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# Research on Research.

Second Order subject of First Order importance

An earlier issue of "Campastimes" carried an article on engineering education abroad.

Two questions were left open for a later date. These were (1) What is researching in the U.K. like as compared with researching in India? and (2) What are the personal motivations for living and researching abroad?

On further reflection it appears that (1) can be answered properly only by those who have researched in both places and this I have not done ~~and~~ while an individual answer to (2) is bound to be

mistleading! Consequently the answers to the questions must await the completion among Indian students of a survey <sup>now</sup> under way at Imperial College.

However, there is another important subject that ~~forms~~ forms (or should form) the background to these questions and I propose to deal with this in the present article.

### Academic freedom and social responsibility

By the latter I mean responsibility towards society in the widest sense including accountability.

Society sets up an University in the belief that those who live and work

in one, by virtue of their knowledge, will  
 not only improve the <sup>living standards</sup> ~~welfare~~ of the people  
 by the application of existing knowledge but  
 will also decide what improvement means  
 and will decide the future course of certain  
 events by enlarging the boundaries of  
 their knowledge and their consequent  
 application. To fulfill the latter function,  
 which is clearly a ~~social~~ social function in so  
 far as it directly influences society, the  
 concept of academic freedom is  
 introduced. Society <sup>guarantees</sup> ~~guarantees~~, in principle,  
 that in the performance of <sup>their</sup> ~~his~~ duties  
 as members of an academic  
 community <sup>no</sup> ~~or~~ a person will ~~not~~ be

Why not?

subject to the value systems currently prevailing and that ~~he~~ <sup>they</sup> ~~or she~~ <sup>or she</sup> ~~he~~ <sup>or she</sup> shall not in any way be persecuted or victimised for any views he ~~or~~ she may hold about any matter within or without his or her chosen field of study.

Clearly, there are a number of tacit assumptions made while formulating such a sweeping dictum. ~~Failure~~ <sup>has</sup> to recognize the assumptions or their violations ~~has~~ <sup>has</sup> been one cause of accusations about the infringement of academic freedom.

One such assumption is that academic people shall act in the best interests

of society. This implies that, while the modification or demolition of an existing value system is perfectly in order, there is clearly a duty on the part of academics to provide an alternative which they think is better. Not only that, they must also outline the operations that may be required to bring about this change.

Another assumption concerns the

relationship among academics. Each must recognize the other's right to dissent and must also recognize that such dissent may not be "punished" according to the unwritten, evolving rules of academic behaviour.

## The social function of the scientist/technologist

The scientist must be in contact with society no matter what his speciality. He must communicate with his sponsors, namely the public. This <sup>could</sup> ~~must~~ be done either directly or through the financing body. The latter is controlled <sup>largely</sup> by politicians. This is so in every country whatever its political system or ideology.

Any sponsoring organisation (in <sup>this</sup> ~~our~~ case ~~subject~~ society at large) expects a return on its investment, either a material or non-material return. The return expected from

the scientist is a material one. The  
 onus for convincing ~~his~~<sup>their</sup> sponsors that  
 the work they are doing is worthwhile and  
 worth supporting lies entirely with the  
 ● scientists. It is up to ~~them~~ them to see  
 that they talk a language that their sponsors  
 can understand. It upto them to be  
 patient and persevering. In short if they  
 are committed enough to want  
 ● ~~refer~~ reform, technical and/or social  
 it is their duty to <sup>go</sup> through the sequence  
 of operations (as individuals or as  
 members of the General body of  
 scientists) short of final execution in  
 the normal course and be prepared

to undertake final execution if called upon to do so.

The second social function that a scientist must perform is to be actively engaged in the formation of model communities

Consisting of academics, <sup>in the</sup> performing of social experiments on such communities, <sup>of</sup> ~~the~~ <sup>in the</sup> evaluation <sup>of the</sup> results. <sup>and in the</sup> ~~the~~ <sup>of</sup> refinement <sup>of</sup> the model until it is ripe for "scale up" to society at large.

## Research on Research

I have tried to show how the freedom to pursue a line of thought is subject to certain tacit assumptions

about social responsibility. We have seen how accountability to one's sponsors entails the performance of social functions of communication operations of and the physical implementation. It follows that if either of these is not performed or performed badly, society has a right to invest its money in other areas where the return is finite, tangible and evaluable. The rest of this article is concerned with the formulation of questions about the mechanics of communication and the problem of evaluating the progress and results of research to provide criteria for

funding. The task of trying to answer the questions is what I call, ~~Research~~ without profundity, ~~understandably~~ Research on Research. Before plunging into the subject I shall ~~defi~~ introduce a few concepts.

