Science and earth sciences

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Editorials in *Current Science* are always interesting because they inform, and they stimulate reflection. I venture to record my impressions on two editorials on the topic of earth sciences[1,2], one written in the immediate aftermath of the 2004 tsunami, and the other published recently. Both editorials articulate concerns that public perception of science is unreasonably dominated by physics and physicists, and that earth sciences in India lags behind physical and biological sciences in prestige and excellence. Coming from the leader of a prestigious science institution in India and a distinguished scholar, Balaram's concerns motivate introspection along two lines; first, on the place of earth sciences within science in general, and second on the status of earth sciences in India relative to physical and biological sciences.

It is true that the single most popular image invoked by 'science' is that of Albert Einstein. This dominance of physics raises a more general question of how academia perceives various components of science. Broadly, science can be classified into physical, biological and earth sciences. Physical sciences is devoted to understanding the nature and behaviour of material things as an end in itself. Consequently, knowledge from the physical sciences is used as a tool by scientists who seek to understand the biological and the geological world. An upshot is that physical sciences, of which the reigning queen is physics, is commonly considered to be 'basic', and that earth sciences (and, perhaps biological sciences) is an adjunct to physical sciences. This is unfortunate.

Geology is a historical, interpretive science having its own identity[3]. Part of the reason why physical sciences is given significant attention is that it emphasizes quantification and precision. During the 19th century, Maxwell[4] and Thomson (Lord Kelvin)[5] enthusiastically advocated a view that science without numbers has very little value. This view is not anymore tenable[6] because earth systems are known to be highly heterogeneous, interconnected on many spatial and temporal scales, and subject to uncertain external forces. Physical laws can help interpolate within observational data and explain the past, but cannot extrapolate into the future or predict with confidence. Therefore, modern earth sciences is a combination of precision and intuition, and quantification and descriptive thinking. Major global crises that our technological society is facing such as climate change, water management, destruction of ecosystems and the like, pose daunting challenges that defy precise description, and demand the creative intuition of the human mind in formulating sustainable strategies of survival with the best available observational information. In the seamless spectrum of human knowledge from the humanities to the 'basic' sciences, earth sciences and physical sciences occupy their own bandwidths.

Joseph Fourier[7], who, as a natural philosopher, belongs in the company of Newton, Maxwell and Einstein, embarked on his famous work on analytic theory of heat inspired by the role of solar heat in driving atmospheric and oceanic circulation, thermal circulation deep in the earth's crust, as well as background temperature of the cosmos. He observed with awe, 'Profound study of nature is the most fertile source of mathematical discoveries'.

Balaram's observation[2], 'The new description of the science of the earth, "Earth Systems Science", may hardly serve to shore up the image of an extremely important field, which is often considered a poor relative of the other sciences in India' should be a matter of great concern, especially because problems of water, land, ecosystems and the environment that threaten India's immediate economic future demand the energies of people who comprehend the complexities of interconnected earth systems, and have the skills to devise ways of helping society to adapt to these systems. Recognizing this, in 2005, the Indian Academy of Sciences, Bangalore had the vision to rename its *Proceedings of the Indian Academy of Sciences* (*Earth and Planetary Sciences*) as *Journal of Earth System Science*.

The reasons as to why earth system science is considered a poor relative of the other sciences in India may be many and complex. Among these, the following two appear credible. First is the populist perception that mathematics, physics and chemistry demand highest levels of intelligence. The second is a more mundane reason of jobs, financial security and career opportunities. Currently India is pursuing a hope of economic growth based on physical and biological technologies, and entrepreneurship. Not surprisingly, India's best young talents have little inclination to pursue earth sciences. However, it seems likely that India's economic expectations may be seriously jeopardized if earth sciences continues to be a poor relative of the other sciences, and the country fails to nourish excellence in earth sciences as a means of sustainable management of water, land, ecosystems and the environment.

Public perception of superiority of physical sciences can be moderated through education. As for jobs and career opportunities, it may well come to pass that India's water and natural resources crises may inevitably lead to governmental action that diverts resources and attention to earth sciences-related technologies. Should that happen, earth sciences in India may assume its rightful place among its siblings.

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5. Thomson, W., In *Constitution of Matter Nature Series Popular Lectures and Addresses*, Macmillan, London, 1831, vol. 1, pp. 80–134.
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