Tables 3–9 give data on various energy resources like hydro, coal, gas, uranium and thorium. Our oil extraction process is rather low, about 20% *vis-á-vis* about 80% elsewhere. Improvement in extraction efficiency would bring in significant energy savings. With respect to uranium and thorium, we have limited uranium resources but abundant thorium. Those who have lot of uranium have no interest in the use of thorium. Those who have less of uranium and lot of thorium like India, should work towards the fast breeder. The recoverable uranium reserves (35,000 tonnes) will support 10,000 MW-PHWR while the recoverable thorium reserves (400,000 tonnes) equivalent to 600 bn tonnes of coal will support 350,000 MW-FBR.

Table 10 and Figure 2 give data on costs. The unit energy cost from recent plants is higher due to higher input cost and incorporation of several safety features. The OECD data shows that the nuclear cost is cheaper in comparison to coal. We should specially take note of the situation in France.

Finally, I make a few suggestions about planning for power reactors for the next century following Sarabhai's earlier proposal. I think we must create industrial complexes around power stations and use up all the power there to avoid long-distance transmission where losses go up to even 30% (mostly by theft). The maintenance of the lines is also a specialized science. Domestic supply must be treated as a separate demand.

Research as a career – A study of factors influencing choice

N. R. Rajagopal, G. Kartikeyan and Ruchira Tewari

For a dynamic R&D organization the values and attitudes of its researchers are crucial. Do our young researchers exhibit a keen desire to take up research as a career? The following sample study probes this important aspect of R&D through the responses of our young researchers.

RESEARCH as a career has been the topic of discussion elsewhere in the world. Generally it is perceived that a scientist opts for this profession consciously in preference to others. The spirit of inquiry, the thrill of unravelling the mysteries of Nature and, now, finding out new things that may bring economic/social betterment to fellow beings and himself/herself seem to constitute the motivation to undertake Research & Development (R&D). Do our young researchers make a determined bid to enter the portals of R&D institutions with research as a career in their minds or do they gravitate there buffeted by circumstances beyond their control? Why is the number of personnel actually engaged in R&D so small? The declining trend of expenditure on R&D as a percentage of GNP (ref. 1) with the resultant decline in the attractiveness of science as a career is of serious concern especially when we claim to have a large reservoir of S&T personnel. Opinions[2,3] on the university research scenario have been expressed by academicians. Yet no answers to the above and related questions have been obtained based on analysis of authentic data from research workers. A study of the attitudes of young scientists at the research fellow (RF) level was therefore deemed necessary. These RFs are selected and placed by the Human Resource Development Group (HRDG) of CSIR in universities and higher technological institutions of their choice to pursue research. In terms of the number of fellowships and range of disciplines covered, HRDG accounts for the largest collection of young scientists undertaking R&D. Being one of the largest, it is imperative for CSIR and other funding agencies to know whether these fellows and associates really aspire for scientific research, choose research as a career and whether they find themselves motivated to continue.

The data was acquired from a sample of RFs on an individual basis through a questionnaire, inquiring about their decision to pursue research, their views regarding the prospects of scientific research as well as theoretical

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Table 1. Male and female responses to questionnaire

	Male	*Female*
Total sent (766)	461	305
Total respondents (315)	194 (42%)	121 (40%)

scientific research in India, laboratory environment, extent of supervisor's involvement, etc.

It was observed that 315 of 766 mailed questionnaires were completed and returned, yielding a final response rate of 40% (Table 1).

Of the 315 respondents engaged in research, 253 (80%) are in science laboratories, and 22 (7%) in engineering-oriented laboratories. The responses came from 75 (24%) JRFs, 153 (49%) SRFs and 87 (27%) RAs. The average age of JRF, SRF and RA was noted to be 24.5, 27 and 30.5 years respectively.

Researcher by choice

This section reveals that apparently a large section (119/315) of respondents are interested in pursuing research as a career. The respondents were shortlisted by repeatedly asking the question regarding their choice among several career options.

