Professor R H Paul Commemoration Lecture 1995

TECHNOLOGY, SCIENCE AND ART - THE CASE FOR A RENAISSANCE OF THE RENAISSANCE

by

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Preamble

It is a great privilege, and a challenge, to be invited to deliver the Professor Paul Commemoration lecture, especially as I was not one of his brilliant students, as the previous speakers on this series have been, but only one of the mediocre ones.

We marvelled at the knowledge, and interest, that Professor Paul showed about almost everything under the sun. He also inspired us to think, and to get out of the dependency syndrome onto which centuries of colonialism has driven us. As tradition demands, in a commemoration lecture, I will attempt to present some of the work that I have been associated with, and also try to relate them to the ideals that Prof Paul stood for.

The Renaissance

The Renaissance, as generally understood, refers to the period of European history between the Middle Ages and the Modern period. The word itself carries connotations of rebirth and renewal. The period in question is variously interpreted as lying somewhere in the range from the fourteenth to the sixteenth centuries, but is sometimes taken to go back as far as the eleventh century. However, the idea of identifying a particular period as belonging to the renaissance is of comparatively recent origin, perhaps about two hundred years. The period immediately before the renaissance, of about a thousand years, belongs to the Middle Ages, sometimes also seen as the Dark Ages.

In the classical idea of the renaissance, the Middle Ages is seen as an age of darkness, after the collapse of the Roman civilization, when decadence has set in, and human existence has degraded to mere survival with not only no cultural, literary or scientific activity, but also when human virtue itself was at a very low ebb.

The renaissance, meaning rebirth or renewal, started with the movement for the study of ancient thought, including its languages and literature as a remedy for the ills of "modern barbarism". Whether such study and the attention paid to the wisdom of the "ancients" was the cause or the effect, it is true that at the end of the renaissance, there was a great awakening of spirit and the western world started on its voyage of discovery and conquest of both man and nature. The scientific revolution commenced immediately after, with the work of Harvey, Galileo and Newton; Copernicus having started it during the renaissance itself.

Just as much as Europe was then seen to be at a dead end, we, meaning the world, are now facing a crisis situation, endangering not only civilization, but the existence of man and beast. It is unfortunate that, unlike at the time of the renaissance, the time frame for changing patterns of human thought and behaviour now bear very little relation to the time scales of the dynamics of the other changes, set in motion by man himself.

In our school days, we have been taught a very simplistic view of science, as consisting of observation, formulation of hypothesis, experimentation and verification and finally the establishment of a theory. There is certainly no harm in such a presentation of science to school children, but the tragedy is that this is not generally updated as the student progresses in his education. There are other myths regarding both science and technology that have entered the general body of belief of not only ordinary citizens, but even of those actively engaged in the application of science and technology, such as engineers.

These two factors, the relative time constants of the dynamics of human behaviour and of the natural environment at this moment in time, and the generally held perceptions of science and technology are of particular interest in today's climate. Let us examine these a little more closely.

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Technology and Science

In today's world, we are accustomed to address the twin ideas of science and technology in one breath. This has not been always so, and in fact technology, in the modern sense, preceded science. Technology, in a sense, is the mechanism by which man differentiated himself from the other animals. Starting with the use of the hands and then tools, at first made of stone, man started to develop the technology required for his existence, without any reference to science, or a theory of the phenomena that he observed and attempted to control. Science, at that time, was in the speculative domain, bringing up theories about nature, but with no attempt either to verify them or to use the theory to change the environment.

As noted before, the real scientific revolution started with the work of Harvey, Galileo and Newton. Their science was actually made possible by the technology that was evolving simultaneously, but up to that point, independently. Galileo made use of the telescope, which was a pure artifact, of independent origin, to observe the motion of the planets and the stars to verify the theories of Copernicus. This work brought him into conflict with the Church, not because the doctrine of the Church could not accommodate the fact that the earth goes round the sun and not the other way around, but because the earthly interests of the leaders of the Church and of the nobles that drew support from it would have found it difficult to accommodate such a revolutionary change in attitudes, without also admitting the questioning of their own "divine" rights. Brecht has brought this out dramatically in his play on the life of Galileo. The birth of modern science was also the point at which it started prostituting itself, by Galileo's acceptance of the "conditionalities" under which he was permitted to continue his research: not to write in the vernacular and not to teach it to ordinary people, thus ensuring their continued subjugation.

