inherent order of nature. It was also an example of a theory being identified with an individual.

In a way, the individual has always been of some importance in society. This is simply because humans are social beings, and many scholars have studied this importance in different social formations. However, the new emphasis on individuals in science seems to be somewhat different from this general importance — a definite step in a certain direction. When we talk about stone age painting or culture, individuals and their names do not become important to the discussion. We consider it an expression of a whole culture and of a period. But as soon as we come to written history, our perspective begins to change. Why this change?

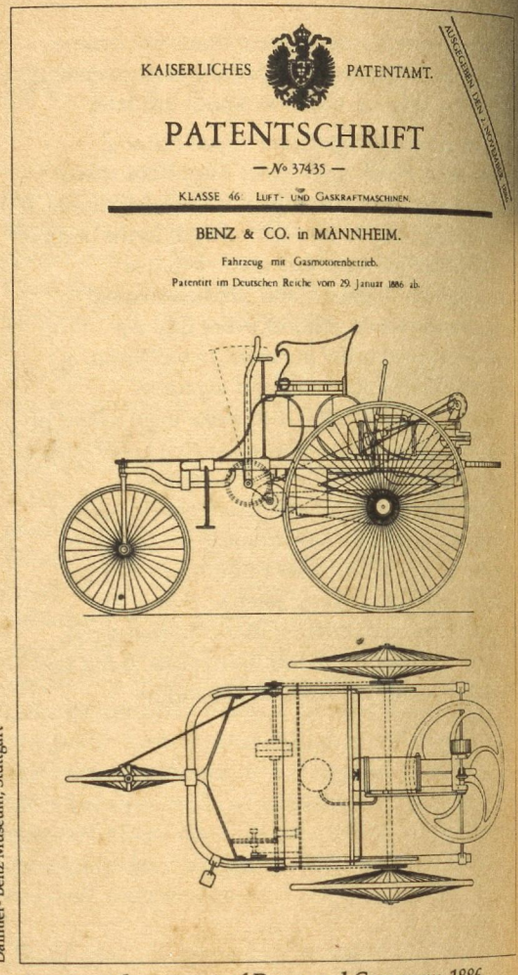
We all gave a thought to this and here are our views, no doubt somewhat speculative. Firstly, we thought, this change may be attributed partly to some of the differences between the oral and the written traditions. The spread of literacy opened access to knowledge to all individuals who could read, and this resulted in a certain democratisation of knowledge. Along with it however, a written work also carried a colophon — the stamp of its individual author.

Because of this, if we recognised earlier individuals as part of and representatives of a collective, we begin to look at later individuals less as representatives of a collective, but almost exclusively as individuals in their own right.

Secondly, innovations in different kinds of day-to-day skills, like farming and cooking amongst others, were always taking place. New processes, new implements were being developed and used. All this was happening as part of a collective. Alongside these practical innovations, a few individuals also began to give thought to those aspects and problems which were not directly related with day-to-day 'useful' activity. Because of this, two things might have happened. One is that thinking about these more theoretical aspects must have been an elaborate process, requiring systematic efforts from individuals or groups. By virtue of these special efforts taken by such individuals or groups, their studies and results would be associated with their names. Also, this sort of effort needed time and money. In those times it would generally become possible only with the sponsorship of kings or noblemen. This substantial dependence on sponsorship must have given rise to a further emphasis on individuals' names being associated with their work. How else could one prove oneself worthy?

Subsequently, as society became more and more divided on the basis of work, skills became more divided and closely associated with occupations. And this correlation began to be seen as essential and natural. Reputations of individuals' achievements became the basis of their fortunes. This made it all the more important to tie up one's achievements with one's own name.

In contemporary society, the whole issue of one's identity has become a complex and tangled one.


KAISERLICHES PATENTAMT.

PATENTSCHRIFT

— № 37435 —

KLASSE 46. LUFT- UND GASKRAFTMASCHINEN.

BENZ & CO. in MANNHEIM.

Fahrzeug mit Gasmotorenbetrieb.

Patentirt im Deutschen Reiche vom 29. Januar 1886 ab.

Daimler- Benz Museum, Stuttgart

A patent document of Benz and Company, 1886

Today, when an individual is part of a group, the competitive pressure to stand out , to distinguish oneself from the group and to acquire a seperate identity, has increased tremendously. In such a situation, only a few individuals have the opportunity to appear outstanding, credited with the deeds to which their names adhere. Meanwhile, the remaining are thought of as, and become, an increasingly faceless crowd.

COLONIALISM & THE INDUSTRIAL REVOLUTION
1800 to 1900

10

The battle of Plassey in 1757 was an indication of the shape of things to come. Gradually the British were to emerge as the supreme colonial power in the subcontinent.

Murshidabad in Bengal serves as an example of how craft centres decayed and population declined in once prosperous towns, as British-made goods flooded Indian markets. Even the thriving steel industry in Telengana was affected. Indian wootz cakes and steel ingots — misleadingly known as Damascus steel — were an important commodity in international trade. We see swords made of this steel at Hyderabad's Salar Jung Museum. An expert analyses crucible remains and highlights aspects of the manufacturing process.

The Birla Industrial and Technological Museum in Calcutta provides the setting for a scene on the industrial revolution in Britain. One individual could now produce in a day what would have taken him or her much more time earlier. The tremendous social and economic changes that went with it are discussed.

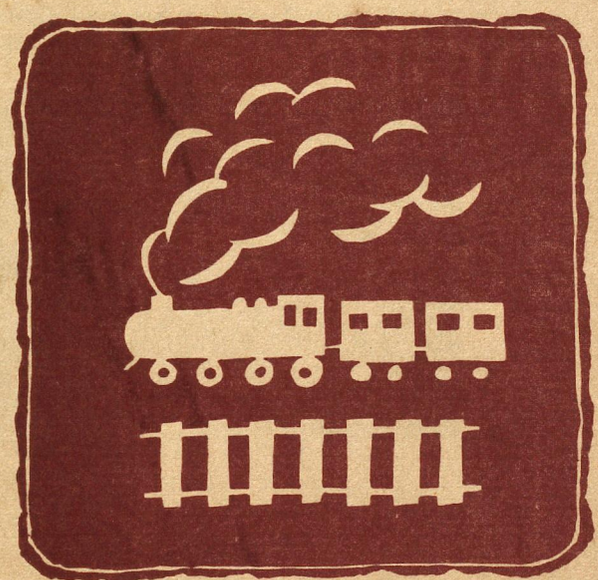
In India, the East India Company conducted extensive surveys of the country's natural resources. These findings led to the development of raw material processing industries and the encouragement of certain crops useful to British industry. The consequent growing discontent of the artisans, the peasants and the nobility presaged the 1857 war of independence.

The 1857 war is narrated in song form. We visit the Lucknow Residency and realise that the revolt relied on the old leadership and on outmoded ideas.

Yet the exposure to new ideas from the West had brought about a fresh awareness. The efforts of social reformers and educationists, such as Ram Mohan Roy, are discussed.

The railways played an important role in the consolidation of Britain's hold over the subcontinent. At Delhi's Rail Transport Museum our reporters reconstruct the manner in which the railways were developed.

The demand for institutes of higher learning grew. At last, Mahendra Lal Sircar was able to establish the Indian Association for the Cultivation of Science, from which a new generation of Indian scientists was to emerge.





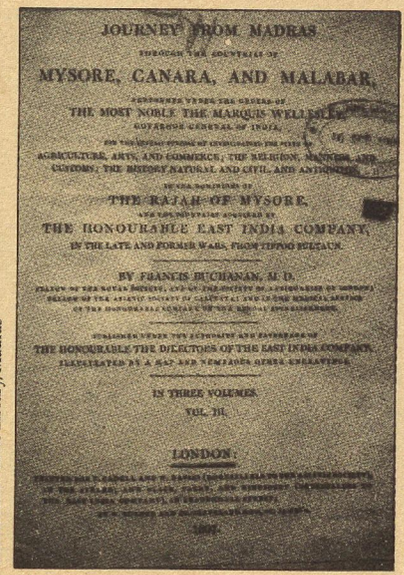
Natural resources: the colonial stamp

The British left in 1947, but even if they had wanted to, they could not have taken back with them the effects of their long rule. The change in our circumstances caused by their coming had given rise to a set of practices that were deeply inscribed into our social structure. Many of these effects are still with us. Perhaps the deepest imprint is seen in our relationship with nature and natural resources. We have also inherited a change in perspective, brought about by modern science.

The period in which these changes made their presence felt was the latter half of the nineteenth century. British rule covered a substantial portion of the subcontinent, and its impact continued to travel in a set direction right upto 1947, touching more and more aspects of life in the subcontinent. This chain of effects begins somewhere in the late eighteenth century, by which time the Industrial Revolution was in full swing, and had become capable of affecting the entire world. In India it meant the large-scale destruction of traditional crafts, a process that continued to force people back to the land, and agriculture. Some of the economic effects of this have been mentioned in the film. Let us take a look at what it meant for our natural resources.

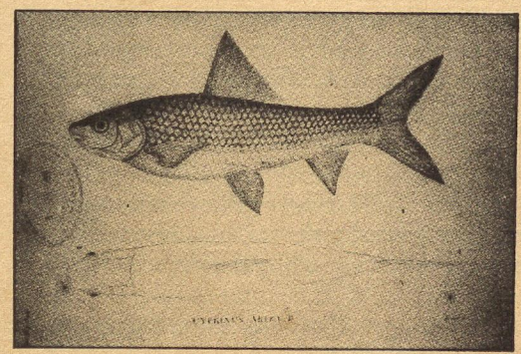
Imagine craftsmen and their families, long settled in the cities, returning to their villages. Their kinsmen, if they had any, were already weighed down by taxes and assessments, and could barely make ends meet. How then were these new entrants to the village to be accommodated? One way was to divide existing land, though smaller holdings would cause everyone to suffer. Perhaps the new zamindars could be approached for tenancy. Given, however, the high revenue assessments, the crises brought about by integration into the world economy, and the increasing indebtedness to usurers, it was clear that in whatever way the sharing took place, there had to be a sharp fall in living standards. There was only one way to prop up this falling standard: bring under tillage whatever land was left untilled; clear it of other vegetation and sow it with grain; whatever its quality, it was land and would yield something. This is what happened, extensively. Whenever this happened, government records, especially collectors' accounts, reflect a great sense of achievement. Bringing untilled land under cultivation meant utilising an idle resource, converting it into an economic asset; it also meant, of course, an increase in revenue.

When we look back at this process in the light of the scientific knowledge we have since acquired, it begins to mean something quite different. It is now becoming well-accepted that in any natural sub-region, around one-third of the land should be under tree cover or, more accurately, leaf cover, all round the year. In the context of our monsoon weather pattern this becomes even more important. When everything dries up in the summer, this leaf cover helps to retain some moisture in the soil, protects it from erosion and allows for a longer period of bio-activity which regenerates its fertility. And, as much of this kind of land is at some height as compared to the cultivated land, nutrients are washed off during the rains onto the cultivated lands and are the basis of their regeneration. Secondly, the soil of these higher lands is often shallow, and is more suited to deep-rooted perennials than to shallow-rooted annuals. When the perennials are removed from such lands and they are brought under shallow-root annuals, the lands remain bare and exposed in the summer and dry up very fast. Erosion by wind and sun make them progressively shallower. In sum, the natural or primary productivity of both kinds of land suffers.


JOURNEY FROM MADRAS
THROUGH THE COUNTRIES OF
MYSORE, CANARA, AND MALABAR,
PERFORMED UNDER THE ORDERS OF
THE MOST NOBLE THE MARQUIS WELLESLEY,
GOVERNOR GENERAL OF INDIA.
FOR THE EXPRESS PURPOSE OF ASCERTAINING THE STATE OF THE
AGRICULTURE, ARTS, AND COMMERCE; THE RELIGION, MANNERS, AND
CUSTOMS; THE HISTORY NATURAL AND CIVIL, AND ANTIQUITIES
IN THE DOMINIONS OF
THE RAJAH OF MYSORE,
AND THE COUNTRIES ACQUIRED BY
THE HONOURABLE EAST INDIA COMPANY,
IN THE LATE AND FORMER WARS, FROM TIPPOO SULTAUN.
BY FRANCIS BUCHANAN, M. D.
PUBLISHED UNDER THE AUTHORITY AND PATRONAGE OF
THE HONOURABLE THE DIRECTORS OF THE EAST INDIA COMPANY.
ILLUSTRATED BY A MAP AND NUMEROUS OTHER ENGRAVINGS.
IN THREE VOLUMES.
VOL. III.
LONDON:

Connemara Public Library, Madras

After Tipu Sultan's defeat, the East India Company commissioned Francis Buchanan to assess the natural resources and economic potential of Mysore . Shown above and below are the title page and an illustration from his report, published in 1807





Asiatic Society, Bombay

An illustration of a cotton plant from an East India company document on cotton manufacture

Unlike the collectors and other officials, the farmers could not have cleared this untilled land with any feeling of joy. They had been forced to do so. Even today, farmers admit that cultivating such land for shallow-root annuals is not its proper use. But with their very survival at stake, what else could they do? As a consequence, agricultural productivity at the beginning of the twentieth century had fallen below that of the medieval period: this was the transformation brought about by British rule to our most important natural resource, land . Even now, more than one-third of land 'under cultivation' is, strictly speaking, unsuitable for cultivation in relation to the normal seasonal foodgrains.

A similar thing happened with our forests and this, too, had serious consequences. In the eyes of the British, the forests like everything else, were an economic resource from which direct returns were sought. Thus forests were extensively cut down, mainly for the railways. Trees like teak, which take anything from twenty to fifty years to mature, were felled in large numbers.

By the 1870s the British had established firm control over the forests. As they wanted to conserve this resource for their own use, strict restrictions came into force regarding forest produce. They also tried their hand at some sort of scientific forestry, with generally poor results. All this was part of the overall scientific policy that they claimed to follow.

Of course there were, even from the scientific point of view, many shortcomings in what they were attempting. For example, their understanding of forestry was clearly based on their extensive experience in managing temperate forests. This could not be applied directly to our tropical and subtropical forests, with their much larger bases of diverse species. Besides, the administrative needs of the British often took precedence over their scientific understanding. This points to another serious shortcoming. When science becomes policy, it usually makes certain social assumptions which may not always be explicit. The social assumption in this case, was that the forests were crown property; while the social fact was that the forests were the basis of the lives of the adivasis who peopled them. British policy effectively dispossessed the adivasis without having to put the deed into words. As a result, the adivasis had to take to settled agriculture on a large scale, or migrate in search of employment — which was often another name for semi-slavery.

