

COMMUNICATING SCIENCE AND COMMUNICATING ABOUT SCIENCE – AN CONTENT ANALYSIS OF SELECT SCIENCE VIDEO PROGRAMMES

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Abstract:

Media studies hitherto have been preoccupied with developing a theory and understanding of the impact of scientific and technological information on the target audience. These studies aim to understand how the information is produced and the modalities adopted for purveying of scientific & technological information and knowledge. Even in the studies on the impact of media, the shift is taking place in understanding how the audience 'make sense of' the scientific and technological information communicated through the mass media. Informed by the social learning theories a turn has come about in recent scholarship of science communication studies which views audience as an active participant in the production of scientific meaning.

No era has been more visual than the twentieth century and science is not an exception. However, in the recent scholarship a fair share of attention has shifted towards the media production of scientific and technological information. As Kemp has argued the great difference between the visual qualities of twentieth century science and what went before it, is the new predominance of the representation of things that are technically invisible. Further scholars such as Keller have shown that in modern science depend upon the visuals to 'make visible the invisible' and reify the modern scientific concepts and theoretical constructs.

Of the entire spectrum of visual medium such as television, videos, posters, multimedia and so on television still has a vast reach unsurpassed by any other media. Therefore it is only natural that the television images of science and scientists are important as a subject of study. Televised images provide an opportunity for the viewer to observe the actions, attitudes and thoughts of others, which in turn can influence the viewers' action, values, thoughts and behavior. In particular, the self-efficacy towards scientific activities may be greatly influenced. Investigations of television programmes have brought certain typical images of science and scientists in media productions. The very programme format, narrative style and emphasis given in the programme cue a certain view about science.

In the light of the insights garnered, this paper will detail the efforts of Vigyan Prasar in communicating science through visual media and in particular critically examine the content, format and narrative structure of a television serial titled 'Asia Hi Hota hai' telecast by Vigyan Prasar and DECU.

1. Introduction:

Media studies hitherto have been preoccupied with developing a theory and understanding of the impact of scientific and technological information on the target audience. However, in the recent scholarship a fair share of attention has shifted towards the media production of scientific and technological information¹. These studies aim to understand how the information is produced and the modalities adopted for purveying of scientific & technological information and knowledge. Even in the studies on the impact of media, the shift is taking place in understanding how the audience 'make sense of' the scientific and technological information communicated through the mass media². Informed by the social learning theories, this turn in science communication studies has come about within the paradigm, which sees audience as an active participant in the production of scientific meaning.

Television, in the contemporary world, and particularly in India, has a deep reach³. Scholars inform that we share a television culture globally. Research shows that children and adults hold some stereotype views of scientists and science⁴. Research however, also indicates that science programmes and image of science and scientists in other programmes such as dramatic serials, soap operas, news casts, sit-coms, documentaries and children's shows influence the view of science among the television viewing audience.

2. Television in India

Today, Doordarshan, the state funded television network in India, with its 1,166 transmitters, 49 programme production centres and output of 1,485 hours of programming per week is probably the world's largest television network. Doordharshan is the only channel with terrestrial reach; and by law certain specified channels of Doordharshan are to be carried in the Cable Television free of charge. Hence in terms of reach Doordharshan is unsurpassed. In addition, Indian audiences have access to over 100 satellite channels including ones in the regional languages.

Table 1

Television reach in India						
(numbers in lakhs)	URBAN		RURAL		TOTAL	
Estimated Household All India	545	29.0%	1332	71.0%	1877	100.00%
TV Households	415	76.1%	379	28.5%	794	42.3%
Non TV Households	130	23.9%	953	71.5%	1083	57.7%
Cable & satellite HHs	166	39.9%	249	65.7%	415	52.2%

Source: WWW.ddindia.com website of Dhoordarshan.

Doordarshan had in the recent past run a very popular science series 'The Turning Point' a science magazine, and 'Planet on the Edge'; dealing with environmental issues. Channels like BBC, STAR TV, CNN do occasionally air few science related programmes. Presently, of the 69 all – inclusive channels available in Indian markets, only two are wholly science channels. National Geographic Channel and Discovery are two prominent infotainment genre channels widely available for those who have access to Cable & Satellite services. In fact Discovery channel is available with dubbing in certain Indian languages, indicating its rising popularity.

