Empowering undergraduate biological science degree courses towards job and food security in India

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By 2020, India is set to become the world's youngest country with 64% of its population in the working age group. Every human on Earth is a natural resource manager. Biological invasions, ocean acidification, *force majeure* and other climate changes and trans-boundary crop diseases are persistent threats. Science has much to contribute towards creating a nation that is economically sound. There is the need to carry out programmes in science and technology that focus on the minimum basic needs of the common person and on the promotion of sustainable development, which will provide meaningful employment, particularly in rural areas[1]. A disquieting tendency in India is the disinterest in science among the younger generation. The conventional three-year plant and animal science degrees in India lack economic excellence in every form.

Where there is work, there is money and where there is money there is food. It becomes important to look at agriculture not only as a food-producing machine, but also as an important source of livelihood generation. The younger generation will be reluctant to take up farming as long as income prospects are poor. Bridging the growing gap between scientific knowledge and its field application is necessary. The major mission should be to help every scholar become an entrepreneur. A reorientation in the mindset of farm graduates can be brought about only by innovative changes in curricula and courses[2]. The importance of attracting young undergraduates to the environment of scientific research at an early phase of their science education has already been highlighted[3]. At the tertiary level, feasibility of restructuring of the curriculum in science and engineering courses needs to be taken up. Development of a course combining science and engineering (but with a different weightage) may give rise to a wider base for the students, which will help them in their job search, bring more intellectual completeness and application skills for pursuing their career[4].

An engineering graduate settles down in life four years after his/her + 2 examination, while those who opt for science do not[5]. A botany or zoology degree of yesteryears that has transformed into plant/animal biology and biotechnology degree provides virtually nil entitlement of professional value. The suffix 'biotechnology' is a farce with feebly applied biotechnical components. Why are our biology degrees optionally not crafted to produce graduates who can deliver vocational biological economies? There is an obvious need to provide students with formal training, but this is unfortunately being done in very few universities and best done only in the institutes of technology[6]. With diminishing interest in science, summer training and remedial courses should be made obligatory[7]. Not all students in India find funds to take medicine, pharmacology, engineering, agriculture or fisheries courses. All biology degree courses must undergo a renaissance, transcending to a four-year B Sc degree in plant science or animal science technology, the third year being vocational learning and fourth year internship practice on field. The laboratory of biology in Indian science education needs an audit. Bioprocess and bioenergy engineering needs to be cultivated in the minds of every biology graduate. Teaching the science of bioresource conversion is a must for developing the tenacity to low-cost eco-technologies for the graduating teens, enabling them to be promising farmers for the country.

It is imperative to redefine and reorient the genre of knowledge that is found wanting to underpin the future sustainability of India's biological economies. A biological science graduate must be capable of natural resource biomonitoring and/or deliver bioproductivity. It is time that the Ministry of Agriculture both at the Central and State levels should be redesignated as the Ministry of Agriculture and Farmers' Welfare for ensuring the income and livelihood security of the farming community which constitutes over 60% of the Indian population[8]. How efficient it would be, if fish is cultured in all the cultivated rice fields of India? How productive India will be, to have low external input sustainable agriculture (LEISA) implying carps, mud crabs, scampi and pearlspot farmed in all derelict pools, puddles, ditches and or brackish waters? Plant/animal science technologists should pursue life-cycle assessments of economically significant crops and grab the science of plant/animal crop farming principles and practices, in harmony with traditional expertise, focusing on techno-economic analyses of key bioproducts, viz. mycorrhiza to gliricidia, tubers and turmeric to teak, cardamom/cinnamon to coconut, plantain and pepper to paddy and pulses; carps and clams, catfish and crustaceans to ornamentals and oysters, milkfish and mullets to croakers and cobia, seabreams and snappers to pearlspot and pompano on graduation day.

