teaching and that I saw no reason to stop teaching because of this Fellowship. Instead I asked for, and got, a two-year holiday from serving on committees!

It is time we stopped confusing the promotion of science with the promotion of scientists. If we are at all serious about promoting science, we must get science out of the ivory towers into the streets and gullies, so to speak. We must communicate to young people the excitement of doing science, and the passion we feel that drives us to work absurd hours in pursuit of scientific excellence. This is most definitely not done by instituting more and more awards! As a first step, the so-called elite institutions (including Balaram's own) must start by teaching undergraduate students. It is preposterous that the professors in these elite institutions think that teaching undergraduate students is something beneath them, and is to be left to lesser mortals. Giving a few lectures now and then to college or high school students might serve to assuage their guilt feelings but does nothing to promote science. The catastrophic decision to separate undergraduate teaching from graduate education must be reversed, by force if necessary. Can we think of any institution abroad which has an outstanding graduate programme (MIT, Berkeley, Stanford, Oxford, Cambridge, etc.) which does not also have an outstanding undergraduate programme? It is only in India that we are foolish enough to divorce graduate education and research from undergraduate education. Let us strive to emulate the Russian model whereby an all-time great mathematician such as Kolmogorov taught not only undergraduates, but occasionally even high school students. (The same could be said of the French school as well, e.g. Cartan, Dieudonné, etc.) In addition to this, well-endowed government R&D organizations (such as my own) should take in large number of eager undergraduate students to do projects (which CAIR already does, I am glad to report). Complete sets of laboratory experiments in various disciplines could be prepared, with the aim of communicating the excitement of discovery, and not the skills of passing examinations!

And as a noble first step, let us reduce all cash awards to 20% of their current value!

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Some new inputs on the *Ghauri*

This concerns the article authored by me entitled, 'The origins and antecedents of the *Ghauri* missile – An assessment', that appeared in *Current Science* (1999, **76**, 280–285).

David Wright of the Union of Concerned Scientists, in an e-mail to me, has pointed out that the effect of the earth's rotation on the velocity and range of the missile (especially for short- and medium-range missiles) is very small and can be neglected. Wright's comments are in order.

While the earth's rotational velocity does affect the velocity requirements for a satellite launch, it does not contribute significantly to the range of short- and medium-range missiles. This is because the contribution of the earth's rotational velocity to the range of the missile is nullified to a large extent because both the launch and the impact points of the missile rotate with the earth during the duration of the missile's flight.

In our paper, we had estimated the range of the *Ghauri* with a 1 tonne payload as 950 km when launched in a north–south direction where there would be no contribution from the earth's rotation. This range will hold true irrespective of the launch direction. With this range, the *Ghauri* may just fall short of hitting Hyderabad. This range can be increased to 1120 km not by launching in an eastward direction but only by reducing the payload to 700 kg.

As mentioned in the paper, Pakistani newspaper reports, which gave the launch and impact points, suggest that the *Ghauri* was tested over a distance of 705 km. This would mean that the trajectory of the *Ghauri* was not chosen for maximizing range, but was, instead, a lofted trajectory. Such a trajectory may have been chosen for being able to monitor the flight of the missile and from the need to confine the test within Pakistan. One of the anomalies mentioned in the paper was the mismatch between the reported flight time and estimated flight times using a trajectory that maximized the range. A lofted trajectory would be more consistent with the reports in Pakistani newspapers of flight times and the altitude reached by the missile.

This does not change, in any way the conclusions drawn in the paper about the liquid propulsion technology used in the *Ghauri* missile (viz. clustering of *Scud*-type engines), the most likely specific impulse and its North Korean origins. The range of the *Ghauri*, as stated in the conclusions in the paper, will continue to remain between 950 km and 1120 km with a payload of between 1 tonne and 700 kg.

Recent newspaper photographs of the supposed *Ghauri*-II launch further strengthen our belief that clustered engines were used. Judging by the length to diameter ratio, it seems probable that the so-called *Ghauri*-II is actually the *Ghauri*-I, perhaps with a much reduced payload to increase range.

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