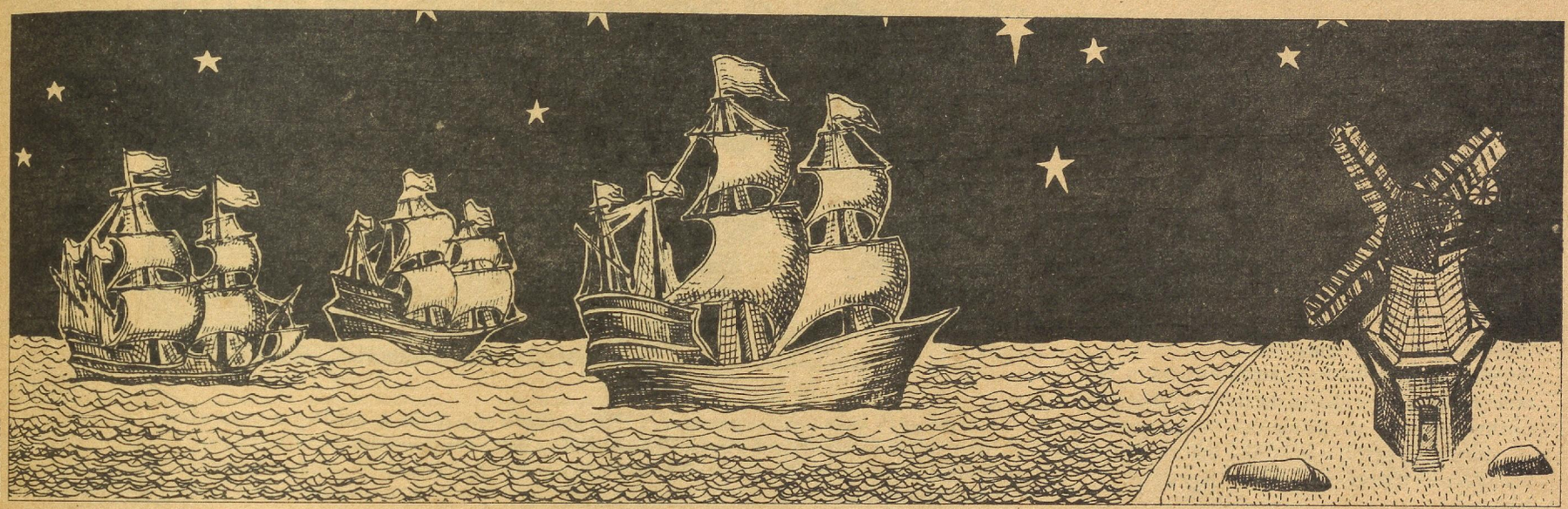
Even today, we tend to think of our forests in a similar manner. We adopt a narrow, 'pure', scientific outlook, without bothering to make the social assumptions explicit. This type of attitude had begun to grow more visible after 1858, when the East India Company ceded rule to the Crown.

With the British also came the all-pervasive importance of money, and newer and wider powers were vested in the hands of the money-lenders and the landlords. This created additional burdens which, again, had to be shouldered by the adivasis and other farmers. Up until the beginning of the twentieth century, therefore, a spate of adivasi and farmers' revolts took place as living conditions deteriorated. Everywhere, famines and epidemics raged. The last decade of the nineteenth century was remarkably crowded with these events. Some formal and informal organising of farmers occurred; threatened by the spectre of a general revolt, the British introduced a few alleviating measures which helped to keep things barely under control. The direction of their policy did not change, only the pressure was a little more bearable.

Land and forests — the most important of our natural resources have not yet been able to shed this colonial imprint. A large portion of our cultivated land remains unsuitable for cultivation, deforestation continues unabated. The measures being proposed reflect the same colonial heritage of narrow scientific thinking: state-run social forestry programmes to tackle deforestation and progressively tighter state controls over forests. Farmers, we have found, do not need to be convinced of the importance of trees, nor do adivasis of the worth of forests. Without taking their problems and compulsions into consideration, can any scientific policy succeed in protecting and improving our most vital natural resources?



Flour mills and sailing ships



Behind every major historical event lies a series of smaller events that lead up to it. These events form its essential background. The industrial revolution is one such major event. The chain of events that led to it stretches far back into the past. There are many links in the chain, but I want to dwell on two that I have found interesting. One concerns flour, the other has to do with the crossing of the oceans. The first is linked to a common daily need, the second related to a few exceptional adventurers.

In Western Europe, and especially in Britain, households did not grind their own requirements of flour as we did. It was ground at the miller's, in large batches, in a mill controlled and often owned by the feudal lord. These mills were run on the energy of running water or sometimes, by animal power.

Why did they choose to store not grain, but flour? Perhaps their climate allowed it. Given the heat and humidity in most parts of the Indian subcontinent, we could not think of storing more than a month's stock of flour. Whatever the reason, in the English countryside, mills had been a common feature, probably ever since feudal lords acquired feudal rights.

These mills were excellent examples of mechanisms. Along with them emerged a stratum of millwrights, often itinerant, whose job was to maintain the mills, and to ensure their proper functioning. Here, then, was a section of experienced mechanics who could deal with and improvise on mechanisms. Inevitably, their presence played a major role in the development of mechanisms that led to the industrial revolution.

And now onto the oceans. We know that the upheavals in West and Central Asia disrupted all the known trade routes by land and sea from Europe to China and the Indian subcontinent. Thus Europe was faced with the challenge of finding a new and safe sea route to India, China and South East Asia. What were the far-reaching consequences of this challenge?

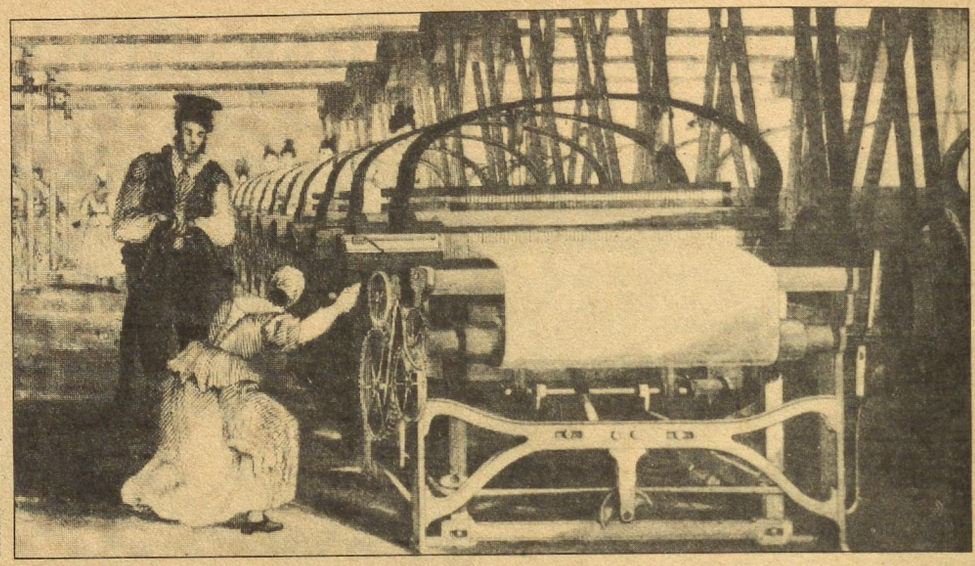
The attempts changed the very character of sea travel. Earlier, seafarers had never ventured very far out to sea, preferring to stay close to the land. The nearest coast, thus, always provided some kind of reference for determining their position. But when it came to crossing the oceans, it was a completely different enterprise. For months there would be no possibility of sighting land, nor were there convenient landmarks for reference in the ocean. The only way to determine one's position was by observing the stars.

This gave astronomy and astronomical observation methods a tremendous boost.

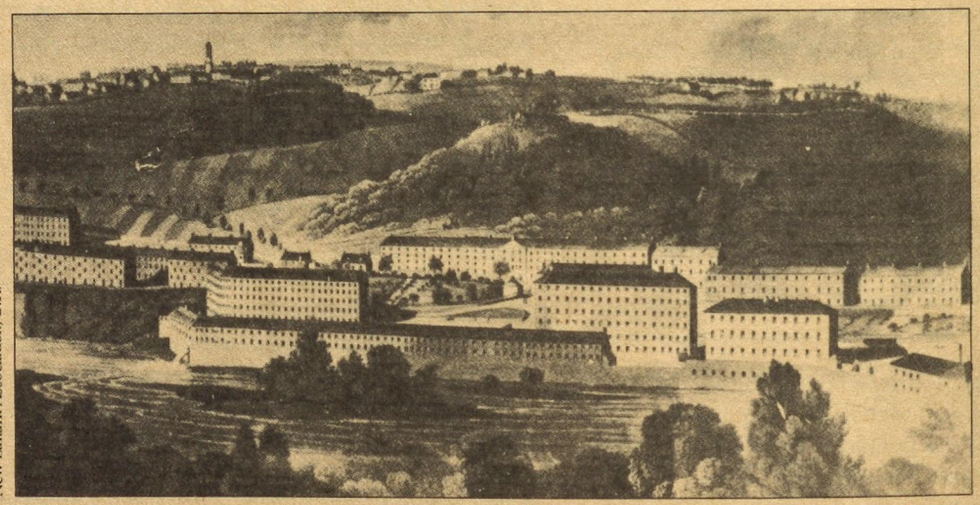
There was another aspect to the problem. It was not sufficient to just observe the stars, it was also necessary to know, as closely as possible, the time of the observation. Until then, clocks had mainly been pendulum clocks; but can you imagine a pendulum clock keeping any kind of time on board a swaying and rocking ship? So competitions were held for the most accurate chronometers, as non-pendulum clocks were often called. This led to improvements and innovations in clockwork. One is well aware how important clockwork precision is to machines.

In an earlier piece in this book, Raghu has mentioned the stagnation of astronomy in the subcontinent, which he links to the social use of astronomy. Astronomy here remained tied down to the determining of *muhurtas* or auspicious times. We seem never to have shown the desire to cross the oceans. And why should we have? What need had we of crossing oceans? It was Europe that needed to find a way across the oceans — to us. They were backward, not we.

Perhaps a factor underlying our backwardness today is our complacent satisfaction in the thought of how advanced we were then. If machines did not evolve here, it was not for lack of skills or innovation on the part of our craftsmen. The problem lies more in our social structure and this is what we must examine more closely.



Science Museum, London



New Lanark Association, U.K.

Cartwright's loom (above), patented in 1786, marked a step in the de-skilling process. Cloth weaving no longer depended on skilled weavers as machines now replaced thousands of artisans. Mill towns like the one below come up, producing thousands of metres of inexpensive cloth



Samir Mandal

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CROMPTON & CO., LTD.

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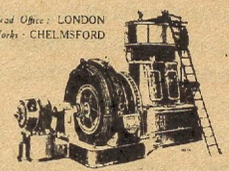
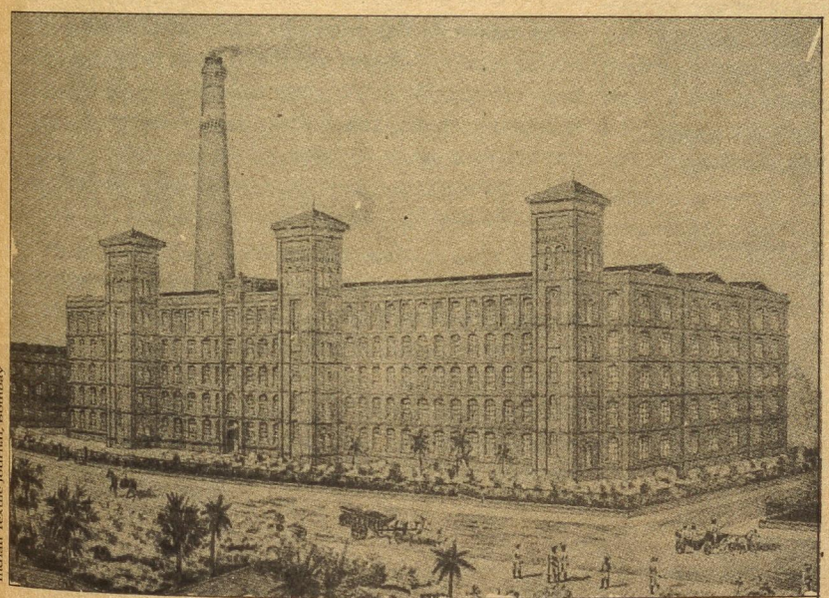
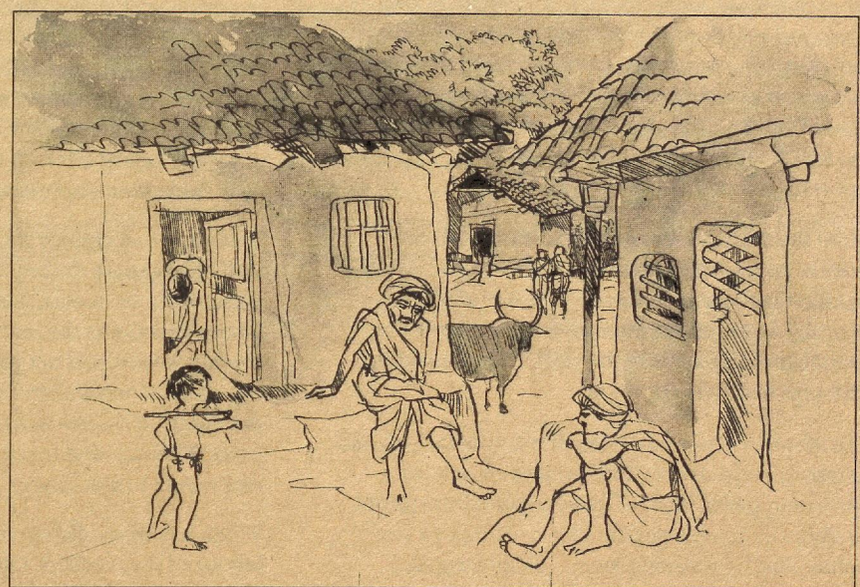


Bombay Branch:—
ALLEN BROS. & CO. (INDIA), LTD.,
Commerce House, Ballard Estate, - - Bombay.

British buyers began to be seen (above) at Indian cotton mandis. At the same time, British tariff policies closed the market for skilled Indian weavers (below right). Like other artisans, they became impoverished. As they were forced to find other work, many craft skills were gradually lost to society. Advertisements (above right) for British textile machinery appeared in Indian journals while textile mills, such as the one shown below, began to be set up here during the 19th century



Indian Textile Journal, Bombay



Samir Mandal



Whom does science serve?

Time and again the potential of science and its social application have differed, often very widely. The potential that a scientific idea has on its own is one thing, and what it may lead to in the course of its social application, quite another. Science enthusiasts and popularisers need no introduction to the immense potential of science; their knowledge of it is the very basis of their convictions. But if they ignore the use made of science, then they may find themselves becoming unwitting instruments, furthering interests and serving purposes they would not even dream of promoting.

An excellent example is that of the role of machines in the industrial revolution. It would seem that machines were a means of easing human labour, but was that why they were introduced? Did they actually do so? The answers are to be found in the social context in which the machines functioned.

Before machines were developed, craftsmen had developed a variety of hand tools in the manufactories. Assemblies of these hand tools became the basis of machines. And then there was division of labour. Both had developed within the manufactories based on handicrafts and 'hand' labour, yet both were important for machine production.

Before the manufactories based on the so-called division of labour appeared, there was no class of unskilled labourers. If someone lacked skill, they generally apprenticed themselves. Over time they would learn and acquire the skill. Doing unskilled work was not an occupation.

With manufactories came the division of labour, and the labour process was split up into its smaller constituent parts. Each of these small bits acquired the status of an occupation. Now, sitting in a one posture and hammering away all day long also became an occupation. I prefer to call this a division of the *labourer*, not a division of labour. It is not simply that different people just handle different bits of the labour process for convenience. Each of these bits becomes a narrow slot into which the labourers are then forced. So what this process divides is not just the labour; it cuts up both the labourers and their capacities into fragments. Since unskilled slots did not require any spending on training, unskilled labourers and their labour also became very cheap. With such cheap labour available, initially machines were not to develop easily. Something more had to take place.

Ironically, division of labour in the manufactories also increased the relative importance of skilled workers. Even after division of labour, there would always be a few pieces which required the full complement of associated skills . Since all other labourers had become unskilled (or rather de-skilled) the importance of skilled labourers increased. This happened while the conditions of the new unskilled workers deteriorated drastically. These skilled workers were obviously socially related to the unskilled workers. They had relationships of kinship, of residence and of work. And the skilled workers took the lead in organising resistance.

Spokesmen of employers are found cursing the skilled labourers during the entire period of manufactories, seeing them and their control over the labour process as the main obstacle to business. In the machines they saw not just a labour-saving device, but also an instrument that would wrest control from the hands of skilled workers, and show them their place. This was the social function that attracted the employers to machines.