1. Relevant and Irrelevant research:

At the very outset, I must emphasise that this is not the same thing as "applied" and "pure" research. The latter distinction is artificial and on many occasions meaningless and I fail to understand why people continue to talk in those terms while formulating policy.

6.

A couple of examples will serve to illustrate my point.

Irrelevant "applied" research: Ballistic missiles nose cones while re-entering the

● atmosphere get heated up. Data are needed on cooling these <sup>with</sup> gas injected through the porous surface of the cone. ~~Some~~ The

equipment to undertake the project is available in India. To ~~undertake~~ <sup>do so</sup> the project

● would be very "applied" but highly irrelevant.

Relevant "pure" ~~research~~ research: "Ad hoc" catalysts

for many chemical ~~reactions~~ processes

(e.g. fertilizer production) have been

exhausted and the "suck it and see" technique of developing new ones is

becoming increasingly time consuming, inefficient & expensive. To understand catalytic behaviour it is necessary to understand the behaviour of electrons near solid surfaces. An investigation into such behaviour would be classified as "pure" ~~use~~ research but would be highly relevant.

### Gestation period and lead time:

Considerable time elapses before the results of research are put into practice by industry. This time maybe anything from one to twenty years or more. The time maybe divided into two blocks, the gestation period and the lead time. The gestation period is the time taken for

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research to be translated onto the drawing board. In other words it is the time <sup>that elapses</sup> ~~taken~~ before "thumb" ruling is replaced by slide ruling from the moment the decision to switch from one to the other is made.

The onus for reducing this ~~trans~~ time lies with the people in Universities and Research Organisations.

The lead time is the time that elapses before drawings are converted into hardware. The onus for reducing this lies with the people in Industry though it is obvious that this time is affected by the content of research in so far as <sup>the latter</sup> it affects design for production

Having introduced those concepts one  
~~draws~~ ~~the~~ ~~is~~ now in a position to get  
to the kernel of the discussion.

~~The Mechanics of Communication~~  
~~There are two aspects~~

The argument for scientific planning  
can be put ~~into~~ succinctly in one  
sentence. ~~It~~ In a phase-<sup>in</sup>-coherent system  
energies add, while in a phase-  
coherent system, amplitudes add.

We want amplitudes to add in  
scientific work. It follows that  
science must be "laserised" into

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a phase-coherent system. In the deployment of limited resources one needs to make a rational choice among ~~the~~ research

One can projects. I now formulate the first

- Question that a scientific administrator, ~~the~~ ~~understand~~ should ask himself:  
Given a ~~fixed~~ limited resources, what are the  
I criteria that should form the basis of  
allocation of these resources among  
various research projects?

Clearly, social relevance, gestation period, ~~or~~ technological "fall out" potential lead time & expense I will all come into the picture. Precisely how they should be taken into account is the question.

I might add that social relevance is

not to be confused with "material usefulness".

Thus a 'prestige' project which allows one to profess "equality" with scientists anywhere else in the world is ~~not~~ morale boosting and improves the psychological climate for scientific work. Question is, how much money will you spend on it?

Let us assume that a rational choice has been made and that resources have been allocated. Then ~~later~~ At time comes when it is necessary to evaluate the results from ~~the~~ the projects. How are you going to do this? Will you give the successful

project more money because it has shown promise proved itself or will you give it less saying that it is time another project got a chance? What

• are your value judgments based on?

• The tendency to give more money to a project that succeeds reinforces that area of science in a highly non-linear fashion — and another project

• still non-existent or in its infancy

can languish — Will you give each

or every project the "critical" amount of

resources (Men, Money & Materials)

to ensure self-sustaining growth?

How will you decide?

One  
Q<sub>1</sub> can now formulate the second  
question that ought to have a rational  
scientific  
answer ~~rather~~ rather than the current "ad hoc"  
ones:

What are the criteria that should  
be used in assessing the results of  
research effort? and what ~~are~~ <sup>applied</sup>  
how shall they be modified ~~in~~ <sup>to</sup>  
time to deal with determine the  
distribution of additional resources?

The above two questions should exercise  
the body ~~concerned~~ ~~with~~ ~~the~~ that  
makes the choices. The <sup>next</sup> ~~second~~ series of  
University or  
Questions concern ~~the~~ <sup>scientific group</sup> ~~scientific organisation~~  
and the receiving the money and the

individuals who ~~work in it~~ <sup>earlier</sup> form the group.