Later on in history, with the defeat of feudalism in Europe and the ascendancy of the bourgeoisie, science and technology transferred its allegiance to the new masters. During the only other period of modern history where a different class held sway, during the (historically) brief interval of Soviet power, it also very obediently served the masters of the moment, the bureaucracy.

Today, technology and science are very much interdependent, in that most technological processes make use of and are dependent on modern scientific knowledge, and conversely, progress in science needs the instruments of observation and control made possible by the application of technology. This mutual dependence does not, however, take away the subordination of both to the needs of the dominant social class.

I would like to present just two cases to illustrate this point, one from the real world of today and the other from the 1930s.

The first relates to the acquisition of the British Government owned Cambridge Research Institute, a research institute working on the breeding of plants, by the Unilever group. Ten years after the acquisition, Unilevers notes that the share of the global seed market controlled by the ten largest firms have increased dramatically during that period and predicts a further increase of that share, and a further narrowing of the number of firms in the business. It then goes on to state the reasons why it decided to get into a market which, to the uninitiated, might appear to be unrelated to its traditional sphere of operation: to ensure access to raw materials and markets. Note that these were exactly the reasons for the last two world wars.

The second case is taken from Shaw's introduction to his play "The apple cart", by way of explanation of the idea of Breakages, Ltd., that appears in the play. I quote:

> The title Breakages, Limited, was suggested to me by the fate of that remarkable genius,the late Alfred Warwick Gattie, with whom I was personally acquainted. I knew him first as the author of a play. He was a disturbing man, afflicted - or, as it turned out, gifted - with chronic hyperaesthesia, feeling everything violently and expressing his feelings vehemently and on occasion volcanically. I concluded that he was not sufficiently cold-blooded to do much as a playwright; so that when, having lost sight of him for some years, I was told that he had made an invention of first-rate importance, I was incredulous, and concluded that the invention was only a Utopian project. Our friend Henry Murray was so provoked by my attitude that to appease him I consented to investigate the alleged great invention in person on Gattie's promising to behave like a reasonable being during the process, a promise which he redeemed with the greatest dignity, remaining silent whilst an engineer explained his miracles to me, and contending himself with the reading of a brief statement shewing that the adoption of his plan would release from industry enough men to utterly overwhelm the Central Empires with whom we were then at war.
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> I approached the investigation very skeptically. Our friend spoke of "the works". I could not believe that Gattie had any works, except in his fervid imagination. He mentioned "the company". That was more credible: any one may form a company; but that it had any resources seemed to me doubtful. However, I suffered myself to be taken to Battersea; and there, sure enough, I found a workshop, duly labelled the premises of The New Transport Company, Limited, and spacious enough to accommodate a double railway line with a platform. The affair was unquestionably real, so far. The platform was not provided

with a station; its sole equipment was a table with a row of buttons on it for making electrical contacts. Each line of railway had a truck with a steel lid. The practical part of the proceedings began by placing an armchair on the lid of one of the trucks and seating me in it. A brimming glass of water was then set at my feet. I could not imagine what I was expected to do with the water or what was going to happen; and there was a suggestion of electrocution about the chair which made me nervous. Gattie then set down majestically at the table on the platform with his hand hovering over the buttons. Intimating that the miracle would take place when my truck passed the other truck, he asked me to choose whether it should occur at the first passage or later, and to dictate the order in which it should be repeated. I was by that time incapable of choosing; so I said the sooner the better; and the two trucks started. When the other truck had passed mine I found myself magically sitting on it, chair and all, with the glass of water unspilled at my feet.

The rest of the story is a tragi-comedy. When I said to Gattie apologetically (I felt deeply guilty of having under-rated him) that I had never known that he was an engineer, and had taken him to be the usual amateur inventor with no professional training, he told me that this was exactly what he was; just like Sir Christopher Wren. He had been concerned in an electric lighting business, and had been revolted by the prodigious number of breakages of glass bulbs involved by the handling of the crates in which they were packed for transport by rail and road. What was needed was a method of transferring the crates from truck to truck, and from truck to road lorry, and from road lorry to warehouse lift without shock, friction, or handling. Gattie, being, I suppose, by natural genius an inventor though by mistaken vocation a playwright, solved the mechanical problem without apparent difficulty, and offered his nation the means of effecting an enormous saving of labor and smash. But instead of being received with open arms as a social benefactor he found himself up against Breakages, Limited.