When machines did come, they did not ease the labour of the workers. On the contrary, intensity of work increased. Machines did carry the possibility of saving workers' labour, yet their labour increased and they lost their skills. What saving there was of labour, was in the form of labour required *per unit of production*; it made no difference to the total labour put in by workers. The saving added to profits, and more and more labourers became unskilled.



The Complete Dictionary of Arts & Sciences, London, 1764-6

Division of labour, an 18th century tannery in Britain

This is a process that has repeated itself time and again, with every wave of mechanisation. Its most recent example is that of computerisation. In short, the declared potential of machines and the actual use they are put to, are quite different, and can even be contradictory, things. This gulf between the potential and the actual will always have to be kept in mind, if we are to fully understand the possibilities of science.



Nature: from resource to property

Reading Ranjan's notes on the scientific revolution, one thing struck me very sharply — that sometime during the scientific revolution, a big change had taken place in our relationship with nature. The science that was emerging was giving birth to the mechanical age. The machines people made were of course a part of it, but only one part. A new kind of perception contributed by science was the other part — an understanding that looked at each phenomenon as a mechanical event. The deterministic course that science chose was an outcome of it.

All this meant a new way of looking at nature too. The universe was seen as a huge machine, in which everything that happened was predetermined. All parts of this machine-like nature had been made by and were directed by, definite laws. It was assumed that if we learned to recognise these laws, then by knowing the present configuration, we could exactly determine future configurations. Though the laws themselves were predetermined and could not be changed, humans could intervene and change configurations, and bend nature to suit their needs.

Earlier, science had often looked upon nature as something unpredictable, controlled by forces which humans could not understand or control. Because of this, there was a certain amount of respect and reverence for nature, growing perhaps out of a basic feeling of fear. Attempts were made to understand this behaviour, in order to be able to cope better with nature's sudden changes. In a sense, we acknowledged that nature exerted, and would continue to exert, some amount of control over us and our lives.

This understanding was totally overturned with the views that came with the scientific revolution. Now nature became something humans could manupilate . Be it the flora of a particular region, or the nature of the soil, water and atmosphere, or the creation of synthetic materials, or adaptation of natural materials, or the control over life forms, or the control of fertility — for the reductionist philosophy of science that emerged, all of these phenomena could be handled, observed and manipulated at will. By looking at and understanding the parts, science thought itself to have the power, and wanted to be in control over the whole.

This new attitude disturbs me because of its drive to dominate nature, though, of course, it comes mixed with an equally aggressive desire to understand it too. However, what has developed and dominated the mainstream attitude is this urge to control. By our times it has come to be projected as the final aim of science: not only that of understanding nature, but of wielding power and domination over all its aspects.

When this kind of thought was introduced, it was a challenge to religious understanding, especially to Christian thinking about the world and its relationship to god. It did not fully dispense with the idea of a creator who made the whole machine of the universe and laid down the laws of its functioning. The concept of divine intervention continued to a limited extent.

The final challenge to this idea of a static order provided by the creator came with the theory of evolution, when the fixed, hierarchical order of life on earth was challenged. Life began to be viewed and understood as a dynamic system with species evolving, changing and disappearing in conformity with their needs and roles in the environment.

In a sense, the theory of evolution was a radical challenge and threat to the prevalent religious beliefs. Yet, the repercussions that its proponents had to face were not as harsh as one may expect. The philosophy of the mechanistic world had already been imbibed, and it helped create the space for more radical ideas and views to be expressed.

I find it ironic that the mechanistic world view has almost become a dogma for many of us today. Even though developments within the different disciplines of science are pointing towards unmitigated disaster as the only possible result of the drive for unlimited control over nature, such indications are paid lip service at best, and in practice are being completely ignored. One would like to keep doing what one does, the way one does it. Openness to change is once again the casualty.



The contradictions of modernity

The latter half of the nineteenth century in India has always excited me. Looking back at that contradictory period, it appears to me that the seeds of many of our present-day problems can be traced to it, especially those issues taken up by the new movements and campaigns we see around us in recent years — people's science, health, environment, mechanisation, unemployment, computerisation, education, and women's questions, amongst others.

Many of these new movements seem to oppose modern science and technology, and I think that this too can be traced back, to the debates of this period. I would like to approach the contradictions of modernity from this perspective, because these movements are themselves expressions of these contradictions.

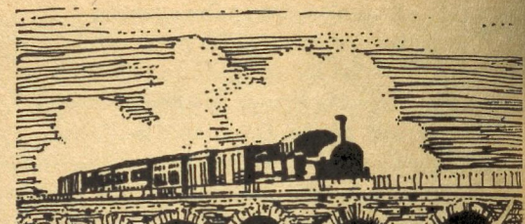
Take industrialisation. The British took raw materials to England, manufactured finished goods, and brought them back to India for sale. Local craftsmen, and cottage industries could not compete with British industry and were ruined. Unemployment grew. Soon there was a demand that Indian businessmen be permitted to establish factories here to provide employment. With much difficulty, a few entrepreneurs managed to import machinery and set up factories, mostly in textiles. Industrialisation came to India in this way, on a limited scale, not allowed to grow enough to be able to compete with British industry.

Independent India also adopted a model of industrialisation. With it came mechanisation, which engulfed all areas of production, including agriculture. In retrospect, one finds that problems like environmental pollution, or unemployment, or depletion of natural resources, originated in this period. We may, if we wish, blame those who pushed for industrialisation of this kind in the 1950s. Before we do that, however, we need to take a closer look: was it possible at the time to foresee all these problems? And even if some problems could be anticipated, did they have any alternatives in the context of those times?

Today, we have come to recognise that modernism also creates its own problems. Yet, can we say that the the inadequacies of the prevalent system of modern medicine would be overcome by going back to an older system that had evolved in an entirely different social context? Is revivalism the only solution to the tangled problems of modernism? Often people see in revivalism an answer to our difficulties. I think, however, that it is necessary to make a clear distinction between learning from our history and trying to relive it!

Modern medicine, modern education, modern law, modern science — there was a stress on modernisation in every area. The social reformers of that period looked forward to such a change. Today, we are beginning to see the contradictions, and the issues appear in a new light. However, how could they not have seen these as a liberating force?

The education system provides a good example. What we today dismiss as an education meant for producing clerks was in retrospect, a step towards modernisation. It broke the constraints of the earlier system and brought education within at least the ambit of all people. How many people could actually avail of it is a separate issue, and so are the motives with which the British introduced their educational system. However, what we cannot deny is that modern education set up a structure that was comparatively more open. Of course, with it also came those aspects we have to suffer through today: it seems to make people more dependent, passive, narrow-minded and lacking in the ability to think independently. But despite this evaluation, can we ignore the historical role it played in its own time?



The first train run, Bombay to Thane, 1853. This marked the entry of railways to India, carrying with them one of the contradictions of modernity

Questions of development and modernisation are extremely complex. The significance of any decision is not permanent. Decisions we take today may be tested and analysed tomorrow in a different context and found wanting. What is important is how we make these decisions. Do we decide with an open mind, taking all known aspects of the issue into account, or do we just blindly extend established responses, strengthening them and foreclosing other options? The unfortunate part is that many would agree with the former, but finally, when the decisions are made, established power equations and self-interest seem to win the day.

THE FREEDOM STRUGGLE & THE SCIENTIFIC COMMUNITY 1900 to 1947

11

Our reporters pore over books in a library, and trace the scientific landmarks of the twentieth century. A song evokes the Russian Revolution of 1917, and the two World Wars, then returns us to India's freedom struggle at the start of the century.

A profile of Bombay under the British reveals how ports were developed as commercial centres. We visit docks, workshops, a textile mill, reconstruct the migration of people to the city, the growth of an entrepreneurial class, and the emergence of highly skilled mechanics.

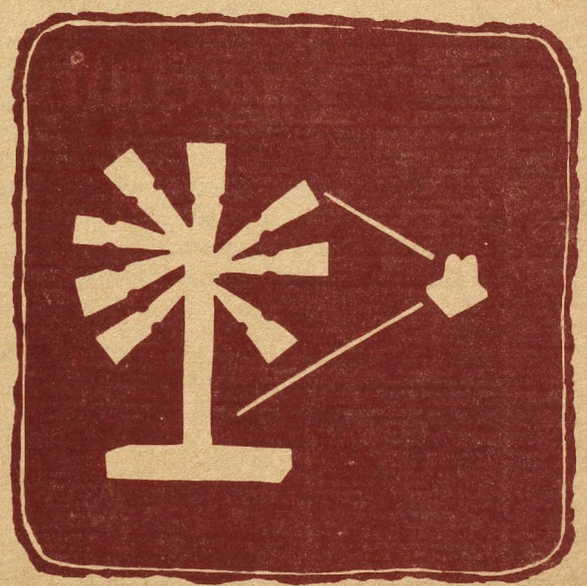
The spread of education contributed to growing nationalism. The national movement also brought scientists into the fray. The work of scientists such as J. C. Bose, P. C. Ray and C. V. Raman is discussed. The institutes they founded, their place of work, their instruments and old photographs are seen. We visit an exhibition on Raman and explore his work in acoustics and the Raman effect.

At the Udaipur Solar Observatory we understand the contribution made by Meghnad Saha's theory of thermal ionisation to astrophysics. These early scientists were, significantly, involved with the setting up of a number of institutes and industries; they had a vision of a free India. Many served on the Planning Committee founded by the Indian National Congress in 1938.

Meanwhile, the plunder of our natural resources continued, and the story of coal is a typical example of this. A visit to the coalfields of Dhanbad helps us understand how unscientific mining practices led to cave-ins and coal fires that still rage underground.

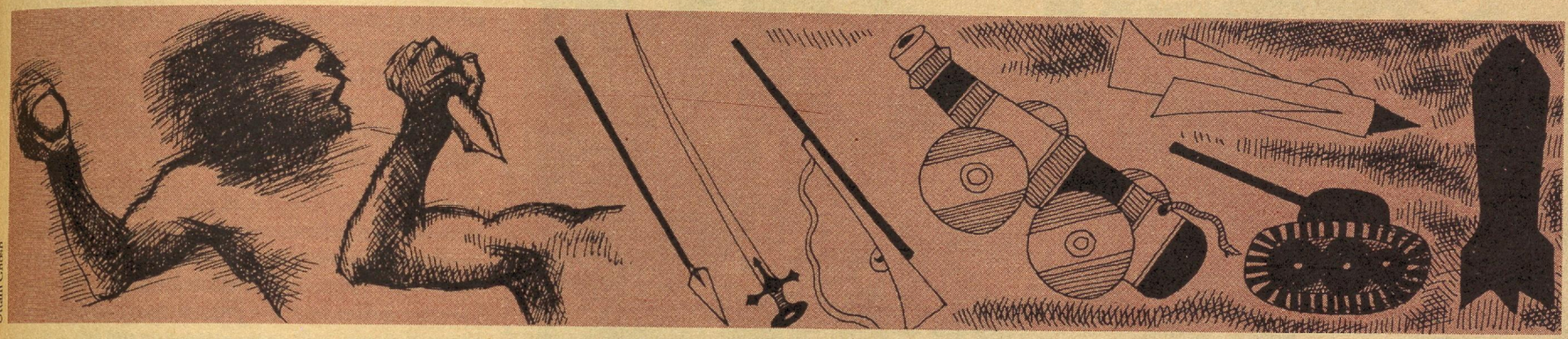
The reporter narrates how geologists and mining engineers came together and, against all odds, demonstrated that Indian coal could be enriched by a washing process. This mobilisation of coal-washing technology was also a nationalist achievement.

Finally, it is 1947 and independence is won. The trauma of Partition is mingled with hopes for the future.



amrita

War



Uttam Ghosh

Studying for our history examinations in school was invariably a trying experience. We had to remember the dates and years in which battles were fought, the names of those who fought them, and also the reasons for which they did so. It seemed almost as if history was only an unending series of battles and conquests. And that our ancestors did nothing but fight among themselves. Whatever material progress had been achieved seemed incidental!

Studying and thinking about the history of science for this serial brought us to a forceful realisation that history is about human achievements through the centuries. It is about the ways of living that human beings evolved, and of how these changed through the centuries. It is about life and living, not about war and killing.

Yet, wars have been major turning points in history, because they have affected the ways of living of large sections. It has never been more so, than in this century, when we have not only faced two world wars, but have also learnt to live under the constant threat of an impending third one.

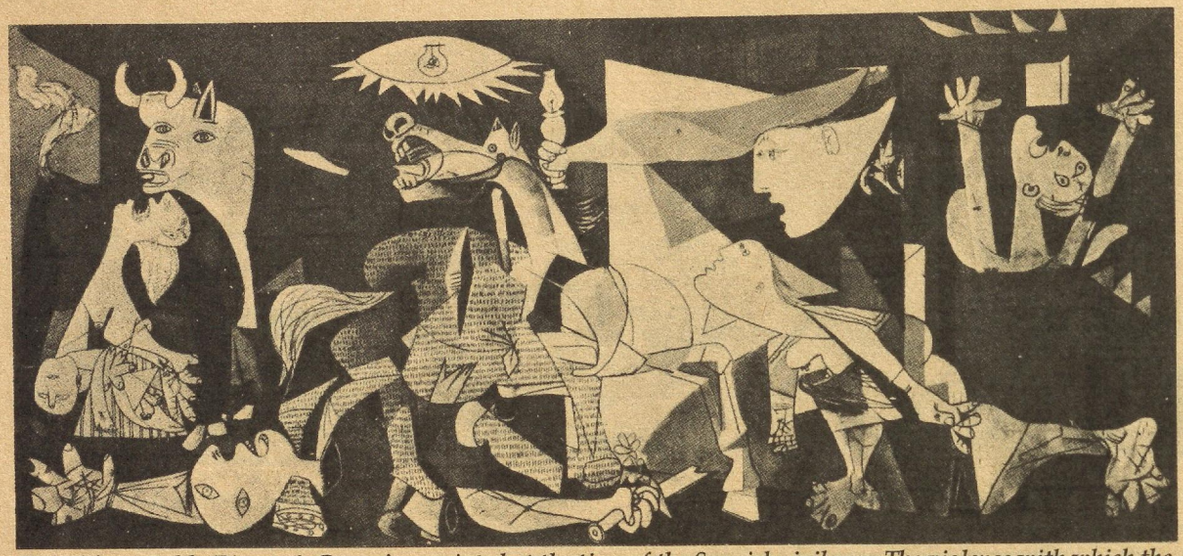
War is man-made, just as much as is science and technology. Hand-to-hand combat, weapons of stone and wood, armies on horses and elephants equipped with strong metal weapons, gunpowder and artillery, rockets and ballistic missiles, improved navigation systems linked to flourishing trade and correspondingly strengthened naval power, aircraft capable of flying and inflicting destructive large-scale air-raids, the proliferating number of devastatingly efficient, modern and accurate weapons developed after the recent information revolution — all of these are important steps in the development of war, a journey parallel to that of science, from pre-history to the twentieth century. Wars have been waged to retain power over kingdoms, to expand their territories — in the end to establish someone's superiority and domination.Religious, nationalist and communal feelings have always been mobilised in support of war. To establish one's superiority it is necessary to have a measure. This measure was found in the emotions of human beings, and wars have been justified through such sentiments — in the name of a religion, a race, a community, a king.

Wars have also been the clash of two powers, of two powerful but opposing currents of thought. A historian has analysed the Mahabharata war as a clash between a declining matriarchal lifestyle and a patriarchal royal power — a clash between a disappearing life style based on a different ethic, faced by the emergence of new values.

Broadly speaking, most wars seem to arise from the growing insecurities within society. A constant dual search has been a part of human nature. We are in search of our identity as individuals, and simultaneously of our place in society. The dynamics of this dual search depends on many social factors like family, caste, region, language, religion, nationality, and so on. Upto the point where there is no great contradiction and clash between these factors, all of them have a meaning and place of their own. Today, however, their mutual relations have changed significantly.

