formulation of fermion path integral the genesis of the *global* anomaly can be traced[4] to the Osterwalder–Schrader[7] (OS) prescription that in euclidean metric $\bar{q}(x)$ should be independent of $q(x)$. Recall that in relativistic metric $\bar{q}(x) = [\gamma_0 q(x)]^+$. Thus, in the passage from relativistic to euclidean metric in the OS scenario, not only are the degrees of freedom of Dirac fermions to be doubled but Hermitian conjugation has also to be abandoned[4]. This is neither natural nor necessary.

The alternative scenario derives from just two principles, (a) the conjugate field $\bar{q}(x)$ is linearly related to $q(x)$, and (b) the relation should obey reciprocity and be compatible with symmetries in euclidean metric, in particular, with gauge and chiral (3) symmetry. The novel representation[4] for $\bar{q}(x)$ is given in terms of the covariant Dirac operator $D \equiv \gamma_\mu (i\partial_\mu - gA_\mu)$,

$$\bar{q}(x) = \left[\frac{1}{(D^2)^{1/2}} Dq(x)\right]^+$$

$$= [P_+ q(x) - P_- q(x)]^+, \qquad (5)$$

where $P_+ (P_-)$ is the projector onto the positive (negative) eigenvalue space of the hermitian Dirac operator. The relation obeys reciprocity if D is non-singular.

The *sine qua non* for an acceptable representation of euclidean Dirac fermion is that the two point Green function coincides with the Wick rotated relativistic Feynmann propagator for a free Dirac particle. This ensures that all Green functions in renormalized perturbation theory are reproduced correctly. The novel representation satisfies this litmus test. What is of great interest is that in the alternative scenario there is no *global* chiral anomaly, though the ABJ anomaly is reproduced correctly in perturbative sector. In the QCD action the vacuum angle θ_{QCD} remains invariant under global chiral rotation (3)

$$S^{\Pi}_{QCD} = \bar{S}_{QCD} + (\theta_{ew} + 2\alpha)\, \Delta' S$$

$$+ \theta_{QCD}\, \Delta S. \qquad (6)$$

The solution[4] of the problem of large mass of the flavour-singlet Goldstone boson is no longer afflicted with the U(1)-dilemma[2]. The chiral phase θ_{ew} is unphysical and there is no longer any problem of fine tuning. The 'natural' choice $\theta_{QCD} = 0$ ensures CP symmetry.

To conclude, the strong CP and the U(1) problems are legacies of the OS description[7] of euclidean Dirac fermion. The alternative scenario emerging from the novel representation (5) is free from these two blemishes.

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COMMENTARY

QUEST: Quality University Education for Scientific Talent

B. M. Deb

Introduction: Crisis in University science education

This article would try to formulate the skeleton of a five-year integrated science education programme, after the higher secondary (10 + 2) level, for talented and motivated students. The principles on which such a programme is based have been universally known and appear to be almost universally flouted by the present Indian university education system. However, before we outline the principal desired features of such a programme, it is necessary to understand the dimensions of the crisis in university science education which we confront in present times. This crisis is a hydra-headed monster.

About a decade ago, a distinguished Indian scientist had lamented that our universities have become 'slums of science'. This shoddiness in science education and research was caused by and reflected in the poor quality of students and of science teachers; unimaginative, ill-defined and out-dated curriculum; primitive academic, technical and administrative infrastructure, political interference and inadequate financial investment in universities. None of these problems can be eliminated overnight. Their cumulative effect over many years has been disastrous, practically destroying the backbone of university science education in our country. This is especially alarming because in the long run our country's economic, political and social independence as well as competitiveness in the global scene depends primarily on our being among the leading nations of the world in science and technology.

In many ways, the notions and value systems in our society are still unacceptable. Thus, bright students in science are discouraged by their parents and school teachers from taking up a scientific career in the mistaken and uninformed belief that a science career is fraught with job uncertainties for such bright students. A paradoxical situation is that in the many positions

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for scientific researchers and teachers in the universities, national laboratories and industrial laboratories, there is today a serious dearth of competent personnel. Since scientists are quite low on the ladder of social acceptability in our country, many parents drive their bright children towards professions which would bring money and power (a combination one might equate with corruption), thereby leading to a high social acceptability. Coupled with the downward trend in science education in our country, this continuous and increasing migration of highly talented and creative youth to non-scientific or non-creative careers is extremely dangerous for the well-being of our society. This is why the so-called 'third largest scientific manpower in the world' is short on quality and its impact on the world scene in sciences is not particularly significant, barring outstanding individual contributions.