A survey⁵ conducted among a sample of Indian population indicates that 42% reported TV and 47.7% radio as major source of information. Of the sampled population, 49.7% reported that they have a TV at home and 66.3% had radio at home. However to a question regarding their perceived reliability of information disseminated by various media, 25% vouched for TV and 24.3% for radio. Only 16.6% considered print media as reliable source of information. The coverage of TV in terms of land mass reached and population covered in India is near total, except for some remote regions not reached due to topography.

While science is universal, the communication of science is always a social activity and thus hauls cultural codes. Therefore, while on the one hand consuming science communication materials being produced elsewhere, especially from the developed west, for its quality and excellence, it is pertinent that materials are also produced rooted in the local cultural cosmos, addressing the local concerns and agenda, least the science communication activity become lopsided and diverged from local realities.

3. Television images of science and scientists.

Studies have brought out various images of science and scientists that are present in the media production⁶. Televised images provide an opportunity for the viewer to observe the actions, attitudes and thoughts of others which in turn can influence the viewers action, values, thoughts and behavior. In particular, the self-efficacy⁷ towards scientific activities may be greatly influenced. Investigations of television programmes have brought certain typical images of science and scientists in media productions. Based upon the literature, we explicate the following images for this study:

Science as magical or mysterious: Instances when science is not explained, reference to mysterious happenings, reference to magic

Science as dangerous: Reference to bodily harm, reference to adverse effects of scientific process and experiments.

Science as truth: Reference to science as a way of finding answers, uncritical acceptance of scientific information, references to science as a fact or as ultimate truth.

Science as solution to problems: References to science as providing solution or preventing problems.

Science as fun: Instances of actors enjoying scientific activities, and when science is portrayed as fun activity.

Science as part of every day life: Instances when actors using every day materials conduct experiments, showing relationship between every day objects and science, instances when actors explain the science behind every day events or process

Science for every one: Instances showing people from diverse ethnic, social and gender groups participating in scientific activities, references to anyone being able to conduct at-home experiments

Science as national pride: Reference to the scientific activity or technological fete as 'national pride' or for the 'glory of the country' etc.

Use/abuse of science: Instances where science is shown to be beneficial as well as dangerous; instances when arguments are advanced for 'science for development and not for destruction'.

Science as sacred: Instances when science or scientific activity is shown as sacred activity or images are constructed to convey a feeling of sacredness. Lessl argues that the images conveyed by the language and rhetoric of the television serial 'Cosmos' by Carl Sagan promote sacredness of science⁸. In her studies on a science programme serial called 'NOVA', Hornig⁹ notes that sacredness of science is conveyed through the portrayal of scientists as high-priests negotiating for us between their mysterious world and our more mundane one.

Using the explanations outlined above, we looked for scenes that exemplified each image. Presence of at least one of the elements is necessary to qualify a scene as a particular type of image of 'science'.

4.AH3: Aisa Hi Hota Hai

Aisa Hi Hota Hai (AH3) is a weekly serial telecasted at prime time on Sunday mornings in the State run television channel- Dhoordarshan's National Network, since May 22, 2005. Primarily in Hindi, widely spoken in various parts of the country, with liberal admixture of English, the reach of the programme was substantial. Viewership of the programme as gauged by the Television Rating Points (TRPs) was considerable.

Each episode of the programme consisted of a 22 minutes. Each episode is devoted to a specific topic, say, surface tension, magnetism, friction, buoyancy and so on. The programme is presented by two chatty and inquisitive kids, characterized as middle school students, Deepika and Shivam, interacting with a lively young and skillful lady teacher. The teacher, referred to as K2 for she always asks the kids- 'Kyon aur Kaise', (How and Why) and leads them to conclusions through discovery approach. A topic is introduced and the story is built-up through a number of experiments and observations carried out by the bubbly kids guided by the teacher. Even the teacher is not portrayed as a usual teacher knowing all answers. The emphasis is on activities that demand inputs only from every day objects and observations. Anchored by two children, each episode presents science the fun way - it entertains while it educates. Most of the activities shown in the episodes can be repeated by the viewers.

5. Goals and objective: as sated by Sponsors

AH3 was not expected to be an isolated television programme but a flagship, harbinger of the exclusive Indian science channel. Hence careful, critical and throughout understanding of the series is pertinent, as this series is projected to be an exemplar- of types of programmes to be endorsed, encouraged and promoted. However, as it is would be unreasonable to evaluate AH3 without reference the sated objective and perspective of the sponsors, a brief elaboration of the same is in order.