Competition has become part of our lives and of our 'nature'. These social factors, capable of creating a sense of belonging and identity, do not seem to have much value in themselves today; they seem to have a value only in comparison with another. The competitive belief is that an individual or a nation can survive or stay ahead only at the cost of another. And the ultimate means of proving it is to assert one's power — by force.

Wars have been fought to redetermine and reassert national boundaries, to gain more power, resources, property and wealth. But at the same time, wars have



Museo Nacional del Prado, Madrid

Detail from Pablo Picasso's **Guernica**, *painted at the time of the Spanish civil war. The violence with which the human form is torn apart and reassembled reflects his anguish at the horror and barbarity of war*

also been fought to weaken others, to take away their property and wealth, to reduce their power, to make them dependent and to exercise control over them. To establish one's strength, it is not sufficient to demonstrate it; it is as, if not more, important to weaken the *other*.

Science and technology helped in this show of physical strength directly, by inventing weapons and methods of war, and indirectly too, by helping improve the economic strength to wage war. In our study of history we have so often seen armies with better military technology winning the war — whether it meant horse-shoes and iron stirrups for the cavalry, or chemical and nuclear weapons.

Besides this, theories of science have been used and also developed in the service of war. Which aspect of a theory is highlighted depends on who is using and proposing the theory. Take for example the theory of evolution. As we said earlier, our evolution seems to indicate that we are a peaceable species, lacking in obvious aggressive physical paraphernalia like claws. We have made up for this by mastering other processes of survival.

Yet, one finds this theory exploited for justifying aggression and wars. "Survival of the fittest" is a catchphrase used to justify cold-blooded murder in the name of war. When fitness is itself defined in terms relevant to war, then surely for the fittest to survive, wars will become essential. Fighting and grabbing, and surviving it, "against all odds" is essential, for that determines and measures the fittest.

There are many such double-edged swords in the period of the scientific and industrial revolution, that cut two ways. This period universalised science, globalised trade and brought the whole world close enough for it to be called the global village. Regions and societies separated by thousands of kilometres are today so linked that local ups and downs directly affect the global scene. But with this development, war has also acquired a global character. Armies had joined forces in earlier times too, but for the first time entire countries the world over aligned themselves with one side or the other and fought with their full strength. No one went untouched in the two world wars. Not just governments and armies —all individuals have been affected.

Since the second world war, international politics, even national policies and plans, have evolved under the threat of another such war. Each nation considers itself forced to participate in the arms race, using up valuable resources in the process and denying people access to them — all so that the powerful can participate in the deadly game of power. And wars go on. The Gulf war has just ended with another round of destruction. Not just destruction, but also casting the threatening shadow of power — rather super-power —over the world.

The developments in communication media and military technology brought the Gulf war to T.V. screens in millions of homes. Thanks to them, the war appeared as a colourful display of fireworks, efficiently masking the screams of thousands of people. Science and technology were used deliberately to make war a thrilling hi-tech extravaganza from which the vicitims' suffering and pain were surgically erased.

Of course that is not all there was; there were other, fleeting glimpses too. During the Gulf war we saw vast amounts of oil burnt and destroyed, we saw it spill into the sea and destroy marine life. We also had glimpses of a few injured persons from Kuwait and Iraq. But more than that, we also heard voices for peace from all over the world. Voices it is our duty to strengthen, so that they may come across loud and clear. For in these voices lies the possibility of a future which concerns itself with life and living, not with death and destruction.



raghu

The new dimensions of reality

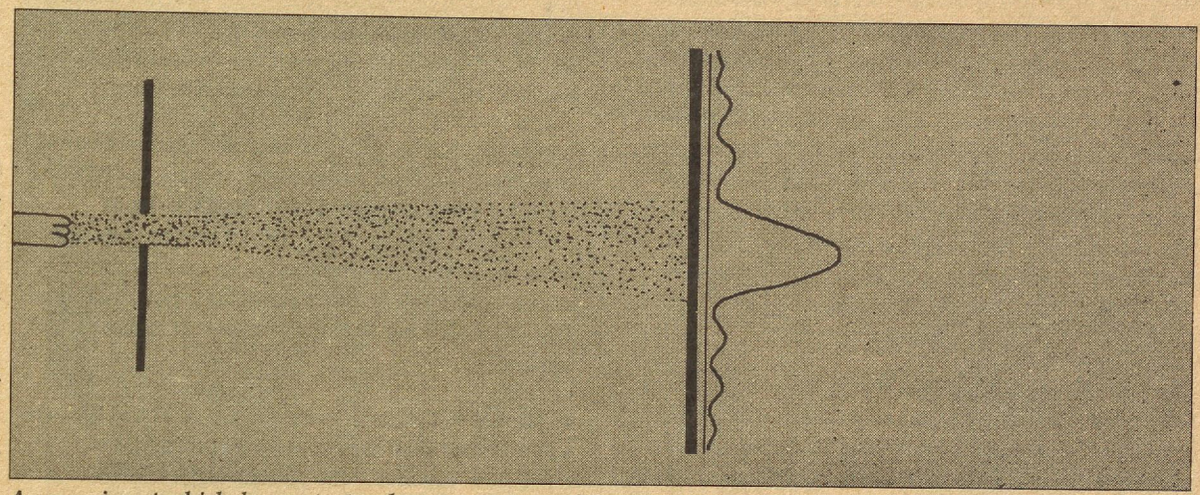
The twentieth century has been extremely important for science. Not only did science progress, it also transformed industry, which has reached unprecedented heights. Today, we constantly use objects which owe their existence to this transformation and explosion in knowledge. And yet, one thing keeps troubling me.

This transformation in science shapes our cultural milieu to a very large degree. Every event, all things have demanded new definitions. The criteria by which phenomena are judged are themselves changing. Yet, the new perspective that quantum theory has given to science has not become part of our thinking at a social level. Why is there no open and serious social discussion of a theory like quantum mechanics, which questions the accepted basis of science? An uneasy silence seems to surround the questions raised and directions opened up by quantum mechanics.

Was the modern revolution in science merely the discovery of the formula $E = mc^2$ and the understanding that it is possible to inter-convert mass and energy? Was all the discussion to amount to just an understanding that the question was not whether the electron was a particle or a wave but that it was both?

Undoubtedly, quantum theory has been of crucial importance to science, especially to physics. It was an inevitable step in crossing from one kind of science into another. But what I want to know is, did it affect the thinking about science, its philosophy? I find this an important question in relation to the history of science.

The perspective that dominated science for three centuries was now shaken to its foundations. The new discoveries directly challenged the determinism and reductionism of the earlier viewpoint.



Raja Mohanty, based on John Gribbins, 1984

An experiment which demonstrates the wave nature of electorons

To break a thing, a process, down into its smallest constituents, to understand them and reassemble them, that is, to understand the larger whole on the basis of the properties of its smallest constituents — this reductionist method of science itself was shaken by quantum mechanics. The behaviour of the smallest particles turned out to be strange and quite unexpected. Scientists tried to visualise them in the same way as they did familiar, tangible objects. But these tiny particles deceived them. So much so, that the very way science saw things and defined reality came into question.

The second point that was brought home was that it is not possible for science to predict anything with complete certainty, even in principle. In other words, there need not be a single answer to every question, even within science.

Is an electron a particle or a wave? The business of science, it had been assumed, was to provide a single correct answer to such definite questions. Science was now forced to say that the electron could be either a particle or a wave, or even both. Which of them is the 'real' electron became a secondary, and in many ways, an irrelevant question.

This was not all. It has been proved that we see the electron in the form that we want to see it in. For example, if we (that is, the experimenters) perform an experiment which expects the electron to behave like a particle (or like a wave), then it will oblige us by behaving like a particle (or like a wave). Some physicists would object to putting their complicated theories so simply. I think, however, that while discussing science, history and philosophy, it is often useful to state matters simply. I might add that even researchers sometimes need to put aside their

mathematical formulae and express themselves thus, in order to think about a problem more deeply.

What our experiment reveals, is crucially dependent on the thinking and the purpose with which we choose and carry out an experiment. A science that had considered itself completely objective, that is, its being wholly subjectivity-free, as its hallmark, has had to change its very terminology. It has now had to accept that the purpose with which and the way in which an individual observer perceives an event will also determine what that observer will see, what the result of the experiment will be. In this way a science that claimed complete objectivity has had to incorporate subjectivity into its very basis.

It is time we re-evaluated all the concepts we had borrowed from the pre-quantum theory science and which continue to shape our lives. Reductionism, determinism, and objectivity — those pillars of the old science have proved themselves inadequate; they have reached the limits of their usefulness. This does not mean that all science learnt and discovered so far is meaningless, or wrong, or useless. The basic lesson of quantum mechanics is that there need not be a single, unique truth. Reality is multidimensional. There is no hierarchical, graded relationship between these dimensions. Within their definitions and their limits, none of its truths are less, or more, than any other. They are all respectively true. The important thing is to discover how they relate to one another, how they can be and are consistent with one another within their different contexts and limits. Otherwise, we are likely to miss this multidimensional truth in search of the mirage of a single absolute truth.

You may ask what all this has to do with the history of science. To which a reply, with some questions: it is true that the new discipline enabled science to recognise its limits and to take a new direction, but what were the social circumstances which enabled scientists to think and to express these new thoughts? Was such thinking only possible in that kind of a milieu?

What was the chain of events that brought us to such a point? And then the question that intrigues me most, how was it that the new findings scarcely affected our life-styles and cultural milieu?

To a large extent, not even science, not even physicists, even though they use quantum theory like a cook book, have really made a thorough-going effort to make the new perspective the foundation of a worldview. Why are they afraid of accepting this change in perspective? Caught in their routines, they are shying away from building with it afresh, creating a whole new perspective. Is it not a refusal to acknowledge that quantum theory has become part of physics and of scientific thinking?

Pursuing such questions is also part of our quest. Among the answers, we shall have to include many differing opinions that have been developing alongside the dominant currents.

Majority thinking has not always been, and cannot always be the only, or the best thinking. Alternative thinking has always existed— sometimes as warning, sometimes as an opposing viewpoint, sometimes as challenge thrown to the mainstream tradition, sometimes striking out into unexpected, unexplored realms. There have always been many different voices, rather than a single chorus. From time to time such alternative thinking has been responsible for major shifts in viewpoint. Instead of enforcing a single truth, the new physics exhorts us to accept diversity and seek out the consistency that can hold together what we know. For it is only by accepting diversity in thoughts and aspirations that we can build a comprehensive worldview, through which we may then be able to glimpse another kind of future.

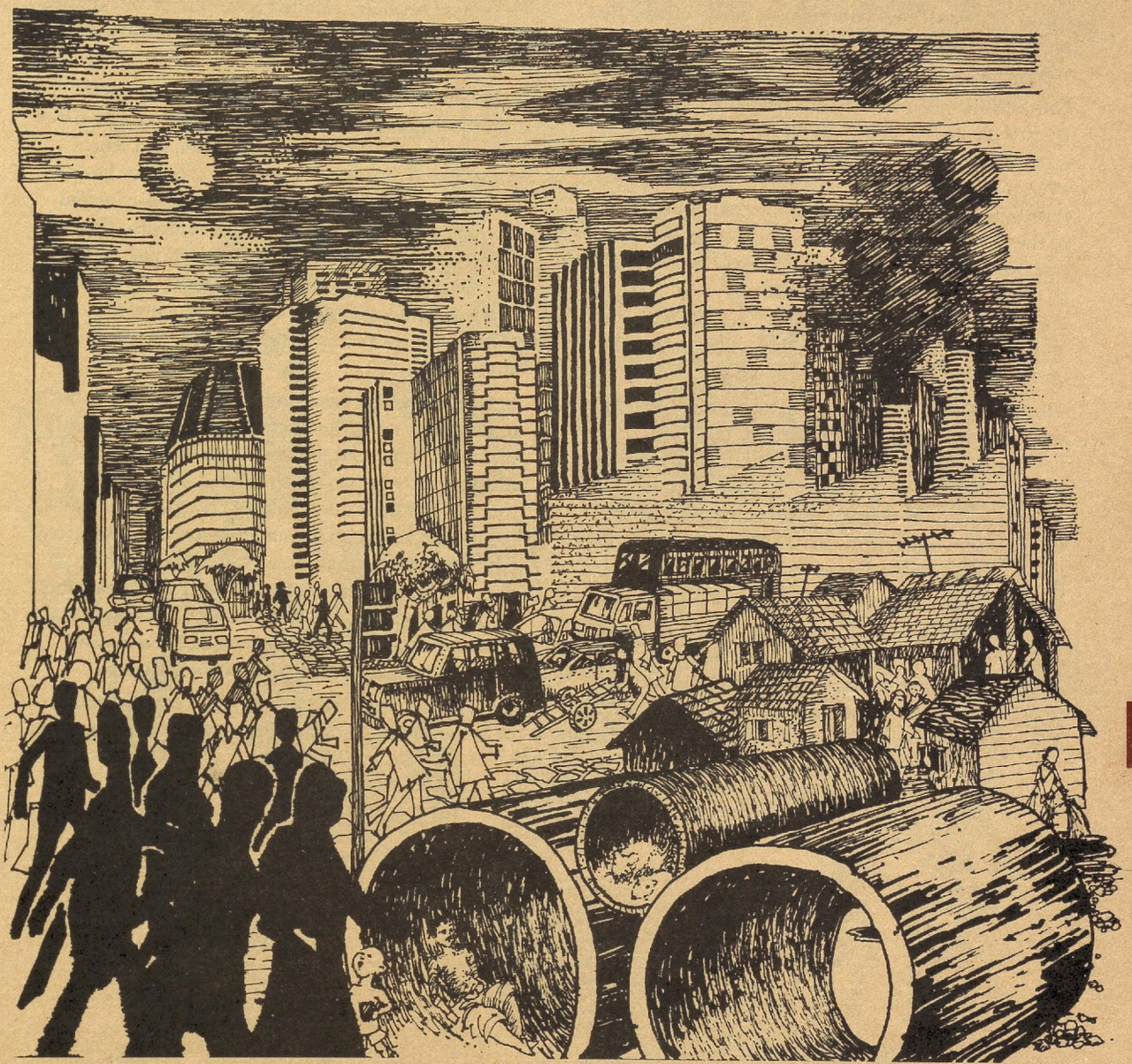


Modern cities: the arena of change

Urban civilisation has been with us since Harappan times. Even though its basic defining characteristics have remained the same, in recent times there have been a number of significant changes. The cities of the Harappan civilisation — Mohenjo-daro, Harappa, Lothal, Dholavira — were all mainly dependent on rivers. Then comes the period of iron age cities based on trade. A centralised order existed, under it all kinds of services and goods were available, and it was possible through a system of exchange to obtain everything needed. This exchange took place not only between the cities and the immediate countryside, it encompassed far-flung cities, and also distant lands. Several other urban civilisations were to flourish on the subcontinent in the two and half millennia that followed.

All these urban civilisations provided opportunities for arts and crafts to prosper, encouraged science in new directions, and often provided the ambience for new ways of thinking. The invention of many new systems of organisation and techniques was necessary for the smooth functioning of these growing cities. And indeed, they did take place all along. But compared to the older cities, the twentieth century cities were built on new foundations.

Modern industry — machines and factories — had replaced crafts workshops, and the old craftsmen were giving way to new machine-tending workmen. A new kind of city began to take shape. Old cities which could fit into the new industrial pattern because of proximity to raw material, or because they were trade centres, survived and even thrived. To maintain industry and all that went with it, they also had to change themselves. Some transformed themselves entirely while others went through only surface changes. Sections of the old city remained



Raja Mohanty

intact, with their narrow lanes, crowded houses and packed markets, while around them grew new patches based on modern principles of town planning. Sometimes entirely new cities were settled, and they grew into huge sprawling industrial and commercial townships.