I have said that the onus for establishing and demonstrating the sociological relevance

of ~~the work~~ of scientists' work lies with

● them. ~~How should this be done?~~ It is

nearly ~~really~~ boils down to the proper choice of problem(s) to work on. How many

times have we seen papers

published by Indian workers which

● are mere extensions of other peoples

work (typical example: working out

a complicated mathematical solution

taking six terms into account when

the original had only two terms!)

in order to ~~of~~ enlarge the list of

"published work". ~~the~~ ~~ambition~~ The ~~prestige~~ <sup>prestige</sup>

values of certain types of "modern" research have a deadly grip on many

of us. Indeed, I noticed the I.I.T

Alumni Association Newsletter mentioning

the importance of combustion studies

on ~~missiles~~ aircraft, missile and

rocket technology. which struck

a note of grandeur and "big

research" in the reader. We forget

that more two thirds of India's

energy ~~source~~ <sup>is</sup> output per year

comes from burning cowdung.

We ~~don't~~ know <sup>far less about how</sup> how cowdung ~~burns~~ <sup>is used</sup>.

than we do about ~~how~~ solid rocket <sup>propellants</sup> charges.

(4)

Cow dung

~~Why~~ Some people burn it <sup>in</sup> ~~the form of~~ balls, others in <sup>circular</sup> ~~shaped~~ discs. Why this difference? Which is the better way of burning it? What

• is the best size to make it in that for most efficient burning? What about ~~will give the~~ <sup>maximum</sup> the gases that the cow dung gasifier? But then, this is all "low brow" stuff. You cannot be sure of getting <sup>"Combustion & Flame"</sup> a paper published in ~~the~~ ~~MEAS~~

• Journal on the reaction kinetics of burning cow dung but you can be sure <sup>if</sup> you ~~to~~ investigate shock induced ignition in a hypersonic gun tunnel. Besides, <sup>is</sup> there <sup>is</sup> lot more gadgetry ~~or~~ involved in the latter. Since ~~you~~ <sup>it</sup> will be ~~likely~~ to get

~~hold of such a~~ close to impossible to  
get such a facility in India you fly  
off to the U.S. and write "letters to  
the Editor" about how ~~mean & beastly~~  
conditions for the growth of science  
in India are rotten ~~and~~ etc. I ~~am~~  
have, of course,  
exaggerated ~~of~~ the picture considerably  
~~but~~ ~~the~~ ~~essence~~ but the point I  
am trying to make is this: The  
choice of <sup>a</sup> problems is crucial. It is  
imperative that the problem be  
extracted from the <sup>total</sup> social environment  
one lives in and not "manufactured"  
to fit an extension of ~~the~~ ~~existing~~ ~~partial~~ ~~solution~~ ~~to~~ ~~a~~ ~~problem~~. <sup>borrowed</sup> ~~borrowed~~

<sup>an existing</sup> partial solution to a <sup>borrowed</sup> ~~borrowed~~ problem. <sup>borrowed</sup>

~~How does one ~~work~~ go~~. The next question can now be formulated.

How is one to make a national choice of a problem to work on; balancing

- personal interest, social requirements, prestige and monetary gain?

Society is not ~~that~~ a giant philanthropist

It does not support scientists anybody

merely for their own pleasure. Artists,

● ~~and~~ sculptors, musicians

are supported and they paint, ~~to give~~

because they communicate their

work to their sponsors, ~~the~~ <sup>namely,</sup> the public.

Whatever a scientist or technologist does,

it is vital that he performs his duty

Part of the social responsibility of scientists lies in seeing that they take all reasonable means to ensure the ~~fastest possible dissemination of their work~~ <sup>of</sup> communication. There are two <sup>para</sup>

aspects to the mechanics of communication.

One is the problem of communication between scientists and scientific organisations. The

second is the more difficult area

of communication between the scientist and the public; scientist and the machinery of government; scientist and sponsor.