Technology and Art

I looked up the words technology, science and art in a thesaurus, and found only art listed in it. Among the synonyms were craft, skill and technique while science was listed as an opposite! This, I believe, is a linguistic hangover from before the renaissance, when science had not yet come into existence and art and technology have not yet broken away from each other.

Upto quite recent times, there was not only a closer integration among these various disciplines, but also some of their most successful practitioners were the same. One name that readily comes to mind is that of Leonardo da Vinci (1452 - 1519) who was an accomplished painter, sculptor, architect and engineer. Even though natural science had not established itself as a separate discipline in his time, he can also be considered as a biologist.

Apart from this rather unnatural division of human activity into watertight compartments, art too has not escaped from the malaise that has befallen both science and technology. Art too has become a commercial entity, to be traded in the market place, and ready to serve the interests of the highest bidder.

The best I could do to bring out what I am trying to express is to refer you to a novel by George Orwell, the author of Animal Farm, called "Keep the aspidistras flying". It is the story of a young man who aspires to become a poet, whose first uncertain attempts have been very favorably reviewed in The Times Literary Supplement, who also tries to escape the world of money, deliberately leaving a well paid job as an advertising artist. It is a defeatist and pessimistic novel, which ends with the breaking of the spirit of the young poet, he been compelled to rejoin the advertising firm.

The meaning of Development

We have been discussing the progress of Art, Science and Technology since the Renaissance and the subsequent Enlightenment. Before we proceed further, I would like to present two brief quotations about our immediate condition, the first from "Is Progress obsolete?" by historian Christopher Lasch in the special (Fall 1992) issue of "Time", dedicated to "What to expect in the new a millennium" and the second from the Inaugural Lecture of Prof Chandra Gunawardena, Professor of Education at the Open University of Sri Lanka.

Christopher Lasch :

It is obvious that the wasteful, heedless life now enjoyed by the west cannot be made available to everyone without stretching the energy resources of the earth, as well as its adaptive capacity, beyond the breaking point..... But affluence for all now appears unlikely, even in the distant future. The emergence of a global economy, far from eliminating poverty, has widened the gap between the rich and poor nations.... famine and plague have returned to large parts of the world..... A continually rising standard of living for the rich, it is clear, means a falling standard of living for everyone else.

Prof Chandra Gunawardena:

In 1950, Murray Strauss found that the vast majority of new university entrants had come from the families in the upper socioeconomic categories - the professional, managerial and entrepreneurial classes. ... In 1965, Jayasooriya found a large concentration of students, well over 2/3 from a markedly working class background. By 1987, according to University Grants Commission statistics, the proportion of students whose fathers were in professional and managerial occupations had shrunk to 7.1 per cent. In contrast, the total percentage of students whose

fathers were in agriculture, animal husbandry, forestry, fishing, hunting, production-related work and transport services had risen to 53.1 per cent. ...The 1990-91 figures reveal, surprisingly, a reversal of this trend. Here we see an increase of the percentage of entrants with fathers in professional and managerial categories to 21.2 .

These are of course just two aspects of what we might call the totality of development, but they do bring to question the whole process. Unfortunately, we do not have mechanisms either to evaluate or to seek acceptance of the processes of development. In the last few years, the United Nations and some of its agencies have developed new measures, such as the Physical Quality of Life Index (PQLI) and the Purchasing Power Parity (PPP) that are thought to be more representative than the traditional indices of GDP and GNP.

This is an appropriate point to introduce the concept of voting techniques, based on some of the work that I did about twenty five years ago, as it seems possible to apply it to this case.

The voting technique

In retrospect, I would consider the following as the main reasons which made me propose a voting technique as a method for the diagnosis of faults in feedback control systems, at the start of my research project at the University of Wales:

> Both Sri Lanka and Great Britain were, in 1970, in the midst of general election fever.
>
> The methods then available for fault diagnosis were all variations of template matching, which were not good at allowing for small and acceptable variations of parameters from nominal values.
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> The existing methods depended on heavy computing to be effective, and a simpler, heuristically appealing method was preferred.
>
> A system that could learn by experience was more desirable.