One striking characteristic of these new cities is the pace of change: in every city the population has expanded to many times its original size. Different avenues of earning keep coming up at such a rate that it is difficult to keep abreast of the changes and adapt to them. Machine-imposed rhythms have moved so fast that humans are left far behind. So much happens so quickly, that even ten-year-olds can say, "When I was a child, it was not like this!" Changes which earlier took place over generations, now seem crammed into a single lifetime.

There was a time when we were directly affected by the industrialisation taking place in Europe, but we had no machines, no factories, either in the cities or in the countryside. Our economy was entirely dependent on the export of raw materials; our city markets sent out raw material for industry elsewhere, and received finished, machine-made goods.

But why mention this? Because relations between the city and the countryside are assuming a somewhat similar shape in the present. Increasing job opportunities in the cities, and declining resources and jobs in the countryside have brought about large-scale migration to the cities. One does not really know if it was the same with the old cities, but today many believe that the key to prosperity and happiness lies in the cities. Today, cities do not mean only good services, planned *bastis* and power centres; they are a mass of contradictions, visible most of all in the metropolises.

Inequality has, of course, existed since Harappan times. All Harappan cities had one section where the houses were larger, the services better, and where political and economic power seems to have been based; the other parts had smaller houses crowded together and narrow lanes where, evidently, the urban poor lived. But in the modern industrial cities, this inequality reaches new extremes — the contrast between the *jhuggi-jhopadis* of the slum and the palatial houses and skyscrapers, is much more apparent.

In this civilisation based on modern science, we have much that is new. The modernisation of transport, communication and the media has had a revolutionary impact. Nevertheless, I keep feeling that this modernisation has not brought about any great change in thinking, in our ways of, and reasons for, living. Modernisation was expected to bring about democratisation; the availability of cheap and durable goods was to assure a decent existence to all human beings. Yet equity has remained a distant dream, while disparities have become sharper.

The greed for profits does not end with exploitation of the workers; it is also destroying the environment. Drinking water, crops and the fields, even the air we breathe is not free of its effects. Already weighed down by the strain of aimless labour, human bodies are deteriorating at a faster rate in this polluted environment. In the developed world and the metropolises of the developing world, the wholesome life has been left far behind.

Science was meant to make our lives richer and more satisfying. We experience instead a strange unrest among the jostling crowds, caught up in the incessant workpace. People find themselves increasingly lonely. As we run our lives by that oldest of instruments — the clock, as we strive to acquire the latest wonders advertised on television, as we rub shoulders with the rest of the crowd, we somehow manage to keep ourselves together, though perhaps bit by bit we also become strangers to our own selves. That may be one of the reasons for the arson and looting — incidents which drag us back a couple of steps each time. It is probably this search for our lost selves, for our identity that is being manipulated into dangerous channels — communalism, regionalism, linguistic chauvinism ...

I draw a little comfort from the iron age cities. They lived through a similar period of unrest, but they also gave rise to strong philosophies which expressed this unrest and yet changed the course of history. Perhaps our unrest and despair today are also a prelude to new thoughts, new ways.



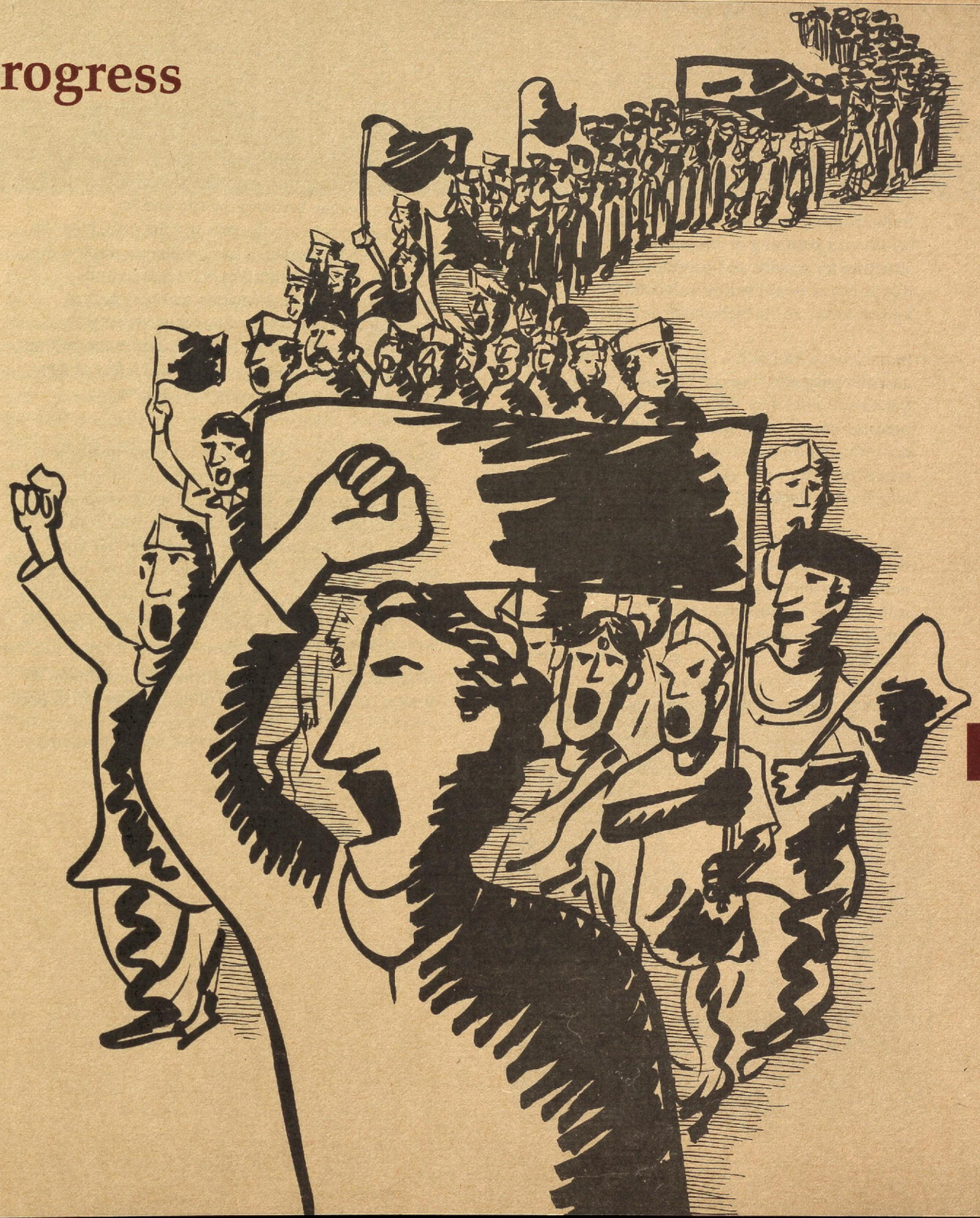
Visions of progress

In the course of the series, as we travelled from the stone age to modern times, we have constantly examined the relationship between science and culture. At the beginning of the episode we spoke about the changing direction of science and its growth in the twentieth century. An important aspect of this change was that science came to be seen as something that would make life more comfortable. The twentieth century also gave concrete shape to the concept of a nation and various political ideologies and systems — democracy, socialism, dictatorship, and so on.

In the subcontinent, awareness of science developed with the national movement, and was linked to aspirations of independence and nation-building. A range of people with a diversty of outlooks joined the struggle for independence. Bound by their common experience, workers, intellectuals, farmers, women, industrialists, and politicians with different approaches, were able to sucessfully organise a collective revolt.

In this context, I would like to talk of Gandhiji. He developed a unique concept of freedom, from which emerged the policy of *ahimsa* or non-violence — an idea related to the ancient philosphies of this land. In today's violent and divided world, ahimsa has acquired a new meaning. Then there was his stress on *swadeshi* as opposed to foreign goods and industry. Swadeshi included *grama-swarajya* or rural self-government and self-reliance which were vanishing under colonialism.

Another aspect of swadeshi was linked to the issue of control over the country's resources, as expressed in the Dandi salt satyagraha. His campaigns made Indians sharply aware that the British were taking away all our resources for the benefit of industries in Europe. The adverse result of this process — the



Uttam Ghosh

destitution of artisans, deforestation,and the effects of over-intensive agriculture —would have to be faced by us later after independence.

Parallel to Gandhiji's, ran the view of those who hoped to modernise India through industrialisation. This was the predominant policy of independent India, adopted with the aim of self-reliance. Based on centralised planning of resources, and a centralised structure for science and research, the foundation for this policy was laid before independence and it is known today as the Nehruvian model.

India is not a monolithic nation. It has great variation and diversity, and it seems necessary to bind it together. If after such a long period of struggle, we perceive ourselves as one nation, then can we really do without a central structure, ideally one that would retain diversity, and yet increase the give-and-take on which unity depends?

As I have indicated earlier, both models are concerned with science and planning, and both emphasise self-reliance. Yet the meaning of self-reliance is different in each. The idea of swadeshi self-reliance means that the smallest units of the country are self-reliant, and thus the whole country becomes self-reliant. In the other model, the basic unit becoming self-reliant is the country as a whole, which means its self-reliance is mainly in relation to other countries.

The centralised model of science and planning is being widely criticised on a number of grounds today. Critics feel that instead of retaining diversity, this model has attempted to impose uniformity. Instead of bridging the gap between the city and the countryside, between the rich and the poor, it has in fact widened it further. It has resulted in pockets of affluence and concentration of industries and high-input agriculture creating many ecological problems that are further damaging society's relationship with nature. Many examples concerning this are before us, we have mentioned a few of them in the film and will discuss some of these in detail later.

One of the aims of centralising scientific institutions was that capable scientists should get all the facilities needed for research. This institutionalised approach, however, somehow isolated our scientists from society. The research in our laboratories did not reflect the concerns of society. Even if it did, often the results stayed in the laboratories and did not circulate among the people. The distance between science and society went on increasing.

A leprologist has recently criticised his institution on similar counts. He is critical of the tendency to import and thrust products, unsuited to our social needs and ecological situation, on our people. This happens despite local alternative products, developed with much effort in our laboratories, being available. He maintains that such policies are constraining and stunting scientific growth. Such open criticism of science policy and its implementation should be welcomed. There is, however, another dimension to this: today scientists recommend that any product or technology must first be tested in its proposed social environment before it is introduced. Such demands may be related to the way in which their research has been ignored. However, would imposing the research results of a few centralised national laboratories on the whole country not be comparable to blindly importing the latest from the west? After all, we have extremely varied social and ecological conditions, so innovations require trials everywhere. This type of contradiction, inherent in centralised institutions, is now being felt in almost all areas of endeavour.

In our journey through history we have visited periods marked by conflicting trends of thought, we have seen how debates and exchanges have led to the evolution of new ideas and new cultures. Today science may appear to be an independent, autonomous force. But until it faces and answers present-day challenges, the road to further progress may well be blocked.

INDEPENDENT INDIA
1947 to the present

12

The attainment of independence brought with it the challenge of development— equitable growth and economic regeneration of a depleted country. This experiment fired the imagination of scientists and technologists.

A scene on Homi Bhabha gives an example of how scientists of the time were involved with building up institutions. The emphasis was on self- reliance.

A trip to Bombay High and a talk with the Chairman of the Oil and Natural Gas Commission, underline the fact that India has come a long way from the time when even needles were imported.

The four reporters, travelling through Delhi in a car, discuss self-reliance and attempt to cope with its different aspects and problems.

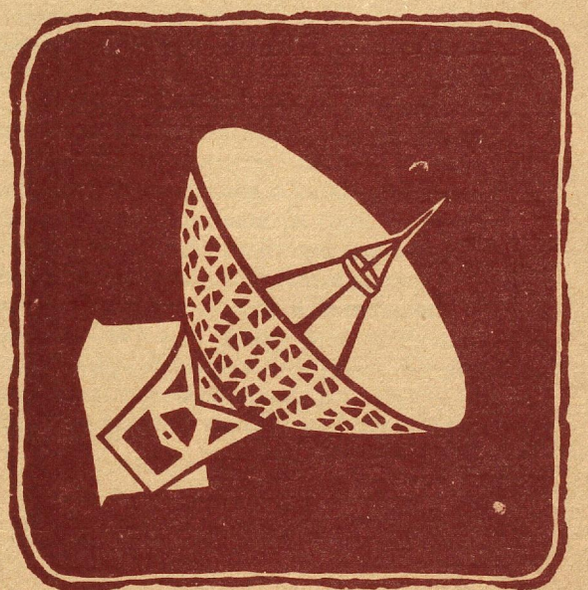
The Green Revolution is often taken as an example of self-reliance in food production. How valid is this claim? We explore this issue through interviews with farmers, an agricultural scientist and an economist.

One of the inputs required by the hybrid seeds of the Green Revolution is water. The proposed system of dams on the Narmada river is expected to make available huge amounts of water for agriculture and electric power for industry. Through scenes set along the banks of the Narmada, and an interview with critics of the project, we outline the controversial issues involved. These include the problems of rendering people homeless, the loss of forests, and technical arguments regarding feasibility.

Independent India has seen various achievements and yet, problems persist. The application of new technologies have shown results, yet often, the price is heavy in the long run, and the benefits inequitable. All this points to the need for greater awareness and participation on the part of the people.

A recent example of people's involvement in planning local development is the Baliraja dam in a Maharashtra village. Here, in a drought-prone area, people have formed a water users' co-operative with equitable water rights. The first political stage of their struggle is over, but the real test lies ahead. Now they must adopt new technologies to use limited water, to stabilise and develop their agriculture; they must make the co-operative work successfully and equitably.

A song reminds us that while we cannot change the past, it is upto us to shape our future.





Beyond the green revolution



Raja Mohanty

The Green Revolution is a controversial and a much discussed subject. Its proponents and opponents are sharply divided. Those who happen to get caught in the cross-fire, find the going very difficult indeed. They are forced to take sides. Something of the kind happened to us — and not only in connection with the Green Revolution. When we first showed this film at different places, the proponents of the Green Revolution were not pleased, nor were its opponents. And so I have been deputed to say something more, perhaps because I am known to be a trifle combative and quarrelsome! So stand forewarned. One more thing — though we will attempt a scientific evaluation of the Green Revolution, it would be wrong to assume that India's adoption of Green Revolution practices and policies was based solely on perceived scientific merit alone. Many political and economic compulsions played their part, as is common to all technological decisions.

At the outset I should say one thing explicitly: as is apparent from the film, our standpoint is based on a critique of Green Revolution practices, though we acknowledge their historical merits. These practises come as a package dependent on the intensive use of energy and huge capital investments — hybrid seeds, large doses of chemical fertiliser, abundant water, a heavy pesticide requirement and, as a consequence, substantial land holdings. The Green Revolution has, for these reasons, been limited to only certain areas and, further, to the affluent sections within them. An added concern is that such practices are environmentally harmful as well. What then, is the alternative?

An instant and obvious alternative derived from such a critique might be: exclude any hybrids or exotic species, completely avoid chemical fertilisers, dispense with large-scale irrigation, and do away with pesticides. In other words, no-tillage organic farming, or what is called 'fully balanced agriculture'. We have *not* proposed such a course in the film, and while its absence makes opponents of the Green Revolution uncomfortable, its proponents charge us with hypocrisy. So allow me to clarify a few issues.

We have no quarrel with the introduction of any plant species, however exotic. The coconut, the green chilli, the potato — all were at one time, exotics. They were imported into the country and settled here, quite comfortably. Nor are we against hybrid seeds; after all, in the process of selection and improvement throughout history , hybrids have played a positive role . What is questionable, however, is *which* seeds are hybridised, and how.

Our approach to chemical fertiliser is similar. We have no disagreement with it per se. The difficulty arises, however, when one important aspect is entirely lost sight of — primary productivity. The productivity of a piece of land without any external inputs, may be called its primary productivity. The use of fertiliser should aim at conserving and increasing the *primary* productivity. Green Revolution practices drastically reduce the primary productivity and lead to total dependence on external inputs in maintaining productivity. Its successes depend on secondary productivity which is an illusory productivity as it disappears with a shortage of these inputs. Moreover it takes place at the cost of primary productivity. We certainly have a quarrel with this kind of fertiliser use.