Most of the respondents (305, i.e. 97%) desired to take up research as a career for different reasons. Fifty-eight per cent of them opted for it to bring out something good so as to serve the country as well as the society; 16% were interested in getting Ph D degrees; 11% thought they were in for good job opportunities; 8% had other reasons to pursue research whereas 6% did not answer. It shows that a large portion of aspiring researchers wished to take up research as a career primarily for the sake of the humankind.

In two different sets of questions about their choice of a career, it was seen that about 61% and 68% reportedly were interested in pursuing research activities. In the first set they were asked what they desired to become. A good number of the respondents (135 – over 42%) showed their willingness to work in R&D labs like CSIR laboratories or as lecturers (67/315 – 20%) or go abroad for post-doctoral fellowships (58/315 – 18%). A few wanted to join the industrial sector (17/315 – 5.4%). Ten per cent (32/315) were not ready for it, whereas a small number of scholars (6/315) did not respond.

Eighty per cent (i.e. 119/135) of respondents of the first set reaffirmed in the second set their decision to pursue research activities. Further analysis showed that about 70% (83/119) of these strongly motivated respondents were pursuing research as a career to bring out something good so as to serve mankind. The rest of the respondents in this group seem to be attracted to careers in multinational companies and other careers (16/135).

Of those who wished to proceed for the post-doctoral fellowship abroad (58/315), 43 opted for research as a career, 6 wanted lectureship and 5 hoped to have a career in multi-national companies; the rest did not show any preference.

A majority (more than 50%) of the respondents who hoped to become lecturers reaffirmed their decision (35/67). Twenty six out of these 67 respondents (nearly 40%) were inclined to a research-related career at the second instance.

A small number of respondents were interested in joining the industrial sector (17/315); out of them seven showed interest in R&D and eight wanted to join multinational companies.

Ten per cent of the total respondents were not decisive when asked for their preference in choosing a career. The same group responded positively for opting research as a career (17/32) in a separate question. Seven out of 32 confirmed their indecision whereas 4 showed interest in career in multinational companies and three opted for lectureship.

Researcher's motivation

How many scholars are working under one supervisor? How much time does a supervisor spend with the scholars? How do the respondents rate their progress? Are they satisfied with the research laboratory environment? How do they feel about the present state of scientific research? An attempt has been made to analyse the responses to the above questions, since the responses contribute to the bulk of motivation of a researcher.

The supervisor's involvement with the scholars plays a dominant role in motivating the young researchers. Table 2 represents the distribution of respondents registered with supervisors having 1 to 5 or more scholars and in Table 3 the average time spent by the supervisor in solving research problems (in a week) is presented. The analysis confirms the view that where the number of scholars registered under the supervisor is less the supervisor spends more time with them contributing to good relationship between the teacher and the taught (181 students – more than 50%, were being guided by supervisors, each of them having three or less scholars to supervise). Moreover 269 scholars – more than 85% – had the benefit of attention of a minimum of one hour per week. The number which had the benefit of a minimum of eight hours per week was 133, i.e. 42% of the total considered here.

The scholars were asked to rate their progress themselves towards attaining their research goals, their labo-

Table 2. Distribution of respondents registered with supervisors, each having one to five or more scholars

Discipline	One	Two	Three	Four	Five or more	No respondents	Total	Mean no. of scholars
Ma	10	9	5	2	1		27	2.07
P	8	15	15	13	10		61	3.03
B	22	14	21	22	34	1	114	3.25
C	11	8	13	13	23		68	3.43
E	1	3	5	1	4		14	3.29
En	6	5	2	4	3		20	2.65
Me	4	2	2	1	1	1	11	2.09
Total	62	56	63	56	76	2	315	3.07

Ma, Mathematical Science; P, Physical Science; B, Biological Science; C, Chemical Science; E, Earth Science; En, Engineering Science; Me, Medical Science.