The policy, perspective and goals of the proposed science channel, of which AH3 is an archetype, were themselves evolved by an elaborate process of discussions, workshops and brainstorming session. All the potential actors such as producers, media experts, officials of the concern departments, subject experts- scientists were involved in charting the science channel philosophy/perspectives. Viewers themselves were not as much involved directly in the process, however the rich corpus of experience of people and institutions who had had attempted to communicate science through the medium of television/ visual were absorbed.

"The human mind seeks instinctively to understand, explore, analyse and manipulate the immediate environment" asserted the perspective document and went on to state that "we believe that this is the content of science and its method is logical, rational and understandable." Science was not understood in its narrow sense of 'natural' science but the basic document summarised it as "to question existing beliefs, be it about a natural phenomenon or a social tradition, and to search for explanations is the basic aim of science. The practice of science has both intellectual as well as practical dimensions." Further the document asserted that the "scientific thinking concerns the manner in which the facts are interpreted and applied. On an individual level, scientific thinking is an attitude of mind, a way of life, a manner of viewing information. In the context of a society, it influences how the community will approach a problem and the values it would affirm in finding a solution for it."

The credo of the science channel was stated as 'science is everywhere and science for everyone'. Therefore it is not unexpected for the document to state "one encounters science in every walk of life - in agriculture, in healthcare, in child rearing, in mitigating disasters and so on. The various disciplines of science come together in an integrated manner during the study of any natural phenomenon." The document asserted that "Science and Technology plays an important role in shaping a nation's present and future" and argued that as "Science is involved in every step that we take so much so that it is impossible to imagine out present modern mobile world without it."

While identifying its intended and potential audience the perspective document stated that it would obviously be “wide- ranging group for knowledge needs are varied and multilayered in a society like ours”. Distancing from the common trend among the non-state funded private television channels the document categorically delineated that “unlike the commercial channels, which aim largely at those with purchasing power, this channel has to seek out the audience that is left out by conventional media” and thus placed underprivileged and sections without access.

In nutshell the perspective –document underscored the following concerns

- Science is rational study of natural world (not just nature)
- Kernel of science is reason and methods
- Science is essentially understandable
- Rational thinking and analysis include questioning of existing belief not only of natural phenomena but also of social tradition
- Science is all permeating and thus in modern world an understanding of the science is essential.

Thus, emphatically the perspective document moved away from the usual ‘gee-wiz’ or ‘wonderment & enchantment’ genre of science communication and argued that science communication is primarily communication of the ‘scientific methods, scientific processes of reasoning and scientific approach’.

6. Programming policy

Educational and instructional television programmes, being usually considered as benevolent, altruist and ‘charitable’ act reaching to those who are otherwise handicapped by ‘deficient’ knowledge. They are usually understood under the rubric of ‘supplementary’ material, they are seen not as integral part of the teaching learning process, but as add-ons. However the programming philosophy stated by the sponsor’s document rightly identify the “triangular relationship amongst the content expert, communication researcher and programme producer” and asserts that this “will form the basis of programming”. Elaborating this point the document clarifies that “content will be important but communication strategy and production values will be as important. It is through a synergy between content development, production quality and audience needs that the channel will come up with programmes, which will seize the interest of audiences.” Scientifically authentic, accurate and at the same time interesting and exciting and be an example of ‘edutainment’- was indeed the challenge before the sponsors.

The serial had scope for the audience to interact and write back to the producers/sponsors. The segment by the presenter being totally open ended- that is experiments/ demonstrations are performed and interesting & engaging aspects pointed out; but explanations are not provided. At times the activities and ‘performance’ were witty; humorous. These aspects of the serial befit the stated policy perspectives of the sponsors- “These are not just gimmicks to promote the channel, but means to build up lifelong habits of pursuing one’s own questions in audiences. The content generated by the viewer gets absorbed and retransmitted as broadcast matter.” True to the claim the serial was interspersed with what was called ‘Q&A specials’. These were specific episodes totally devoted to responding to the queries sent in by the young viewers.