I would like to draw attention to the first of these reasons, which had very little to do with the technical problem at hand. I would like to discuss this point later, in the context of a theory of science.

Let us take a closer look at the problem.

> We are required to develop methods for the diagnosis of faults in feedback control systems, with a minimum of testing and computation, and at the same time, achieving high reliability.
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> A fault is defined as a condition which makes the system inoperative. Thus, a certain degree of perturbation from the nominal or healthy state is allowable. Also, when you consider either individual components or sub assemblies, allowable perturbations are a fact of life. The method should be capable of discriminating between different types of faults, with a high reliability.
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> A "minimum of testing" has a number of meanings. It refers to both the number of test points as well as the number of observations.
>
> The degree of reliability can be improved in practice if we are able to rank the faults in order of probability.

The basic idea of the voting technique is very simple, and can be applied to any set of test data, whether they be impulse responses, frequency responses, pole-zero locations, voltage levels at different test points, or any other. Let us assume, to start with, that we know the behavior of the healthy system, in that we have a set of test data corresponding to it. Let us also assume that there are, for simplicity, two possible faults, and that we have the responses or test data corresponding to systems with these faults. We also have the data corresponding to the system under test.

For each of the tests; we look at the four values, corresponding to the healthy system, system with fault 1, system with fault 2, and the system under test; and "vote" on the state of the system, whether it is healthy, has fault 1, or has fault 2. At the end, we "count" the votes, and the option that has got the highest "votes" wins.

This method very naturally allows for the accommodation of small perturbations and drift, as your choice at each point is very clear. Later on, the method was further refined by incorporating the concept of "negative votes". This can best be illustrated by an example. The following table gives a set of data for the above problem, and the tally of "votes":

Test number or test point	Response → Deviation (Threshold = 5)				Votes		
	Healthy system	System with Fault 1	System with Fault 2	System under test	Healthy	Fault 1	Fault 2
1	10	10 → 0	10 → 0	10 → 0	1	0	0
2	20	10 → -1	30 → 1	22 → 0	0	-1	0
3	30	20 → 1	10 → -1	12 → -1	-1	1	1
4	20	20 → 0	-10 → -1	-13 → -1	-1	0	1
5	10	30 → 1	-30 → -1	-27 → -1	-1	-1	1
6	0	30 → 1	-10 → -1	-4 → 0	1	0	0
7	-10	0 → 1	10 → 1	0 → 1	-1	1	1
8	-20	0 → 1	30 → 1	25 → 1	-1	1	1
Total					-2	2	5

Note that appropriate threshold values have been used in the casting of votes. It is very clear that the system under test is most likely to suffer from Fault 2, as it has the highest number of "votes". It also illustrates how perturbations around the expected values are taken into account. We also note one more important fact, that test number 1 does not provide any useful information, and can be dispensed with.

It is obviously possible to extend this to a much larger number of known faults, and successful results have been obtained for upto ten faults, with only about twenty tests or features. Further sophistications are possible, and have been implemented, to the diagnostic methodology, but it is not necessary to go into them here.

A significant property of this method is that, as noted above, it allows us to design the tests in a more useful manner by considering only those features that discriminate among the different states. It also allows "learning" as the responses given in the above table need not be known beforehand, but can be "learned" on the job.

These results were used in industry, especially advanced industry, almost from the time they were published in the early 1970s, and some of them are known to be still using this method. Some of the concepts presented here have recently been assimilated into the field of artificial intelligence.

Application of the voting technique to the measurement of the process of development.

Let us now get back to the question of development. It is simple to modify this algorithm to compare, say, the state of "development" at two points in time. For example, if we can agree on a list of factors that matter, we could have an estimate to say whether Sri Lanka is more or less"developed" now than it was twenty years ago. This mechanism enables even subjective criteria; which the very nature of the composition of the UNDPs indices makes it impossible to treat; to be accounted for. It also makes it possible to apply it to smaller communities, say only to district or even a village, rather than to composite political entities such as nation states.