It will not be incorrect to say that in the name of democracy our society actually fosters mediocrity and stifles talent, because talented people are always in a very small minority and can be easily overrun by sheer numbers. Certainly, the cultivation of excellence in whatever endeavour one undertakes is not enshrined in our society as an individual or a collective or national goal to be pursued with obsessive vigour. A feudal, hierarchial, casteist and dogmatic value system is not conducive to the blossoming of a thousand thoughts. It is a pity that the pursuit of excellence in our country is regarded as elitist.

The ill-defined and topsy-turvy value systems of our society are also reflected in the quality of our political leadership. It is frequently being said by politicians that higher education is very expensive; our country can ill afford this expenditure and therefore we should primarily focus on universal primary education, gradually cutting down on university education. Clearly, it needs to be emphasized to such policymakers that expenditure on education, including higher education, is an *investment* not only in human resource development but also in the development of an advanced science and technology base in our country. In the absence of such a strong base, not only will India not be able to assess, absorb, develop and utilize sophisticated technology, it will also be in grave danger of technological colonization. Furthermore, higher education cannot be painted as a competitor to and drainer of resources from primary education.

Since 1990, education and research in science and technology do not appear to be a top priority with the Government of India. For example, the earlier science and technology (S&T) budget of about 1.2% of GDP has now been brought down to 0.89% (developed countries spend 3% or more of GDP on S&T). The overall national expenditure on education from 1990 has been as follows: 1990–91, Rs. 1686 crores (1.60%); 1991–92, Rs. 1754 crores (1.57%); 1992–93, revised, Rs 1989 crores (1.59%); 1993–94, budget, Rs. 2376 crores (1.81%). The average educational expenditure of 1.64% of the total national expenditure from 1990–1994 is a far cry from the 6% of GDP as envisaged in the Report of the Education Commission, 1966. Clearly, our government is not fulfilling its duties and our politicians are misinforming the people on education.

Since independence to this day, there has occasionally been a needless debate on whether the country should invest less and less in fundamental science, and more and more in applied science. This is basically a non-issue. Without exception, every technologically advanced country had developed on secure foundations laid by a strong tradition in basic sciences. It is hardly necessary to emphasize that a strong tradition in basic sciences tries to understand natural phenomena at the deepest level and harness them for human benefit; fosters a spirit of continuous enquiry and strives for intellectual rigour; cultivates an attitude of self-criticism and helps to remove age-old dogmas and superstitions. Fortunately, our leading national figures in the early days of independence understood very well that for the Indian society, a major part of which is still primitive and barbaric, salvation lies in the cultivation of scientific temper on a large scale. This can only come through devotion to fundamental sciences.

However, a large part of the critics' complaint of wasteful expenditure in university education is justified. A university education is meant for only the intellectually capable and the motivated. The majority of Indian university students do not fulfill these requirements; yet they have no alternative but to throng the university portals in search of degrees. The completely outdated and directionless general education offered by our universities involves a terrible national waste in terms of finance, manpower and productivity. The problems are further compounded by the primitive, incompetent, obstructive – and downright silly – administrative machinery of our universities which is completely out of tune with today's fast-paced and fast-changing academic demands. It should be obvious that only the bright and talented students, irrespective of their social background, should go for a broad-based science education leading to progressively deeper levels of perception and creativity. The rest should be provided job-oriented/vocational training as well as training in entrepreneurship so that their own significant capabilities are harnessed for national productivity and development, instead of their hankering for standard university degrees.

Unfortunately, as mentioned before, this pursuit of excellence and encouragement of talent has been branded as elitist by politicians and other vested interests. It is necessary for us to realize that talent is not to be found only in a localized environment. Indeed, it can be found in quite unlikely places and like a delicate perfume one has to recognize talent when one sees it. The offspring of highly gifted scientists can turn out to be quite mediocre in intellect while the children of landless peasants may be gifted scientists. All these talented children, especially those from an impoverished background, must be identified, nurtured and brought to the full blossoming of their intellectual and creative power. The breakthrough generated by such a powerful mind is unlikely to come from even a hundred thousand mediocre minds. However, the Indian society specializes in denigrating and smothering talent instead of nurturing it. One shudders to think of the large number of talented children in rural areas who do not have access to or even knowledge of possible opportunities for them and are thereby lost to us for ever. Quite simply, a nation which ignores talent and excellence cannot survive in a highly competitive global environment.

Thus, higher education in sciences in India presents an extremely depressing scenario. The basic features of this scenario have been discussed in numerous national seminars and discussion meetings over the years. However, apart from breast-beating, no solution seems to be forthcoming. It is the purpose of this article to suggest the essential principles, features and components of an exciting university science education programme (after 10 + 2 level) for our country at the turn of the century.

Principles, features and components of the proposed programme 'QUEST'

An educational system is like a highly complex living organism in which even the tiniest subsystem is subtly connected to other subsystems. Therefore, one must adopt a holistic view of education and not think of piecemeal solutions. Experience indicates that in educational reform one does not actually solve any problem but merely provides an alternative framework in which the earlier problems cease to exist. When the new system has caused enough problems of its own it has to be replaced by another system in which the new problems do not exist and so on. Thus, like life itself, education lurches from one set of problems to another.