Table 3. Discipline-wise break-up of time devoted by the supervisor with the scholar per week

Discipline	More than 14 h	8–14 h	1–7 h	Less than 1 h	Nil	No respondents	Total	Average hours per week devoted by the supervisor
Ma	3	10	11	3	0	0	27	7.37
P	12	14	27	5	1	2	61	7.50
B	21	22	52	15	4	0	114	6.90
C	20	12	28	8	0	0	68	7.82
E	2	3	4	4	1	0	14	6.23
En	4	4	11	1	0	0	20	7.25
Me	4	2	3	2	0	0	11	8.36
Total	66	67	136	38	6	2	315	7.31

Ma, Mathematical Science; P, Physical Science; B, Biological Science; C, Chemical Science; E, Earth Science; En, Engineering Science; Me, Medical Science.

Table 4. Average responses in five-point scale

Discipline	Ma	P	B	C	E	En	Me	Total
Respondents' own progress towards attaining the research goal	3.81	3.78	3.59	3.74	3.79	4	4.18	3.73
About respondents' work place environment	3.88	3.61	3.56	3.43	2.93	3.45	3.73	3.54
The prospects of scientific research as a whole in India	3.33	2.73	3.09	3.1	2.79	2.89	3.39	3.03
The prospects of theoretical scientific research in India	3.5	3.08	3.3	2.98	2.79	2.9	3.6	3.17

ratory environment and how they felt about the prospects of scientific research in India (Table 4).

The perceptions of the respondents were quantified in five grades, ranging from 5 (very good) to 1 (very bad), to calculate the average response. The average responses varied between fair and good in all the above mentioned cases. The majority believed the climate to be conducive (fair to good) to do research.

Discussion

Research activities cannot thrive without enthusiastic researchers and a proper climate for them to work in. The distinctive features of highly sophisticated re organizations include a high degree of innovatior environment with plenty of creative opportu According to Baillie[5], there would be a certain of 'sheer faith' in ideas and initiative of scient quiring tolerance of creative individualism.

Analysis of data herein reveals most of the r dents chose research as a career and were intere continuing. They had a healthy attitude to their sion as brought out by the fact many of them ha relationship with supervisors and believed the clir research to be good. In other words here is avai motivated cadre of scientific workers brimming w

possibility of finding out something new – may be resulting in a breakthrough. Recently it has been reported[6] that the Indian share in world scientific output in terms of publications has declined by 32%. It is open to question why this should happen when we have motivated young researchers. Richard Jolly, author of the *1996 Human Development Report* published by the UN Development Programme, notes that a large research and development workforce does not guarantee economic success[7]. Moreover the value system of an individual would be, among other things, a factor of cultural heritage variables, demographic characteristics and the larger social values from which the individual has emerged[8]. The value system of scientists and its relationship with work climate may provide useful guidelines for design of work in such organizations[4].

Limitations

The number of respondents considered in this sample is small as compared to the total funded. Constraints of time and accessibility stood in the way of addressing all the fellows. Yet attempts were made to draw as representative a sample as possible from the point of view of regions, disciplines, gender, etc. Only the answers relevant to the two important questions (choice and motivation) were considered.

Payment of stipend, perhaps a contributory factor to motivation, did not appear to be a problem since the majority of respondents (60%) stated they were satisfied with the current CSIR procedure.

Conclusions

From a sociological point of view, can a definite conclusion be drawn at this stage? Yes, the numbers here lead one to believe that our young researchers are fired with enthusiasm to work for the betterment of mankind and/or bring out something fruitful through their research efforts. They find R&D environment congenial. It is interesting to note a good number aspire to join CSIR laboratories! This study has emphasized the need to deal with larger sections of the R&D population with a view to making an in-depth analysis of the value of their output (to knowledge, industry, economy) and then necessarily locating the missing links that influence the mismatch between motivation and performance.

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