Eyeing the potential eco-technical resources, resolving their know-how needs and devising opportunities to benefit from natural resource management are crucial. Provision of eco-farming information, empowerment of women, focusing on welfare issues based on the increase in the earning capacity of the moderate and the poor ensuring macro non-oil economic stability are needed. Plant/animal resource value assessments harnessing spirulina alga, mycorrhizae, orchids, essential oil herbs (*Chamomile* spp.), mushrooms, seaweeds, nutritious aquatic greens (*Ipomoea aquatica*), halophytic fodder (*Distichlis* spp.) and turf grass for sheep, *Phaffia* yeast, *Dunaliella* alga for pigments, biocontrol species (diatom *Skeletonema* to curb *Gydrodinium* spp.), fishmeal replacement alga, biorational-mosquitocide, lichens as bioindicator, *Ipomoea biloba* as coastal sand binders, mangroves as bioshield, cyanobacteria as fertilizers, earthworms for vermicomposting, polychaetes, amphipods and mysids as live feeds, algae for wastewater treatment, underutilized bioresources as aquatic feedstock (*Azolla*, mesquite seed flour, *Salicornia* meal, maggot meal, algae meal, insect meal), poultry yolk pigmenters (alga like *Haematococcus* spp., *Isochrysis* spp.), agroforestry for bioenergy, aquaponics for integrating multitrophic ecosystems, drip irrigation for conservation, hydrophilic mulches for soil moisture retention, organic and green farming, vetiver for desert reclamation, natural carbon sinks and a host of other resources, manipulating multiple ecological forces to derive the maximum economic benefits, all hold promise for the nation. Food security will remain a national concern for the next 50 years and beyond.

We have to create proper infrastructure at the grassroots level for teaching science in India. Understanding science by witnessing productively successful application models in biofactories is a strong stimulus for the next-generation teens. 'There is no power for change greater than a child discovering what he or she cares about' stated Seymour Simon, whom the *New York Times* called the Dean of children's science. A rejuvenation of existing undergraduate and postgraduate science education system research is desperately wanting. The need for better training in science in India is urgent[9]. There is a great need to re-examine the structure of undergraduate courses. Curricula and examination systems leave little room for experimentation. The role of research project-based learning in undergraduate science courses needs to be explored in India. This is nearly impossible within the framework of a three-year programme, but would be feasible in a four-year course, bringing bachelor's degrees in science on par with the 'professional courses'[10]. Biology students need to graduate on the field with nature. Let us not look back, but look ahead and command a balance between nature and mankind; exploiting living resources within sustainable limits for the benefit of posterity.

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COMMENTARY

Tropical birds and climate change: lessons from the southern Eastern Ghats

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Studies that have focused on the response of tropical birds to climate change have cautioned that these birds are more vulnerable than temperate birds[1,2]. Factors that make tropical birds more vulnerable are the overall higher species diversity of communities, smaller geographical ranges and the narrower thermal tolerances of species[2,3]. Tropical birds that live in the higher elevations face what has been described as 'mountain-top extinctions' as their suitable climate space (Grinnellian niche) shifts upslope with rising temperatures[1–3].

Generally, two types of response to climate change have been predicted for birds. One involves species moving up along an elevation gradient[1,2]. The other is dispersal towards higher latitudes[1]. A third pattern of dispersal may be local and across vegetation types. While there is some evidence that such lateral dispersal is possible in the South Indian tropics[4], little has been published on this. In fact, studies of tropical birds and their response to climate change as such have been scarce in the Asian tropics[5].

The hills of southern India may be ideal geographically for understanding the responses of tropical birds to climate change. These hills are believed to have originated at the same time and hence share similar geology[6,7]. However, traditional geographical classification of the Indian land mass has treated them as two distinct entities – the Eastern Ghats and the Western Ghats[8].

Distribution patterns of the birds in the Western Ghats are fairly well known[9]. However, the distribution patterns of birds in the Eastern Ghats are much less understood[10]. As in the Western Ghats, bird communities of the Eastern Ghats may have been shaped by prehistoric climate changes and what we see today as avifauna in these hilly landscapes could be the result of climate-induced dispersal and local extinctions[8,9]. Patchy distribution of some of the endemic birds, including the Malabar Parakeet and Rufous Babbler may lend support to this suggestion.

At a finer scale, habitat use by the birds in parts of the Western Ghats and southern Eastern Ghats has however shown rather opposing trends. In South India, dense forests are generally common in the Western Ghats with occasional patches in the Eastern Ghats. Contrary to predictions, it was observed that in Uttara Kannada (14–15°N; 74–75°E), one of the most forested districts in the Western Ghats, the most dense forests did not have the highest species richness of birds. Open forests and even plantations locally supported comparable or higher bird species richness[11,12]. Historical changes in the avifauna and the human-aided invasion of wide-ranging non-forest birds into the more open forests and associated plantations were identified as the reasons for the anomaly[9,11]. While a similar pattern of habitat use may be expected in the southern Eastern Ghats, a recently concluded