7. Content analysis

As no statistical analysis of the images is intended and the study is more in the genre of sociology of knowledge studies the segments/programmes identified for analysis were selected for their illustrative value rather than to satisfy the requirements of random statistical sample. The first thirteen episodes of the programmes/segments were examined for this study. The programme segments of animation short film as well as the insertion of the anchor presenter are not considered part of this study.

For want of space all the activities and details are not stated, stating at least a few is in order. Do you know that while peeled orange and unpeeled one does not differ much in their weight; densities are different and hence while the unpeeled one floats in water while the peeled one sinks? Do you know that acids and bases are found not just in chemical laboratories; but all around us? Lemon juice or Imli water (tamarind juice) is acidic. Want to “see” sound? Place a handful of thermocol beads on the surface of the speaker. Play the sound system and watch how the beads dance to the music. Isn’t it amazing that piercing an inflated balloon placed in a tub full of water and you can “simulate” Tsunami? These are some of the typical of the activities conducted by the kids to explicate the scientific concepts.

While episodes examined are absent in images and portrayal of Science as magical or mysterious; Science as dangerous and Science as solution to problems the dominant image observed is 'science as fun'. Scholars have pointed out that 'science as fun' is a very positive image. Strong image of science as fun may encourage the audience to shed their 'natural' fear and increase the audience (especially children) positive attitude towards science, which in turn may invite them to take more science class work and to work harder in science. In this programme, there are no elite 'scientists' or 'omnipresent' science providing answers to all the questions. Rather, the children, narrator and the presenter parley and review the mooted questions, using essentially demonstration and graphics.

Image of 'Science as truth', by emphasising 'facts' rather than process of acquisition of the claimed knowledge in the first place, aid foster an attitude science as yet another belief system and does not do justice to the radical potential of science.

It is indeed regrettable that 'Science as part of every day life' has rather underemphasized in the narratives of the programmes. It is indeed a fact that circumstances and materials from the daily lives are used to demonstrate the scientific principles, however, it is not shown to be used by us, either intentionally or unsuspectingly.

While not holding a philosophical position of 'situated knowledge' or that science is nothing but a 'standpoint', Peoples Science Movement, views people, especially the skilled artisans, as repositories and carriers of knowledge¹⁰. This position, *a la* Bernal, traces the 'origin' of science to the human labour and accentuate the image of 'Science for every one'. To illustrate another programme on fishing practices in Kerala, not part of AH3, we are informed that, while catching fish with bow and arrow, the fishermen direct the arrow just wee-bit below the image of the fish seen under the surface of water. The programme highlights the fact that, due to the refraction of light, the fish would actually be found just below the apparent image and this is exemplified as an instance of how 'science' is imbedded in the traditional practices and artisanal practices. Instances of such images are far and few between in AH3 and thus does not do adequate justice to the claim 'science for everyone, science is everywhere'. Images such as Science as national pride, Use/abuse of science, and Science as sacred are not seen in the programme, probably because the programmes are made as 'children's programme'.

8. Discussion and conclusion

It can be noted from the analysis that in overall terms the image of science in the selected segments of AH3 programme has been positive. While it is appreciable that, the serial foregrounds the image of 'science as fun', underemphasize of 'science for every one' needs to be noted. 'Experts' from the marginal communities of India such as fishers, and artisans are hardly represented in the programme. Such representation may encourage 'public' to take a stronger interest in science. Much more could be done to improve the situation with respect to gender perspective. Hardly any woman is framed as an 'expert' in any of the segments analyzed for this study. Even in those few frames in which women are present, they are shown to be engaged in the background. The dominance of male is not surprising, as LaFollette¹¹, notes that scientific experts in TV drama and magazines are usually an 'older- white- male'. The prevalence of the image of science as a part of every day life and the dearth of image of science as magical or mysterious may held dispel frequently held misconception that science is difficult, incomprehensible and alien.

Science as fun, found as dominant image may extricate the viewers from the painful recollection of their class room science and may encourage strong positive attitude among the audience, especially among the children. The image of science as truth may discourage the viewer from imbibing the spirit of enquiry. Emphasizing certitude does not promote critical awakening in science-society-related issues and thus the science communicator misses the key opportunity to encourage original thinking among the viewers.