Having considered the views expressed in a large number of studies; including some studies commissioned by the World Bank; of which the two quotations given earlier from Christopher Lasch and Prof Chandra Gunawardena are representative, it is my contention that the majority of the people, not only in this country, but considered globally, including those living in the so called developed countries, have been "undeveloping", rather than developing, during the last quarter century. Hence the crisis I referred to at the beginning of this paper.

Use in public hearings

This technique also lends itself for use at public hearings, say on a proposed large development project. The people of the area can be presented with a multi-faceted account sheet giving the various effects of the proposed project, both desirable and undesirable, and their responses can be evaluated in a systematic manner. There are numerous other applications, which might legitimately be classified under public hearings, such as even the election of representatives to governing bodies, including parliament. At the moment, there is no way that you can vote against a candidate, and this method will allow you to do so! This would only be just, as the inspiration for the method did come from parliamentary elections.

The other sciences

It is also necessary to make at least a passing comment on the other sciences, most notably economics and the law, which together have a very strong influence on the life of the people. Economics has been evaluated to a pseudo-science complete with econometric models and all the other paraphernalia of science, but without its rigor. I would like to illustrate this with the following passage is reproduced from the 1993 World Bank Report on "Global Economic Prospects and the Developing Countries":

Meaning of TFP and the performance of developing countries since 1960

A familiar concept in economics is labor productivity, which is defined as output per unit labor. It is a partial measure because it uses only one of several factor inputs in the production process. The concept of total factor productivity (TFP) generalizes the notion to encompass all factor inputs. It is usually expressed as the ratio of GDP to a composite measure of labour as well as capital, the other major factor input.

Typically, the focus of interest is not on levels but on medium-to long-term growth rates of output (GDP), the factor inputs, and TFP. Under commonly used assumptions -particularly that production technology exhibits approximately constant returns to scale and that firms minimize costs - the appropriate weights for forming the composite input measure are the respective value shares of labor and capital in output. In this analysis, which is conducted at the highest (economywide) level of aggregation and where the factor inputs are measured without quality adjustments, the main elements captured by the computed TFP growth rate are: quality improvements in the capital stock, increased skills in the labor force, improved sectoral allocation of resources, and technical progress that is not already embodied in labor or capital.

For the purpose of this analysis, the factor shares for all countries are taken to be 60 percent for labor and 40 percent for capital. Studies of income shares suggest values for most countries within a 10 percentage point margin of these levels, and variations within this range would not materially effect the broad conclusions reached in this book. The capital stock series are derived using a perpetual inventory method from investment data starting in 1950 for most countries. The forecasts of investment and GDP are part of the baseline forecast presented in the book. The labor inputs are proxied by the economically-active population taken from ILO sources.[1]

The above procedure was adapted to estimate the growth of TFP in twenty-two high-income economies and fifty-eight low- and middle-income economies for the period 1960 to 1991. The result show that although low- and middle-income countries have, on average, enjoyed higher GDP growth rates than have high-income economies, this has been solely due to a more rapid accumulation of capital and a faster growth of the labor force. Indeed, the growth of TFP in developing countries has been lower than that in high-income economies (0.3 percent in the period 1960-91 compared to 1.1 percent in high-income economies).[2] In addition, the results point to a trend of declining TFP growth in developing countries, from 1.3 percent per year in 1960-73, to 0.6 percent per year in 1973-80, to 0.1 percent a year in 1980-91.

But the trend in TFP growth in developing countries as a whole masks considerable regional differences. For example, the Latin America and Caribbean region made TFP gains in the 1.5 percent per year range during the 1960s but exhibited zero TFP growth in the 1970s and nearly 1 percent annual decline following the debt crisis. TFP growth was virtually stagnant in Sub-Saharan Africa during 1960-70 but has shown a modest upturn in the 1980s. In sharp contrast, TFP growth for East Asia and the Pacific has been significantly higher than that of other developing regions, especially in the 1970s and 1980s when it was also double that of the high-income economies. And in East Asia and the Pacific, TFP growth averaged 0.8 percent per year in the 1960s but halved after the 1973 oil shock; it recovered subsequently to reach 1.7 percent per year in the 1980s.