Before we come to the features and components of the new programme, called QUEST as indicated in the title of this article, it is necessary to visualize our 'object of desire', viz. the scientist at the turn of the century. Such a scientist must be highly competent in his own broad subject and quite competent in at least another subject. He must have a thorough perception of the deep and abiding internal harmony in science as manifested by several strands running through all sciences. With the passage of time, more and more such strands will be visible. He must sense and perhaps predict future developments in his own subject as well as in other subjects The coming century will see the emergence of new, synthesized disciplines which will develop not only out of two or more scientific areas but also jointly from areas in sciences as well as humanities, social sciences, archaeology, etc. He must have deep insight into the past, present and future of his own social milieu and the impact of science and technology on its progress. He must learn his country's (and the world's) socio-political structure, its resources and growth problems, various constraints, strains, tensions and their possible amelioration through the practice of his own profession. Therefore, he should not only be a tough and disciplined professional, he must also be an excellent and universal human being, sensitive, wise and compassionate. He must have diamond-hard integrity, because science does not permit dishonesty. He must be able to identify and define important problems in real-life or field situations and devise ways of solving them. In other words, he should be accessible for interactions with industry and society at large. He must also be a focal point for the propagation of scientific temper and the uncompromising value system which science stands for. His will be a mind whose windows will remain open to even tiny gusts of new thoughts and integrate them into an ever-expanding conceptual framework.

To generate such integrated, confident and creative scientists, the 5-year education programme (after 10 + 2) itself must be integrated and broad-based. For the first three years, students from all sciences should attend common courses on mathematics, physics, chemistry, life sciences, earth and cosmosciences, computer programming and graphics, electronics-opto-electronics-molecular devices, etc. A strong foundation in mathematics, physics, chemistry and computer science is essential for further development of any branch of science. In particular, all scientists must learn mathematics. An understanding about complex systems, both non-living and living, is essential because much of the new developments in mathematics, physics, chemistry, communication science, etc. are likely to emerge out of such systems and the corresponding phenomena. The origin of the universe and the origin of life have bothered man for at least five thousand years. Much of current science, especially geo- and cosmo-sciences, are trying to tackle these problems. Computer programming and visualization now dominate almost all aspects of our lives and learning, in science, technology, communication, humanities including fine arts, social sciences, archaeology, and so on. Increasingly powerful and miniaturized systems based on electronic, optical, opto-electronic including molecular devices (e.g. molecular switches and transistors) are round the corner. The students should be exposed to their basic scientific principles because these are areas in which it now takes only a few years for fundamental research to be translated into actual technology.

After the first three years, the students can choose a broad subject, if they wish, and pursue that in much greater breadth and depth. However, the entire programme should have a spider-web structure so that even after this separation contact with other subjects is maintained, taking into account the individual preference of a student in the form of elective courses. Any imprisonment of the student into the cage of only one subject must be avoided.

If education implies the overall blossoming of the intellect and personality of a student, then university science education all over the world has been suffering from a serious lacuna. All science education curricula have concentrated on stimulating and activating essentially only one part (the left) of the student's brain. The right part, believed to be the seat of creativity, intuition, aesthetics and fine sensibility, which are so important in basic sciences, is practically ignored. Therefore, it is necessary to expose the students to the nation's (and the world's) heritage in art, sculpture and literature. This would also introduce a significant liberal component in science education as well as integrate the left and right halves of the student's brain.

The effectiveness of a scientist comes from both intellectual and manual skills. In other words, the scientist must have the soul of a poet as well as the working ability and tenacity of a manual labourer. In all instructional programmes, either in the classroom or in the laboratory, the student must be a vigorous participant and encouraged to show initiative. He must continually experiment and 'play'. All laboratory programmes must involve these elements and enable the students to proceed along the road to self-discovery for the phenomena studied. There should be hobby laboratory sessions where the students can 'play' with science. A great deal of imagination must be exercised in devising laboratory programmes; these have been the weakest links in Indian science education right from the school levels, perhaps because of a brahminical repugnance for hard manual labour. Learning through self-discovery, self-experience and a dialogue with nature has been an integral part of science through the ages.

Emphasis needs to be placed on the unifying concepts – many of them mathematical – running through all sciences. Students should be exposed to the history, philosophy and methodology of science. From the very beginning, they should be encouraged to undertake self-planning and self-designing of experiments in the laboratory. This ought to be strengthened by regular seminars, discussions and small research projects suitably interspersed throughout the programme. Leading industrialists and entrepreneurs should instruct them on leadership, entrepreneurship and the challenges associated with them. Throughout their educational programme, students should be taken to leading national laboratories, research groups and industrial laboratories so that they also become familiar with science and technology as practised in real-life situations. Occasionally, students should also visit remote rural areas and teach elementary scientific principles to the villagers with due care and sensitivity.