Content and the form of television science is a highly contested arena. As Roger Silverstone remarks¹² "It has been said that television science accepts too readily science's own definition of its work and practice, failing to cross examine science like other public (activities)...equally (there are criticisms) that television science is insufficiently attentive to science and to details of scientific practice, trivializing, distorting, sensationalizing and fails to take on a significantly pedagogic role". Further Silverstone argues that television science "reveal a tension, both in their narrative and in their process of production, between the claims of information and entertainment, as they are conventionally conceived". Science communicator as a mediator has a delicate responsibility. As a mediator, he/she has to balance between his/her role as an interpreter seeking neutrality, a promoter seeking audience attention, an observer desiring evaluation.

Lafollette¹³ shows how the popular "...science series embraced television's ability to dramatize. They also mixed facts and fictions.." and attracted attention, nurtured a dedicated audience. However Indian TV Science programmes seems to have taken a 'safe' approach to presenting science in a flaccid and passive idiom. The 'producer'

it is assumed will not/does not know science; and hence their role is not seen as a mediator; but rather passive channel. Nonetheless successful programmes have always depended upon active role of the TV producer/director. Cho, Mildred¹⁴ analysing a series of TV programmes describe how science is selectively invoked to validate and further particular political agendas. The narrative structure of the programme that does not take the views expressed by experts as 'given' but themselves to be questioned and examined. The said programme explicated as well how the personal opinions and agendas of individual scientists can greatly influence broad social policy. The series can be seen as challenging scientists to examine whether pervasive societal concepts have caused unconscious bias in their own research. Such genre of programmes emphasising critical appreciation of science advocate rational thinking and analysis that include questioning of existing belief not only of natural phenomena but also of social traditions.

Reception of science programmes in French TV by adults were studied in a survey conducted in France¹⁵. This study shows that there are not one but several very different readings of science programmes. Depending upon the cultural background of the 'public', the viewers reacted variedly to the science programmes. The study discerned four major readings, each a coherent and recognizable constellation of very similar reaction, coming from very different people. The reactions were based upon two major factors; one, the legitimacy accorded to the television as a source of knowledge, two, to the type of memories left by their school experience. The four major readings were (1) *intellectual reading*: Television is not a legitimate source of knowledge about science, a mediator is not desirable (Science should speak for itself), a documentary with unmediated view of science is more preferable. (2) *Beneficiary reading*: Television is a good source of knowledge, a mediator is essential and should be very present. (3) *The intimistic reading*: No particular criticism of TV as a source of knowledge, an extreme sensitivity to what is interpreted as a reminder of school or as suggestion that the viewer may be ignorant or unable to understand. (4) *The excluded reading*: Science cannot be understood and television is no help.

Reflectively, the dominant programme approach and format (the role of mediator, the programme form and so on) embeds implicit assumptions about the audience. If the science were placed only in the 'natural world' and very little of mediation is present in the approach, then it would imply an 'intellectual reading'. Such an approach would result in the canonical 'documentary' format. In contrast, programme with mediator very much present and the science is 'demonstrated' in studio would imply a 'beneficent reading'.

The programme format of AH3 is very much set in the studio situation with mediator very much present. A number of shots and sequences vividly portray the participants – the children and the presenter- relishing the science. Rather than on the answers, accent of this programme is on provoking questions¹⁶. Moreover, many a programme makes effort to explain the scientific concepts using a number of 'science popularization techniques'¹⁷ to make the 'science' not resemble 'textbook'.

In the context of tension and dilemma, many scholars have noted that the media takes an easy way out- let the science speak for itself¹⁸. In the case of television science, this would entail a form of production which would galore with interviews with scientists, shots of laboratories and S&T institution and take refuge in canonical documentary format. On the contrary, if the media producer aspires to play the role of a mediator and science critic¹⁹, then the 'television science' is not measured in terms of the degree to which scientists & scientific institution is present in the programme, but to the extent the producer is balancing the role of agenda setter and political broker, legitimization of scientific elite and the public right to know. If the aim of the television science in Indian languages in India is one that of 'Science for the people', it is evident that programme form should have 'beneficent' construction of the public. The main challenge for the television programme producers would be to deviate from the conventional 'natural world' documentary formats to innovate popular programme formats.

References:

¹ See, Bruce V Lewenstein, 'Science and the Media', in Handbook of Science and Technology Studies, Ed by S Jasanoff et.al., Sage Publishers, New Delhi (1995) pp 343-360.