Uttam Ghosh

The Green Revolution package: water, hybrid seeds, chemical fertilisers and pesticides

However, fertiliser may also be used to conserve and increase primary productivity. I can give two definite examples of the beneficial use of fertiliser. One is to increase biomass production (in this context, the production of the sum total of vegetable matter) and to progressively recycle it so as to raise the primary productivity. Another example is that of phosphatic fertilisers. In many parts of the subcontinent the lack of phosphorus is a limiting factor. Simple recycling of vegetable matter does not help because phosphorus is concentrated mainly in the seed and fruit, the parts that we extract for use and consumption.

Chemical pesticides present a similar picture; here too, we need to change our thinking. Instead of trying to exterminate all pests, we should try to bring down local pest populations to acceptable levels . That is, instead of using pesticides as a means of pest eradication, we must learn to use them as a means of pest control. One of the most successful pest control programmes, the international locust-control (not locust-eradication) programme, is based on this kind of pesticide use. Under it, locust populations the world over are closely monitored; whenever the figure begins to rise above a certain level in any region, pesticide is used in order to bring down the population to an acceptable level. It is *not* used to exterminate every locust. Thanks to it the world has not had a serious locust-induced famine for many years now. An exact opposite is the way cotton pests are being handled in India. Even the predators of the pest have been eliminated through heavy pesticide use, while resistant strains of the pest have also evolved. As a result, far from reducing pest attacks, the incidence is increasing every year. Both programmes use pesticides, but the viewpoints underlying their use are different.

And finally, water. Today water is a political commodity, as much as an economic one. When access is achieved by political means, it has no cost related to its use. Once it is available in abundance, no one really tries to economise on water. No wonder then that in Green Revolution areas, and for sugarcane generally, water is used so lavishly. It is easy to collect statistics on this brazenly wasteful use of water in order to make a case against dams, especially big dams.

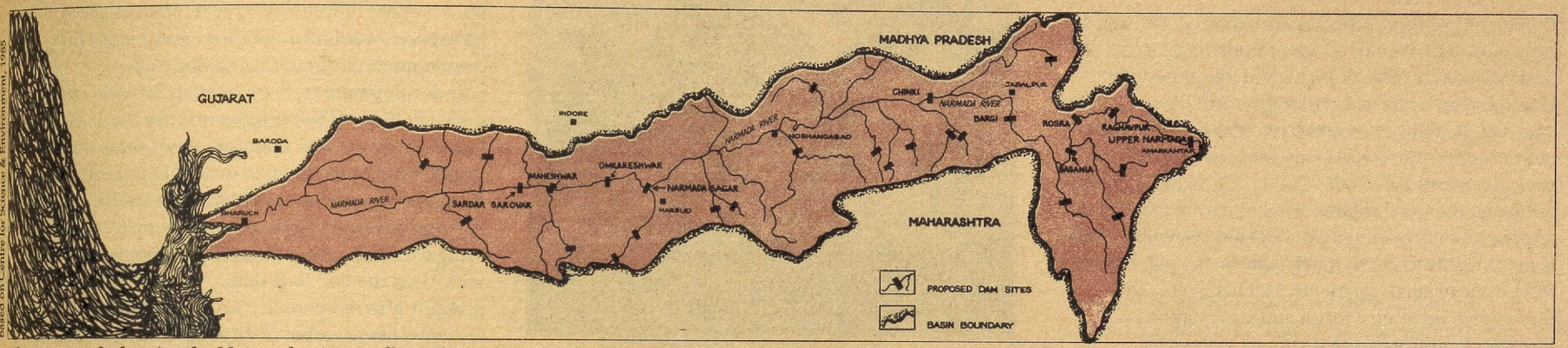
However, let us look at water use in another way.It is well-known that our monsoon pattern is such that in most areas, a secondary water source is needed to maintain a stable level of production. Where dams exist, their water is used only on the lands of a handful of people downstream. But suppose that this water were to be utilised equitably, both upstream and downstream, but in limited amounts. There would be enough water to ensure the subsistence needs of all the people in the area. Moreover, to use water in this limited way, it would be necessary to follow practices that sustain primary productivity. There is indication that for many farmers, basic subsistence may be ensured from as little as half their present holdings, with these practices. Once this happens, they will perhaps be freed of those compulsions which do not allow them to seriously take up tree growing. Such programmes have been thought out and *are* being implemented in the field, like the one at Balawdi-Tandulwadi, highlighted in the film.

To be fair, I know that even the most extreme people do not believe in the kind of instant solution to the Green Revolution's problems that I have described at the beginning of this section. But I constantly encounter this kind of anti-technology attitude among people with whom I share other concerns, and I do get irritated by it. I feel that such proposals, instead of changing or moulding science to suit society's needs, and instead of making scientific alternatives a basis for the future, suggest ways that bypass science and are difficult for people, especially the poor, to adopt.

Perhaps my irritation is somewhat unwarranted. In a sense I have looked at science as an insider. But science reaches many people — including those who study science — as a product or a finished good. It is not entirely their fault that in rejecting its product, they also implicitly reject science. We insiders are as responsible as anyone else.



"Development not destruction"



The proposed plan for the Narmada river valley. This map is symbolic and not to scale

For a Bombayite like me, to spend an evening on the Narmada ghat in Hoshangabad was an experience. The townfolk came there for a walk, women lit small lamps and floated them down the river, offered *pooja* to the river, and bathed. The river, the ghat, and the evening spent there will always remain with me. As I remember the flickering lamps floating down the river, I do not understand why so many people say that the Narmada flows fruitlessly into the sea. A question arises: will it be possible to separate this life around the river from the river on which it is centred? And another question: Does anyone have the right to thrust an external way of life on the adivasis whose way of living is based on the natural resources in their area?

I was discussing these and other associated questions with the activists of the Narmada Bachao Andolan, that is, the Movement to Save the Narmada, or simply, the Andolan, one evening. Development, progress, national interest, production — the Andolan has raised questions about each of these issues that may force us to redefine the place of science in modern society and modern life. The main question these people, who have coined the slogan, *"Vikas chahiye, vinash nahin"*, (we want development, not destruction), have raised is — what is development?

Calling huge projects examples of *techno-shahi* or *techno-raj*, one of the activists asked, "Is it only through huge projects that we can develop? Is building such projects our main aim?" No, of course not, I thought. Building big dams to display our hi-tech skills is hardly the aim. The aim is to provide electricity and irrigation, in order that production should increase, that people should live better. But increased production does not automatically mean better living for all the people on the whole.

"Even if we forget the other questions for the time being , is this the only way to generate electricity and deliver irrigation ? Should dams which render lakhs of people homeless, submerge thousands of acres of forest and fertile land , and eventually silt up to defeat their own purpose, be built? Must we live in the constant shadow of an impending earthquake?" continued the activist, now thoroughly worked up. I know that her criticism is well-founded. It is only after an intensive study of big dams that such questions are being raised. Many doubts have surfaced in respect to the life of big dams. In most such dams, the rate of siltation has been observed to be much higher than had been foreseen.

How long is the length of term we have in mind, in the course of planning? Ten years, twenty, a hundred...? On what basis do we say that a project lasting for a certain number of years will bring about development? I am aware that there can be no settled consensus on such questions, but discussion can no longer be avoided.

Connected with the length of a dam's services and its effects, is the issue of environment. Can we really make up for the soil fertility and the forests we lose through such projects? How do we take care of the longer term effects when they make themselves felt? We have suffered through a number of geographical and seasonal aberrations brought about by natural

causes. But how do we repair the damage our own interventions in nature cause?

Proponents of these schemes are expert at devising a simple answer. First of all, an attitude born of consumerism teaches them that all things and all emotions can be turned into rupees and then assessed. Benefits and costs have both to be worked out in rupees. The forests may be drowned, but the project remains beneficial. That is, the 'benefit' rupees outweigh the 'cost' rupees. Now plans are afoot to afforest an equivalent amount of land elsewhere. As it is not possible to get so much land in one place this is to be done in small segments. Not being able to distinguish between a forest and a plantation is essential to justify this reductionist viewpoint.

Even for these proposed plantations, land is being taken from the adivasis themselves, I learnt from the Andolan activists. Recently the Andolan has given a new turn to the struggle of the adivasis with the government. "Except for health and education workers, no other government official shall be allowed entry into the villages. We shall not take part in either the census or the elections. When this government does not care whether we live or die, why should we maintain any relationship with it? For them we are as good as dead; for us too now they are as good as non-existent." The same kind of sentiment has been expressed by the people opposing the Balliapal missile range in Orissa.

I am extremely disturbed. At every step the government swears by the national interest. Even if some people do benefit from these dams and projects, is that sufficient reason to disregard the destruction suffered by so many? And if the benefits to one section is seen as national interest, while the cost that some others pay for this is accepted as the inevitable sacrifice for the 'national interest', then I think something is fundamentally wrong. In this land which contains, as we have seen time and again, so much diversity of culture, of geography, of life-style, the first question that should be asked of any developmental project is: whose development, at whose cost?



Raja Mohanty

An example of an alternative approach to development is the Bali Raja Smriti Dharan in Balawdi, Maharashtra. A small dam was built on the Yerla river in this drought affected area, with community participation, using local resources

Today, the Narmada project has divided people and turned them against each other. People in the drought-prone areas of Gujarat, including Kutch, where even drinking water is scarce, are being aroused with a dream of water. The Narmada valley people are being portrayed, and as a result being increasingly seen, as enemies obstructing the realisation of this dream. But the questions raised by the Andolan are something we all have to face. In other areas too, there seem to be such polarised and clashing groups.

Koel-Karo in Bihar, Tehri in Uttar Pradesh, Bodhghat in Madhya Pradesh, Balliapal in Orissa, Kusnur in Karnataka, Inchampalli in Maharashtra, Silent Valley in Kerala, Ravatbhata in Rajasthan, Ukai in Gujarat — the list of huge projects of one kind or the other runs on, a list that reflects the large number of people who have been swept into agitations and conflict by development projects. Can calling them anti-development traitors, or environment faddists, or accusing them of being influenced by the 'foreign hand', do away with the problems? I think there is an urgent need to re-examine many of our ideas about development, and to make efforts to evolve innovative projects that can meet people's needs and bring together, rather than divide, people. In the film we visited the Bali Raja dam. A dam built by drought-affected people who came together, and created a new symbol of development. We have to learn to build such projects in which, from their inception, people participate, and which keep people's collective and individual interests in view. In this we have much to learn from all the questions the Andolan has raised.

We all have a role to play in this search for a holistic and integrated approach. And this applies even more to those with an interest in, or a connection with science, because development is defined in terms of modern science and technology. In the blind race to conquer nature, other important issues are forgotten. Without watchdogs, society tends to slide back into the old reductionism: single-minded in our aims, we tend to forget the multiple repercussions of our actions.

Is not recognising the limits of one's understanding — and making that recognition the basis for expanding them one of the first lessons in science? When I find even a handful of engineers prepared to review their thinking on big dams, rather than dismissing all criticism outright, I see a ray of hope. And I think, that those intense and 'crazy' Andolan activists have an important role to play in the development of this new direction in science.



Women's bodies, man's world

We have talked about science and technology in the serial, about gaining control over the fertility of nature, about the changing relationship between science and nature and our attitude to it. But somehow or the other we have not been able to include human reproduction and fertility in the films. Inventions and developments affecting production have been discussed, that is, generally, production has been given due importance, but not reproduction.

Of all natural processes, reproduction, especially human reproduction, has been the most mysterious. I feel it is important to discuss this area and make it part of our search. Science in our times has arrived at a new understanding of human reproduction and the man-woman relationships it is based upon. Further, it has intervened in these processes in an unprecedented way. Whether she likes it or not, issues related to reproduction, and its control have become a part of every woman's life today.

Even though menstruation is freely discussed in advertisements, in many ways, talking openly about sexual matters does not fit into our notion of 'culture'. However has sexuality always remained a secret and unexplored area? Would this miracle of nature have not attracted the attention of human beings? There is indeed a lot of evidence — fertility rites, erotic temple sculptures, depictions of sexuality and childbirth in stone age paintings — to show that this silence is probably a product of our 'modern' culture. It is not that we do not talk about these matters, but there is definitely a lack of openness regarding this area. This attitude has affected science too. Despite searching the literature we have not been able to trace a history of the attitude to reproduction. Even for historians of science, reproduction is not as important an issue as, say the industrial revolution.



Uttam Ghosh

Take as an example, allopathy, which is widely accepted as the scientific health system today. The main features of the reproductive cycle were fully understood by modern science only as late as the 1950s. Perhaps, till then it was not considered an important subject. Even after the 1950s, inspite of having understood the menstrual cycle, societal taboos which consider menstruation as polluting or impure have not changed very much.

A double standard has always been applied to women: for example, their ability to reproduce has been considered important and even venerated for example when fertility rites are observed, and yet for that very reason women have been considered polluting and therefore harassed. Knowledge gained through the rational method of science has not had any influence on such irrational practices or the social understanding based on them. Ironically, even modern scientific research has taken a direction based on an attitude which essentially maintains women's exploitation.

In the course of our search, we have repeatedly found that society accepts science only upto a certain limit. What it readily accepts are its final results, the end products of science. Its method, or the philosophy behind them has never been readily accepted. We see this with regard to quantum mechanics. Its final results are being used today without hesitation in many fields, but its philosophy has not been absorbed fully even by scientists.

Something of the same kind has happened with reproduction and fertility. Knowing about women's bodies and their mechanisms has not changed the status of women in any way. In the face of man's greed for control over everything, this knowledge has become a tool that makes it possible to tamper with every stage of reproduction. And that is being done,

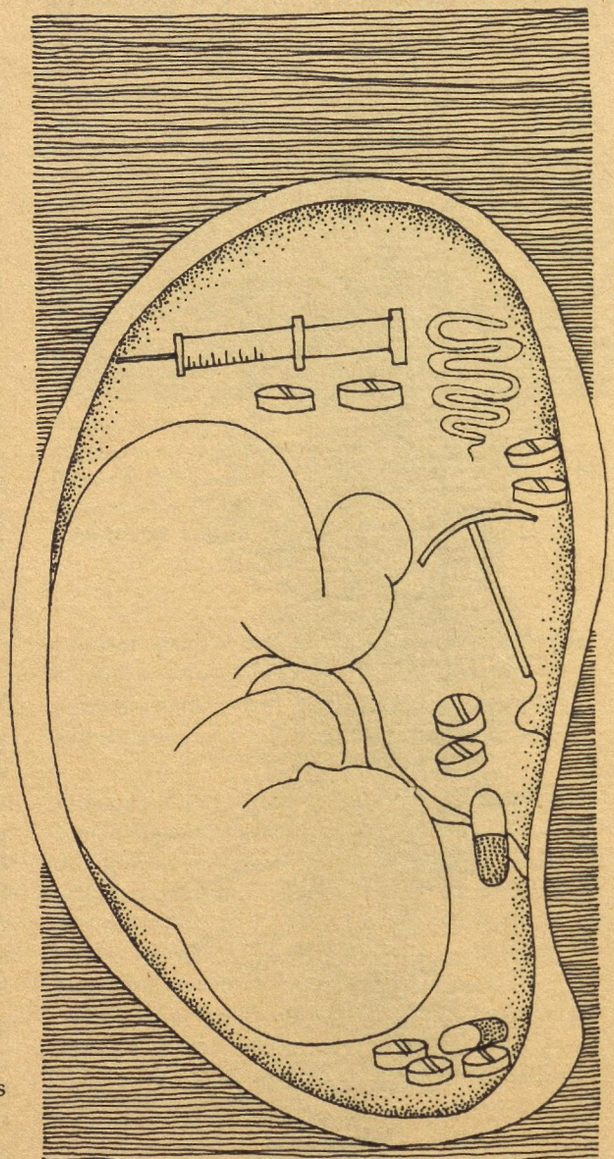
as a routine practice. In the last few decades, this important part of women's existence has become the object of arbitrary manipulation.