Communication among scientific workers and their employing organisations is effected through Journals. With the information explosion outstripping the population explosion by several times it is becoming increasingly

(11) (13)

difficult to keep in touch with work in one's own field, let alone work in other disciplines. However, it is clear that a poor country like India cannot afford duplication of effort and it becomes all the more important that scientists are made aware of the work being done elsewhere in India. Today, one University knows little about what another is doing. One laboratory knows nothing of the work being done in another. Yet, scientists in India usually know about what is being done in M.I.T or ~~Harvard~~ Harvard. Our efforts to document and disseminate our own work is feeble. People <sup>workers</sup> will try

to ~~get~~ publish papers in the Proc. of Roy. Soc.  
or Journal Physics Review letters. By the  
time it gets accepted, published and  
distributed to another Indian scientist  
in another University (if at all, since  
some of the foreign journals that Indian  
scientists patronize never get to  
the library of many Universities) anything  
from <sup>six</sup> ~~to~~ months to three years would  
have elapsed. It makes much more  
sense, is less expensive and far more  
efficient to publish work in Indian  
journals or even as internal memo's  
to distribute these. But we succumb  
to prestige. We fall prey to the desire

- To assert and demonstrate our "equality" with scientific workers abroad. In fact, our choice of research topics is also conditioned by this. The value systems and promotion devices are also pegged to how many papers get published in "reputed" journals.
- ~~Then there is~~ the genuine and legitimate desire to make one's work early ~~and~~ accessible to other workers abroad does not seem to extend to making the same work accessible to Indians! I remember distinctly the day <sup>in my second year B.Tech.</sup> when a certain best lecturer came into a noisy class and declared, "I do not have to prove my worth to you. I have made my -

name in ~~power~~ here and abroad and no amount of shouting by you is going to demolish it". Whatever the case for making that statement in that class at that time, it is indicative of <sup>of social irresponsibility</sup> a mentality that is hardly befitting a scientific worker, much less a teacher. Next question:

What are the most efficient systems of information storage, retrieval and dissemination in India that suit India?

It is quite pointless to say ~~that~~, this is the way it is done in the UK and/or U.S. and transplanting the techniques

(B)

will do the trick. The Centre of Gravity of  
our thinking must be shifted from its  
present location in mid-atlantic to  
somewhere near Nagpur.

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|  
|  
|  
|  
(see next two sheets)

(10) (13) suspicion &

foibles as laymen. Petty jealousy, sheer  
cussedness, are not monopolies of the  
non-scientists.

What are the most efficient systems of  
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be shifted from its present location in  
mid-atlantic to somewhere near Nagpur.

The second, more difficult & contravertial, aspect  
of communication is ~~but~~ that which ought to  
but does not take place between scientists

and society. To condemn those who do not understand science, to look down upon those who do not have either the capacity or the inclination to <sup>comprehend</sup> understand the micro-picture of technology is ~~both short sighted~~ high handed. It hurts science in the long run for those who are starved of information and are told to, in effect, ~~shut~~ lay-off science are precisely the people who control the purse strings. Popularising science is an <sup>important</sup> ~~vital~~ social function that every scientist must consciously undertake to perform. How many scientists bother to tell their ~~wives~~ wives about their work? How many bother to explain the working of a

piece of apparatus to the mechanic who helped to build it? The last <sup>question</sup> party raises a point that has been bothering me for some time. We take considerable trouble to force

● a foreign language (German, French or Russian) onto an IIT student. in the belief that an exposure to the language will enhance his capacity to handle <sup>appearing</sup> information in those languages. It does that. But we do

● not seem to pay equal or any attention at all on the problem of his future communication ~~to~~ with the people he will be working with.

You cannot talk to a mechanic in French or English. ~~Not because of course the~~ ~~verbal languages fall into disuse~~

I believe the options to learn an Indian  
so as to be able one to innovate with it  
language properly, should be available at  
an IIT. in order that at least rudimentary  
communication <sup>a complete communications breakdown</sup> <sub>resulting in</sub> The alternative is a  
growing alienation ~~to~~ of the people involved  
with the nuts and bolts of science and its  
spirit. ~~Some alienation is unavoidable~~

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- ① Need to make a rational choice among research projects
- ② Improvement in production varies as a high power of money spent on research.  
Law of diminishing returns
- ③ Social "sickness" in science - Military expenditure, Prestige science, psychological factors, promotions etc.
- ④ Deployment of limited resources

Which brings me to the last question:

How <sup>should</sup> can the Scientific Attitude be  
communicated to the people? What are the  
best ways of popularizing science?

The aspects of Research on Research that I have touched on in this article constitute the tip of an iceberg. Much of it lies under the surface. If we are to make full use of science and Technology to improve the welfare India's millions it is imperative that a rational approach to scientific planning ~~be~~ adopted. Research on Research is a second order subject

of first order importance.