² See Martin Bauer and Ingrid Schoon 'Mapping Variety in Public Understanding of Science', *Public Understanding of Science*, Vol. 2 (1993) PP 141-155

³ It is reported that in the year 1994-95, there were 1409000 TV households and 1447 community TV sets in Kerala. *Mass Media in India 1994-95*, Publication Division, Government of India (1995) pp190

⁴ See Anita Rampal, 'The Folklore of science and scientists, a case study of school teacher perception', Occasional papers (No XXVI), Nehru Memorial Museum and Library, New Delhi (1991) Mimeo.

⁵ Raza Guhar, 'Confluence of Science and Peoples' Knowledge at the Sangam', NISTADS Publication, New Delhi (1996) p 26

⁶ There are numerous literature. See Mares, Marie-Louise Using Television to Foster Children's Interest in Science. *Science Communication*; Mar99, Vol. 20 Issue 3, p283- 298, for a review of how TV influence; also see LaFollette

'*Making Science our Own –Public Images of Science 1910-1955*', University of Chicago Press (1990) for the images in popular science literature. See Collins HM 'certainty and the Public Understanding of Science; science on television' *Social Studies of Science* Vol.17 Iss 4 PP 689-713 and Collins HM 'Public experiment and display of virtuosity; the core set revisited', *Social Studies of Science* Vol 18 Iss 4 pp 725-748 for an sociology of science analysis and see Jacobi and Schiele 'Scientific imagery and popularized imagery; differences and similarities in the photographic portraits of scientists', *Social Studies Of Science* Vol 19 pp 731-753. See also Spencer Weart, 'The physicist as mad scientists', *Physics Today* Vol 41 No 6 June 1988; Steven L Goldman, 'Image of Technology in Popular Films Discussion and Filmography', *Science, Technology & Human Values*, Vol. 14 No3 (1989) PP275-301.

⁷ Self-efficacy is the degree to which people believe that they can perform a specific behavior.

⁸ Cited in M.Long and J Steinke, 'The thrill of everyday science: images of science and scientists on children's educational programmes in the united states', *Public Understanding of Science* Vol., 5, 1996, PP 101-119.

⁹ Cited in M.Long and J Steinke, 'The thrill of everyday science: images of science and scientists on children's educational programmes in the united states', *Public Understanding of Science* Vol., 5, 1996, PP 101-119.

¹⁰ "... It is not simply a matter of scientists and technologists who 'know' teaching the people who 'do not know'. The scientists has to be aware of the people's own vast knowledge accumulated from years of experience. The professional must learn to respect the ingenuity of the artisan and farmer..." in '*People's Science Movement*', Science Publications (Published for Tamil Nadu Science forum), Madras 1996.

¹¹ LaFollette '*Making Science our Own –Public Images of Science 1910-1955*', University of Chicago Press (1990)

¹² Roger Siverstone, ' Science and the media, the case of television', in *Image of Science, scientific practice and the public*, Ed S J Doorman, Gower Publishers (for European Science Foundation) 1989 pp 202.

¹³ Lafollette, Marcel C., A Survey of Science Content in U.S. Television Broadcasting 1940s through 1950s: The Exploratory Years, *Science Communication*; Sep2002, Vol. 24 Issue 1, p34-72

¹⁴ Cho, Mildred, Dilemmas of a Divisive Concept. *Science*; 4/18/2003, Vol. 300 Issue 5618, p434

¹⁵ Suzanne de Cheveigne and Eliseo Veron, 'Science on TV: Forms and reception of science programme on French Television', *Public Understanding of Science* Vol. 5 (1996) PP 231-253.

¹⁶ Why bits of paper are attracted by comb rubbed on a dry hair? Why some thing float while others sink? What is surface tension? And many more questions are raised in the programme.

¹⁷ For a useful tips on pragmatic techniques see, Deborah Blim and Mary Knudson (Ed) '*A Field Guide For Science Writers*', Oxford Publishers, Oxford (1997).

¹⁸ Sharon Dunwoody, 'Comments (on Television in Science)', in *Image of Science, scientific practice and the public*, (Ed) S J Doorman, Gower Publishers (for European Science Foundation) (1989) PP 212-218

¹⁹ Maurice Goldsmith, '*The Science Critic*', Routledge & Kegan paul, London (1986)