Reproduction became a central issue when the problem of growing needs and natural resources began to be seen as a problem of overpopulation. In certain parts of the world, the primary reason for poverty was ascribed to overpopulation. The solution focussed on lowering the birth rate. And since it is women who give birth, it meant control and manipulation of their fertility. This is the solution the 'advanced' world handed to all of us in the 'backward' countries.

In the developed countries the situation was different. Their population was decreasing, so it was necessary to increase the birth rate. For childless couples, techniques like test-tube babies were evolved. Again, it was women's bodies and their functioning that had to be tampered with.

This 'solution' to under-/over-population was conceived without understanding the complex interaction of social, political, individual factors including those of man-woman relationships which are inherent in reproduction. The easiest way to bypass them all was to enter into and physically control women's fertility.

Such interventions are becoming possible at every step and are becoming so all-pervasive, that the possibility of normal fertility is moving further away day by day. Science does not seem to accept that nature should be left to take its own course. Somewhere it believes, that whatever happens naturally has to be more or less 'wrong,' and that it is essential to intervene to make it 'right'. Motherhood is no longer simply carrying and giving birth to a child; it now means passing through a whole maze of tests at every stage. A woman's saying "no" to this is treated as unnatural! It is as if science has



Uttam Ghosh

interchanged the meaning of the natural with the unnatural.

The outcome is that now fertility itself has been treated as a disease. To prevent this 'disease' from affecting women, a vaccine has also been prepared — for women. In this field, Indian scientists are in the forefront, earning name and fame for themselves and their country.

Today science is universal. To differentiate it into western and eastern science is not relevant. It has a different face in different milieus, but at root, the way it thinks is the same. With reproduction, the attitude is similar: reducing the individual woman to her reproductive cycle, and within that, to her womb. This attitude does not recognise any distinctions of East-West-North-South.

Of course, which part of the world a woman belongs to, which class, and race she comes from, does make a difference to how far her body is tampered with. That is why contraceptive drugs banned in some countries, are sold openly in others; that is why only some women are made into guinea pigs without their knowledge; and why only some women's wombs are hired out, as lodging for the fetuses of some others.

Sometimes this mindless intervention into our bodies makes me so angry I can hardly control myself. On the roads I feel insecure — strangers' eyes bore through my clothes seeing only a female body. Then there is that meaningless logic by which society judges the monthly cycle of my body as polluting. And then, the reductionist science that reduces me to my body and its fertility, in order to control it. At the root of all these experiences is a view that denigrates women.

I think it is only in the coming together of women, our collective determination to free ourselves from this tangled web, that something may be achieved. It may turn our anger into a liberating expression of our creativity in building an equitable world.



Self-sufficiency and self-reliance

I have often had the experience of having read something and felt that I had understood it in principle, only to realise later, because of some incident or some points raised in a discussion, that certain aspects of the issue had altogether eluded me. Actually, I think all of us understand only as much as we want to at a given moment.

One such incident occurred a few days ago when I dropped in at Shehnaaz's. Almost as soon as I entered the flat, I sensed tension in the air. A group of Shehnaaz's scientist friends were there, engaged in a heated discussion on the brain drain phenomenon.

The discussion seemed to have been sparked off by a report in that day's newspaper. A biologist working in a national research institution had criticised the way the institution was run, and had said that if things continued in the same manner, Indian scientists would have to launch a 'Quit India' movement.

None of Shehnaaz's friends was comfortable with this statement but at the same time, they were all dissatisfied with their work situations. It was a complex discussion. They knew that society had to spend a great deal of money and resources for the training of scientists like themselves. It was as if Indians shouldered the expenses, and when a scientist left, others reaped the benefits. In effect, a zero return from our own investments. On the other hand, Shehnaaz's friends had strong feelings about the lack of research facilities and funds, and the administrative problems they faced in their work.

At such times, I become an outsider. Neither have I anything to do with formal science, nor do I know any scientists, other than the scientists whom I met while working on this serial. Yet, that day I sensed that a consensus was about to be reached — much as you sense the outcome of a conversation as it slowly develops in a novel or a play.



Uttam Ghosh

The consensus on brain drain was something like this: more research facilities should be made available, researchers should be independent, they should be allowed to grow and they should receive better remuneration.

Before a firm final opinion could be voiced, however, Shehnaaz turned aside the flow of the conversation in her typical way. She suddenly smiled and said, "The problem will not be resolved just with these measures. Of course, these measures are necessary but they are not sufficient. You could increase facilities, encourage growth, improve economic status at a certain pace. Elsewhere, in other countries, the same things would improve at a much faster pace — what then?"

There was an uneasy silence in the room for some time, but this soon gave way to a comfortable ease. The atmosphere of dissatisfaction and tension cleared up. I felt they had realised one thing — that they were also an interest group like any other. Their concerns reflected this. When they returned home, they must have carried this understanding with them.

I had gone to Shehnaaz's house to meet an African student we knew, who arrived as the others were leaving. He was in India to do a comparative study of West African and Indian tribal literature.

Shehnaaz could not resist bringing up the issues that she had been discussing all afternoon. So we were back to the topics of brain drain and self-reliance. Our friend from Africa listened for some time. Then he stopped us and said, "Look here, I get very uneasy when you people start talking about these issues. I have seen this happening in both India and China. Your nations are big. You have a tradition of small industries and crafts. It's easy for you to talk of self-reliance."

He went on, slightly agitated, "Most countries in the world are small. My nation is just a small strip of land running from sea-shore to equatorial forest. We cannot dream of self-reliance like you. We simply want an egalitarian world order." Perhaps he was not able to distinguish between self-reliance and self-sufficiency. Or maybe it was we who were not able to do so. After all, at the base both ideas are founded on one concept — that of the nation-state.

The river Mekong in South East Asia flows through three countries — Laos, Cambodia and Vietnam. Can these three countries be self-reliant to the point of excluding each other? On another occasion, the same African friend had spoken about one of the differences between the effect of colonialism in Africa and in Asia. If we look at a map, we find that most national boundaries in the African continent are straight lines. This is because the colonisers had actually sat down at a table, and sharing the spoils, carved the unknown regions of Africa into separate blocks. Later, these became independent nations. What kind of units would such nations be?

As I continued to think, it struck me that the relationship between self-reliance and self-sufficiency was similar to that between self-respect and self-glorification. If we want to maintain our self-respect without indulging in self-glorification, it is necessary to have respect for others as well. Similarly, if we want to be self-reliant without falling into the trap of self-sufficiency, it is necessary to join hands with others, to be mutually dependent on one another, provided we do so on an equal footing. Self-reliance is, after all, a means, not an end in itself.

RETROSPECT & PROSPECT

13

We begin with a look at the promising technology of remote sensing, at the National Remote Sensing Laboratory in Hyderabad. Satellite pictures can provide information about water and mineral resources, monitor deforestation and predict the weather. But people for whom this technology is intended must have opportunities to interact with it, so that it becomes a part of their lives.

Glimpses of people's science movement activities highlight the task of building awareness. A reporter visits some villages in Udaipur where a voluntary organisation is training local people for afforestation programmes, adult literacy classes and improvement of community health. As their journey comes to an end, the reporters feel the need to recapitulate their past. They retrace the developments from the stone age to modern times, as excerpts from previous episodes remind us of places visited, people met, the songs sung on the way. One of the songs reminds us that we must know the past to understand our present and shape our future.

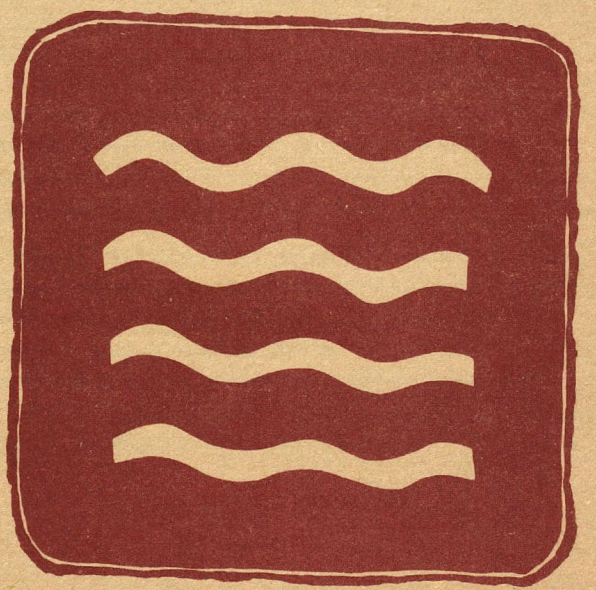
School education has an important role to play here. In Hoshangabad district of Madhya Pradesh, an experiment in science and social science teaching is under way. An excursion to collect plant and soil samples and exciting classroom activities illustrate the fresh approach taken, both in teaching methods and the writing of textbooks.

The mass media also have a responsibility. P.C.Joshi speaks of the gap between the 1960's vision, such as, community TV sets, developmental programmes—and the present reality: TV acts as an elitist toy that helps spread consumerism and obscurantism.

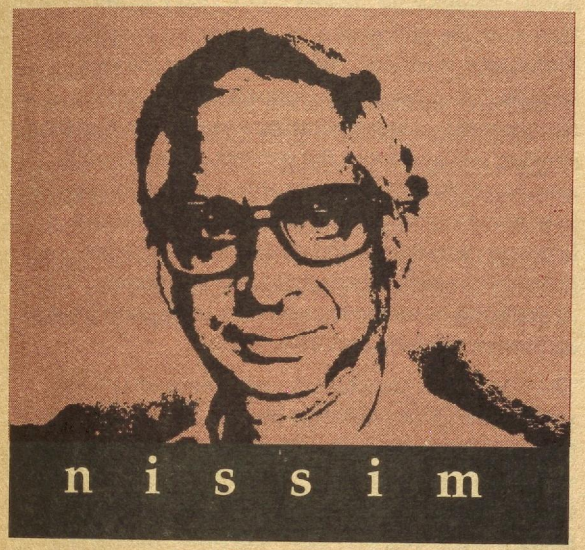
In Meerut, which has witnessed repeated communal outbursts, the typical circumstances, attitudes and interests behind such occurrences are analysed, through the anatomy of the town as well as interviews with the townspeople and victims.

If we look at pictures taken from the moon, we see how fragile our planet appears. The divisions of caste, religion, language seem absurd; in the light of destructive technologies like the Star Wars which threaten to ring the planet, we need durable international peace, not the hatred and strife of narrow divisions.

At the end some of our team members meet Prof. Yash Pal, chairman of the advisory committee that guided the making of *Bharat ki Chhap*. Their conversation is full of hope for a future in which India will use science with imagination and confidence.



The journey continues . . .



I have always been interested in theatre. On several occasions I have also enacted historical characters. Somewhere my personal philosophy of life, I think, is linked to my training and work in history. As a result, I often face problems of a special kind.

A young friend of mine saw these films, read parts of the manuscript of this book, and making a face, asked, "Why are you giving so much importance to communalism?" According to him, it was just another issue being used by a certain section, just as unemployment was being exploited by drug peddlers and criminals. It so happened that most of the articles he had read were concerned with the issues of communalism, regionalism, Indian identity and so on. However, on reflection, I think that this emphasis has to do with my being a historian.

One thing that the history of science shows us, is that whether it is communalism or patriarchy or racism, science on its own cannot do anything to tackle such issues. Science can, in fact, be moulded and used as a tool by such forces — as in Nazi Germany, or as reflected in the image of women created by modern sociobiology, or in the racism that is latent in all of 19th century European biology. History shows us that unless science aligns with progressive trends in society, it cannot become an instrument of liberation. In fact, it acts to the contrary: the biggest impediment to the study of history has been the sectarian outlook— be it the history of society or the history of science.

When I think about communalism, various historical periods and events come to mind— Germany during the second world war, the witch-hunting in medieval Europe, holy wars or the massacre at Karbala. I experience a mixture of fear and frustration. Is our country heading for such a future, or more accurately, being driven to it ? There are false claims that in our past there was just such a period of intolerance, whereas, especially where *religious* persecution is concerned, there never was.

When I first thought of doing these films, I was teaching in a university — a job to which I have now returned. I try, and have tried earlier too, to teach my students history with a perspective different from the usual textbook perspective. Yet, my success had been limited, perhaps because my efforts were confined to the subject of history. My attempts to make links with the present often appeared contrived. I was growing more and more dissatisfied, and having lived out the major part of my life, was even beginning to despair.

Then, as we worked together on these films — and more recently, on this book — I grew closer to the young people who were my colleagues. In contrast, my interaction with my students had been much more limited. With my young colleagues I shared much more than the past. And not only with them, but almost all the people who participated in the making of the films — the experts and the craftsmen, the people at the archaeological sites, museums, laboratories, factories, libraries, the officials who went out of their way to help us — all shared not only in the task at hand, but also in the overall concerns, however briefly we may have interacted. This sharing of concerns has given me heart, and I am finding once more the will to grapple with difficult situations, to search for ways out.

I have also realised that being a historian sometimes limits my outlook and vision. Take for example, the connections that my young friend, who asked why we were talking so much about communalism, was able to make. On reading Rahi Masoom Raza's "Appeal in the Name of Allah Miyan and Ramji", an article that first appeared in the Hindi periodical *Ganga*, I realised that it was possible to develop an attitude similar to mine, to share concerns, without confining them to the limits of a historian's discipline. In fact, Rahi Masoom Raza could express these ideas in a manner that few historians can equal in clarity and effectivenesss.

In the course of this work, I also understood the importance of oral history, especially in subjects like the crafts and agriculture. I am convinced that today reliable information about agricultural practices in the past can only be had from oral sources. There are many vital details that the documents do not mention. They were, after all, documents written by persons who were not actually farming, and are bound to be incomplete in many ways.

And then, I was deeply impressed by the social science textbooks that the Hoshangabad experiment has evolved. They make an interesting attempt to present history through the use of oral narrative and conversation. One of my historian friends pointed out that behind such textbooks lies a special approach not only to teaching, but also to history. It is a



commitment to making history come alive for a specific region and period, through an interaction of those who teach and those who learn. This is more than just a matter of wanting to make educational experiments. As we have seen in the films, the programme faces very real problems as it interacts with a social milieu that militates against what it attempts. However, if it continues to grow, enriched by wider social and collective thinking and interaction, this school programme in Madhya Pradesh could become a dynamic instrument of change — a lesson from which the whole country could learn.

And so, in the process of making these films with my colleagues, my approach to many things has changed— perceptibly in some, perhaps in small imperceptible ways in many others. I have, of course, gained considerable insight into the history of science. But as importantly, instead of being limited by the bounds of my self and profession, I have gained the strength to connect, to see my dreams as dreams shared with others.

Back to Calcutta... a city which offers images reflecting every stage of modernisation and development, all at once. Once again the delicate balance on the roads between all kinds of modes of transport — tram, metro, rickshaw... I have been missing not only the university, but also the street environment for a long time now.

I learnt a lot during this journey in search of the history of science. One set of strong impressions is connected with language as a medium of communication. The journey was full of many insights and opportunities, exciting moments and great enthusiasm, and as we break from it for the moment, I find it necessary to look back and relive some of these experiences.

As I moved around the Bhimbaitka rock shelters, looking at the paintings, I found myself in dialogue with the people of those times. I became a woman belonging to that long-vanished community, standing by their side, participating in their activities. Similarly, the Harappan script fascinated me, as I talked to archaeologists who have spent a good part of their careers trying to unravel its mysteries. And yet, even without understanding their language, did I not understand something about the Harappans and their life, through the shell bangles, the terracotta toys, the mushtikas, the ruins of their cities? All of us, in fact, shared a unique experience, sensing a link, a continuity between then and now, them and us. And I hope we have been able to convey this excitement to you.