A central feature of the forecast in this book is a reversal in the overall developing country trend through gradual recovery in Latin America, acceleration of the macroeconomic and trade reforms in Sub-Saharan Africa, and continued steady economic performance in East Asia and the Pacific.

1. With the above data, the growth rate of TFP g_t', is computed as:

$$g_t' = g_y' - [\, \alpha\, g_l' + (1 - \alpha)\, g_k' \,]$$

where g_x' stands for the OLS (ordinary least squares) growth rate of x in logarithmic percentage changes during period t, y is GDP (gross domestic product), l is labor, k is capital, α is share of labor in output, taken to be 60 percent, and t is 1980-91 and 1992-2002. (For presentation purposes, the logarithmic percentage changes have been converted to arithmetic ones.)

2. The numbers reported are median estimates.

Such arguments, made without proof, and invalidated by application to available data, are used to justify the "advice" given to third world governments and the "conditionalities" they are subjected to. Some of the contradictions are apparent even in the text of this extract.

As regards the Law, or jurisprudence which is the science of law, its crisis is made manifest by the proliferation of alternative tribunals throughout the world. I myself have been associated with the Permanent People's Tribunal, set up as the successor to the Russell tribunal and also with the local Mahajana Vikalpa Vinischaya Mandalaya, the People's Alternative Tribunal.

The law is basically conservative. The effect of the tendency for the 'preservation of the existing order' may be seen by an examination of even such an otherwise exemplary document as the UN Declaration. This declaration, while purporting to uphold a number of inalienable rights, also upholds the right to private property. In its application, it has come to mean the exact opposite of what it sets out to do, making the right to property, including personal property alienable. Even though an individual cannot sell or otherwise alienate ones life, it is possible to do so with all ones possessions, leaving him destitute. The right to private property has come to mean the right to appropriate other people's property. The law, as a conservative force, can be seen to be opposed to the processes of science, and its reform will have to await the proposed renaissance of the renaissance!

The Renaissance of the Renaissance

I stated earlier that one of the main sources of inspiration for the formulation of the voting technique was the general elections that were then taking place here in Sri Lanka and in Britain. Even though this particular bit of research may be insignificant, it nevertheless points out one factor very clearly, that of the interaction of society with science and technology.

Let us now come to the crisis. It is a crisis of sharing the fruits of development, a crisis of the environment, a crisis of diminishing natural resources, even a crisis of affluence for some. I have stated, both at the beginning and in the last section, without proof, that the world is in a crisis situation.

I would also like to raise, without prejudice to any individuals or organizations, a matter that should be of particular interest to all of us as members of the Institution of Engineers that has been brought to my notice in the natural course of the activities of the Institution. This relates to the work of the professional engineers, and the beneficiaries of that work. There are two specific instances that come to mind. One of them concerns a candidate for the professional review who stated, as a matter of course, that a bribe amounting to 25% of the value of a contract had to be paid to the minister of a foreign

country to secure a contract. This is nothing unusual, and it was only last week that the Boeing Corporation was found guilty of a similar corrupt practice. The other concerns two young graduates seeking recognition of their training. Since graduation, they have been working, professionally, for a company whose business is gambling. I would add these two isolated instances also as pointing to the existence of a crisis.

Although I have offered no proof, I have proposed a methodology for its verification, and hence for its falsification. It can hence be classed as scientific, in the sense of Popper! The dominant theory of science today is, arguably, that due to Kuhn. Kuhn postulates that science progresses from pre-science through paradigm and "normal" science, anomalies, crisis and revolution to a new paradigm, etc. I would like to take this one step further, or rather, nest it within a greater loop. All the paradigms, "normal" sciences, anomalies, crisis, and revolutions of modern science from Galileo to today, including the revolutions from Newton to Einstein, are to be nested within an outer loop, whose common characteristic is the subjugation of science to the service of authority and power. This is now in crisis, and a revolution is, if not in the offing, at least called for.

Now to get back to the title - the renaissance was a movement for looking back, beyond the current decadence, not to go back to the past, but to learn from the past and go forward. We certainly have a long way to go, and that is not backwards. However, there is also a lot to be learnt from the past, about conservation, about respect for life, about cultural diversity and a host of others. But before all that let us look at the present and know where we are, without being dazzled by the bright lights. There is a case for the renaissance (renewal or rebirth) of the renaissance.