The written word, the painting or science or technology — these are of course specific to the human beings who created them. This I accept. However, the philosophy of life that the megaliths of Pudukottai expressed did not reach me through language. It spoke to me through objects, their arrangement — signs pointing towards emotions and evoking feelings about the concept of an after-life, about accepting death as a natural part of human life. I am moved when I think about this new kind of language, a dialogue, the medium of which are objects — vessels, stones arranged in a pattern, agricultural implements, specially bred grain seeds — all human artefacts and inventions.

Then there was rasashastra, the science of alchemy, with its intriguing sandhya bhasha, the twilight language. I am amazed at how the very structure of words tells their stories. That language mirrors, or is a symbol of, an outlook on life is a concept I had been familiar with. But perhaps I had never internalised it, and these exposures helped me to clarify my thinking.

Language is just one of the various means of communication; one's outlook towards the world finds expression in numerous ways. Art, literature, science, crafts are all reflections of culture. This way of contextualising language is something I have learned on this journey.

If some questions have been clarified, new ones have also appeared, disturbing doubts have surfaced. Newspapers report extremes of identity, of patriotism, pitted against one another all over the world, often with language as a demarcating line. The creation of our states on the basis of language has raised many problems. Language has become one more identity clashing with other identities.

I do not think of this entirely as a retrograde development, because somewhere underneath it, lies a drive to freedom. And when language becomes a medium that sharpens the edge of revolt against oppression, it acquires an expressiveness that I value

greatly. In the times of unrest we are living through, I see regional developments in language often as so many voices speaking the common language of revolt. I see them also breaking the bounds of established literature and becoming, with all their diversity, a link between the oppressed all over the world. This makes me a little more optimistic and hopeful. All these various modes of communication connect the world, bring its people nearer to one another. In them lie hidden the possibilities of realising the dream of one world, possibilities that inspire and encourage me to face the future with greater confidence.

I have done a lot of physics, but now at the end of the series, I think what has changed is the way I look at it. It is as if earlier, in my concentration on molecules, atoms, nuclei, and every conceivable subatomic particle, I had no occasion to stop long enough to think about it all as a whole. Also, a career in physics, as in any other discipline, has also increasingly meant less and less time to reflect. And even if we did have the time, I doubt whether the way we are taught science and the way we learn, prepares us to develop the sort of openness in thinking that is needed in our times.

Nuclear power and nuclear research both raise questions that troubled me even earlier. Somehow, I did not expect to discover that many good scientists working in this area, would get so cut off from society as to turn their backs decisively on the social implications of their research. These issues were part of the reason I was attracted to this film project and joined it midstream. Such disappointments would be among the many unexpected things I learnt during this period.

In the subcontinent, both the mayavadi, or idealist, and the bhoutikvadi, or materialist philosophies existed from very ancient times. These were two opposed perspectives on the relationship between human beings, or society, and nature. Since then we have come a long way. The acceptance of the materialist perspective of modern science is now a dominant trend, almost a compulsion, all over the world. One of the important aspects of our exploration of history was to recognise the meaning of such immense transformations. To do this, we had to learn to come out of our unconsciously inherited intellectual attitudes, and look at ourselves with an openness, an attitude that carried us to many other fields too. It was difficult, but a rewarding experience.

For instance, when I was writing the article on the quantum revolution , one of my friends gave me a book by Robin Morgan, *Anatomy of Freedom*, subtitled *feminism and quantum mechanics*. Frankly, had I come across such a book two years ago, when I was fully absorbed in my research, I would most probably have made fun of it, and actually reading it would have been out of the question. But I had changed. I read it, and it touched a chord in me. I felt that it treated the strange relationship between the personal and the social, or the personal and the political aspects of life, especially women's lives, much the same way quantum mechanics treats the wave and particle aspects of the physical world. It also brought home to me the special nature of women's problems. They have to deal with this duality because their political problems are so indissolubly linked to their personal ones. I found in it an unfamiliar perspective, a holistic view which gave a new turn to my thinking.

Quantum theories should have shaken to its foundations the determinist, objectivist science that believed in a single unambiguous answer to every question. But scientists often use quantum results in a manner which an author has likened to the use of a cookbook, with no thought to its larger implications. And, the expected shake-up never happened. It did happen to me. So that I am getting ready again for research in physics with no less enthusiasm, because I do not think I have rejected science. I have become aware of a new dimension to it, acquired a new way of connecting with it, of understanding it.



I had rejected subjectivity in science, believing my own unique brand of mechanically objective method to be *the* correct scientific method. I did not recognise the subjectivity, the preconceptions that lay behind the choice of such beliefs. They made it easier for me to relate to science, as an external collection of objective laws.

I no longer believe that isolating an object is the only means of knowing it. It acquires its full meaning only in its total context. With science too, I have learnt to see it not simply as an external body of knowledge, but as part of society and social rhythms. And also to see it, not as the realm of a person-free objectivity, but connected to my own fluid subjectivity. I can



acknowledge my own personal reasons and preferences in it, and in the choices that people make.

Much of this thinking goes against the grain of someone with my background. It seems I am about to begin a new journey, a beginning made possible by this joint exploration of one aspect of a vast continent of knowledge. I expect the journey ahead to be more difficult, but also, much more interesting.

Generally, I tend to run away from numbers and arithmetic. But some figures make me stop and think, they even scare me. One such figure is the sex ratio of the Indian population. The latest, a preliminary estimate, has it that in 1991, India had 929 women (of all ages) for every 1000 males. In 1981, the figure was 934, and the number has been falling with every census. The falling sex ratio strikes me as significant also because in this wide-ranging exploration of science and technology, I had set myself a personal goal: the exploration of the social situation of women in India.

After the discovery of agriculture, women suddenly seem to disappear from the scene. In the course of our journey I did get an occasional glimpse of their existence, but this late 20th century statistic seems to negate it all.

This takes me back to the time when I had decided to pursue a career in the biological sciences. When I had to make a particular food for some specific bacteria and take special care of them, I would get depressed, because while I pampered them, countless people went without food and shelter. Of course, now I laugh at my naivete, and my attitude must have seemed absurd to my colleagues. Did I not know that my work served the very principle of causality, which spawned so many disciplines in the life sciences and brought about a revolution in health care? Did I not know that the old 'compassionate' perspectives like ayurveda could only be that way, never having seen a microbe? How had I missed the main perspective that had emerged in the modern health sciences?

Yes, I did know all that, and still do. But, through this exploration of the history of science, I have also come to recognise the limitations of science. Take the whole drive to control things, to have control over reproduction, control over nature — *control over* being the key term. This perspective, inherently committed to the elimination of diversity, makes me uneasy, because in the name of development, we are perhaps forcing ourselves, and our whole world into an unnatural uniformity.

One of the reasons for my involvement in this project was that it set out to treat science differently: not simply as a body of accumulated knowledge, but as part of culture and society. This approach values our diversity as species, as sexes, as groups, as communities, and gives me hope that our diversity could be preserved. Without such a perspective, science is seen as a collection of products and achievements. And this leads to an intense competition for those achievements and products. No one seems to have the time any longer to stop and think about where all this is taking us.

I hope I am not creating the impression that we have to reject all that science has achieved. I do not mean to imply that humanity should discard technology and return to the forests and to food-gathering. But I do think that there is an urgent need to put a brake on the unthinking, spiralling revolution taking place under the name of development, and to re-evaluate it from a holistic perspective.

And in this journey of discovery with my colleagues, I have also discovered that I am not alone. There are a number of people who do not want diversity to be replaced by uniformity, people who value coexistence and interaction. And even with regard to women — people who see a threat to our coexistence and diversity not only in communal riots, but also in the falling sex ratio of the Indian population. That gives me hope, and if the films have contributed to increasing their number, that to me is reward enough.

In my training as a civil engineer, I never had anything to do with the origins of geometry. But in the making of these films, I have learned to look at the basics quite often. One such occasion was my exposure to the pattern of bricklaying called the English bond, in Harappan architecture .Interestingly, I had actually drawn it many times before at the drafting board at college. I was as surprised to find that the origins of geometry may lie in construction techniques, or that they would form an unexpected a bridge between the Shulbasutras and Harappan masonry.

In Harappan times, the masons and bricklayers would have had to know a good deal about many things. Some geometry as well as some carpentry certainly seem to have been necessary. But what fascinates me is that a subject as abstract as mathematics should have its origins in the very practical art of construction. That mathematics should have its origins in the crafts tradition and not in linguistics or speculative thinking .

Now that I have to resume my studies in civil engineering, I hope I return with a somewhat changed perspective. I have long been aware that my profession is closely linked to two of the most notorious social spheres— crime and corrupt politics. My recent experiences have shown me that the problems of an engineering professional go much deeper than coping with these.

Most engineers, or their parents, choose the profession, I think for the money, not because they are truly attracted by the vocation. But eventually, even the highest earners grow tired of the inane, inefficient and ordinary construction all around them. A friend of mine works with a remarkably innovative engineer. He was telling me about a simple design for roads that would take care of post-monsoon deterioration and eliminate the need for the constant repairs so familiar to all of us. The design had much to recommend itself: a full concrete layer was not necessary; it gave greater employment to local labour; it needed some skills that could be easily acquired by workmen; and it used considerably less energy-intensive materials. And in the end you had more durable roads, with little recurrent repair and maintenance. I wondered why such an elegant design with such all-round benefits was not being accepted, let alone becoming common. My friend just looked at me. He told me that the resurfacing and repair of every kilometre of road in the post-monsoon season yielded a profit of around a lakh of rupees . And, he continued, do you know how many kilometres of road there are in the country?

No doubt he is right. We are back to that common explanation — self-interest, hard cash. But the discussion cannot just end there. There are many more aspects to be considered. I think it is as important to see whether techniques allow workers to progressively increase their skills as a matter of course or not. Whether engineers have the scope to exercise their talent or not. Science alone is not of much help here, because while science solves many problems, it can itself become a problem. The weight of established technologies may act against an emerging innovation, even to the extent of smothering it. Such factors are usually ignored in the established methods of scientific and technological choice in industry today. Often the operative criterion is whether the technique is widely and rapidly replicable.

Take the most common construction technologies in use today. The materials and methods that they use have only this to recommend them: the overdesigned components can be blindly scaled up and down without too much effort, and the workers need very little skill. Engineering design talent is rarely called upon. Yet more and more types of designs based on other principles and new materials are becoming possible. Not only in housing, but in dams, pipes, roads, embankments — a fair amount of innovation potential is already visible. Besides new materials , older materials can be used in new ways. An example is that of natural fibres, which are stronger and show much less creep, the residual deformation under constant load, as compared to artificial fibres of corresponding dimensions. They have to be treated to protect them from degradation, sometimes covered or coated completely; with such treatment, their strength compares even with that of steel. However, blind replication of designs is not possible, and workers need to be skilled, or to be taught the skills. But then that cuts out all the fringe benefits that a material like cement brings with it, not to speak of the profits from employing cheap unskilled labour, so easily available.



And yet I have come across a number of exceptions, and I think it is in these that one sees the outline of an alternative future. There are people to whom technology is not an end in itself, who do not just blindly copy everything that is made out to be technologically advanced. They realise that it is a complex instrument that must satisfy diverse needs.

Such efforts, I think, are the things which I have come to value, much more than I did earlier: these glimpses into the future, a hope for tomorrow. In the course of working on these films I have absorbed one very important thing. I have learned to recognise from a study of the *what is*, the outline of *what can*, or *could, be* and the distance between the two. If we do not learn to recognise the signs of what could be, we will



always remain limited to the what is, perhaps for no better reason than that it is there.

The films are completed, and it is now time for me to re-enter the world of computers. I realise that this will be a difficult readjustment, after being away for such a long time. Elsewhere in this book we have talked about the direction and pace of contemporary science. There is a constant race to be abreast, if not ahead of others. Accepting, and keeping up this pace has become a part of becoming and remaining a successful scientist.

That is only the first of my difficulties. During the year that I have spent outside my field journeying through these films, numerous questions have been awakened. Normally I would have let such issues lie. Now I am caught up with questions about our changing relationship with nature, our drive to control and dominate, the mechanisation first of processes and then of lives, and arising out of all this, an increasing passivity in every field. Subsuming all this are the implications of automation, being made into a reality by computers.

Not that I was unaware of all these things earlier, but there was — and is — also a strange kind of joy in working with the computer. An inanimate object, completely under one's control, and yet posing a challenge at each step. I cannot but help get excited by the process of getting the maximum possible out of a computer as elegantly as possible, while simultaneously solving all the problems it poses along the way. Sometimes I would grow uneasy , because despite having strong feelings about the ideology of control and domination underlying working on these machines, I found myself enjoying my work. My experience of working on these films has sharpened this unease even further.

We met many people who have been victims of the one-sided development of science and technology, people who have in the process been marginalised, uprooted, had their lifestyles disrupted. Whether it is the people of the Narmada valley, or the adivasis of Bastar, or those affected by the Green revolution or other development projects — they have all finally been raising questions about science and technology. It seems more urgent than ever before that these questions be studied, and equitable alternatives evolved.

Amongst many of the alternatives being proposed, I am troubled to find an implicit , if not explicit, rejection of technology per se, that makes me very uncomfortable. As we traced the sequence of science and technology through different periods, nowhere did we come across a time when technology was absent. Even stone tools are technology. In fact, even agriculture itself may be seen as control. Are we ready to reject even these basics of human life?

All of us are looking for ways out of the crisis. Our film journey is only a metaphor for a much larger search. We need to explore how far we can go on the basis of today's knowledge. Surely, it is not impossible to work all our present knowledge into a different kind of perspective, an alternative framework. To evolve a non-mechanistic worldview, it is surely not necessary to reject the laws of mechanics.

In this connection I remember a science fiction novel, *Woman on the Edge of Time*, by Marge Piercy. It is a futuristic vision of a highly egalitarian and what could be characterised as a highly 'technologised' society. Since this society's technology made it possible to carry out the reproductive process outside the body, individuals could choose to be man or woman as and when they wished, and people related to one another as persons rather than as men and women. Advanced research in biology was used to maintain a rich and diverse natural habitat and a sustainable eco-system.

That is an alternative after my heart, however imaginary it might be. Now as I go back to my computers, I find a new enthusiasm to help realise such a vision grow within me. The signs and lessons from the past, and a holistic view of the present that does not reject science per se, shape my perspective. Now the challenge before me is not only in the questions my inanimate thinking boxes pose, it is also in working towards making this vision, as yet only a dream— real.

End note

Having read the book, and while seeing the films, you may have been struck by the tremendous sense of involvement this work generated among those who took part in it. We would like to continue exploring the continent that connects science, history and society. Your comments would be extremely valuable to us at this time.

We are particularly keen to hear from teachers and others who have found this material useful. Whether you are a parent who was able to make the Harappans come alive to a child who was memorizing facts from a book, or a college lecturer who used these films in an introductory course for first year students, or perhaps an artist who got some visual ideas for your work, we would like to learn about your experiences in using the films.

What were the areas in which you found resonances with your work? What did you find lacking, or difficult to follow? What did you enjoy? Can you suggest ideas for other films or books in this context? Should you want extra copies of the book to use, for example, as classroom material, do let us know. If there are requests, we can also make the scripts available.

In addition to the original Hindi, and the English subtitled version of the films, we are dubbing versions in Tamil, Telugu, Malayalam, Kannada, Marathi, Gujarati and Bengali. If you would like to be informed when these are ready, please write in. Also send us addresses of others who should be informed about any of these nine versions.

This attempt, as we have often said, is only the beginning of a continuing journey. Join us in the search!

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■ **Box cover**
Handprinted *ajrakh* fabric from Kutch
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■ **First edition:** 1992

■ **Printing**
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