Finally, the issue of the women students in science needs to be addressed carefully. Currently, in several sciences, especially chemical and life sciences, women students significantly outnumber men students in many Indian universities. However, subsequently most of them are lost to the scientific profession. The percentage of professional women scientists in India is depressingly low, for well-known reasons. This is also a global phenomenon. Thus, the percentages of women among Nobel Laureates of the world and among Bhatnagar Laureates of India hover only around two. This is an enormous wastage of women's intellectual power, which a traditional and hide-bound society is imposing on itself.

Teaching, learning and assessment

The two most important elements in any educational programme are the teachers and the students. It is well-known that major progress in education can come only from intelligent, conscientious and dedicated teachers. For an educational programme such as outlined here, both teachers and students must be special people. Therefore, all the students should be provided with national scholarships which would finance their education for five years. The teachers should be highly competent, idealist and excellent human beings, with a fierce commitment to their teaching and research. Their greatest pleasure in life should be to stimulate and observe the gradual blossoming of their talented students' minds. The ancient Indian tradition of *Guru – Shishya – Parampara*, which involves very close interaction between the teacher and the student as well as the transmission of the teacher's knowledge, perception, professionalism and code of ethics to the student, is in urgent need of revival.

Apart from chalk-and-blackboard instruction, teachers should utilize charts, transparencies, overhead projectors, slide projectors and computer visualization in their instruction. Lecture demonstrations, which are now extinct, must form an integral part of science education at all levels. Remarkable advances have taken place in educational psychology. Teachers need to expose themselves to such methods and employ them judiciously in their instructional procedures.

While problem-solving by students is well-understood as an essential aspect of learning, it is relatively less appreciated that problem-designing by students is a much more demanding, rigorous, real-life and conceptual application by the student of his knowledge. Peer-interaction and group dynamics can be incorporated in day-to-day instruction, seminars and projects. The student's performance can be graded through a number of such elements which focus upon his conceptual framework, perception, creativity, application and working with his own hands. The programme should eliminate the traditional obsession of Indian universities with routine examinations.

A semester or a trimester pattern of education is called for the design of such a programme, because of the variety of courses and the flexibility of students' choices embedded in the programme. Each year of the five-year programme may be divided into two semesters of 90 days each, with at least one month's clear gap between them. Alternatively, each year may have three trimesters of 60 days each, with at least a month's gap in between. Either of these patterns will provide considerable leeway to the programme designers, in contrast to the slack and out-dated annual system which is making a surprising return to some Indian universities.

Conclusion

It must be clear that the implementation of such a science education programme calls for great insight, new attitudes and new philosophies on the part of universities for a careful marshalling of teacher, student, infrastructure and material resources. The creaking structure of our universities and the obscurantist as well as obstructionist attitude of their bureaucracy would immediately destroy such a programme. However, there are half a dozen universities in our country where a certain quality of vision is discernible. Their administrative infrastructure can be remodelled and strengthened to undertake such a programme. Provided the university bureaucracy functions under the collective wisdom, advice and active control of the teachers and scientists, it will be possible to implement such an ambitious programme.

In passing, it is necessary to emphasize that although the proposed programme is an idealized one there is nothing in it which is not implementable. Indeed, the present author has experimented with most of the components mentioned above during his professional career. It is high time that the science education community wakes up and embarks on such a programme. There is no doubt that within a few years the products of such a programme would radically transform our country and make it one of the most powerful nations in science, technology and social development.

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Discovery of a middle Holocene sub-fossil bone from Tiruvallur Taluk, Chingleput District, Tamil Nadu

We record here the discovery of a sub-fossil bone of *Boselaphus tragocamelus* (nilgai) in the upper Kortallayar basin, Chingleput district, Tamil Nadu (Figure 1) and examine its significance in terms of dating, relation to the archaeological record in this region and in the understanding of past climatic conditions. The Kortallayar basin forms a part of the Palar basin, Tamil Nadu. Geologically, the Upper Gondwana sandstones and shales of the Sriperumbudur and Satyavedu formations are capped by Quaternary formations in the form of fluvial/erosional features of ferricretes, pebbles, cobbles and boulders (Middle Pleistocene to Holocene) and alluvial deposits of sands, silts and clays[1].

The region falls in an area of wet tropical moderate bioclimate and dissymmetric rainfall regime with 330 mm in the south-west monsoon and 803 mm in the north-east monsoon[2]. The vegetation consists of the *Albizzia amara* and *Acacia* series of the semi-evergreen series consisting of scrub woodland, closed and discontinuous thorny thickets and scattered shrubs[3]

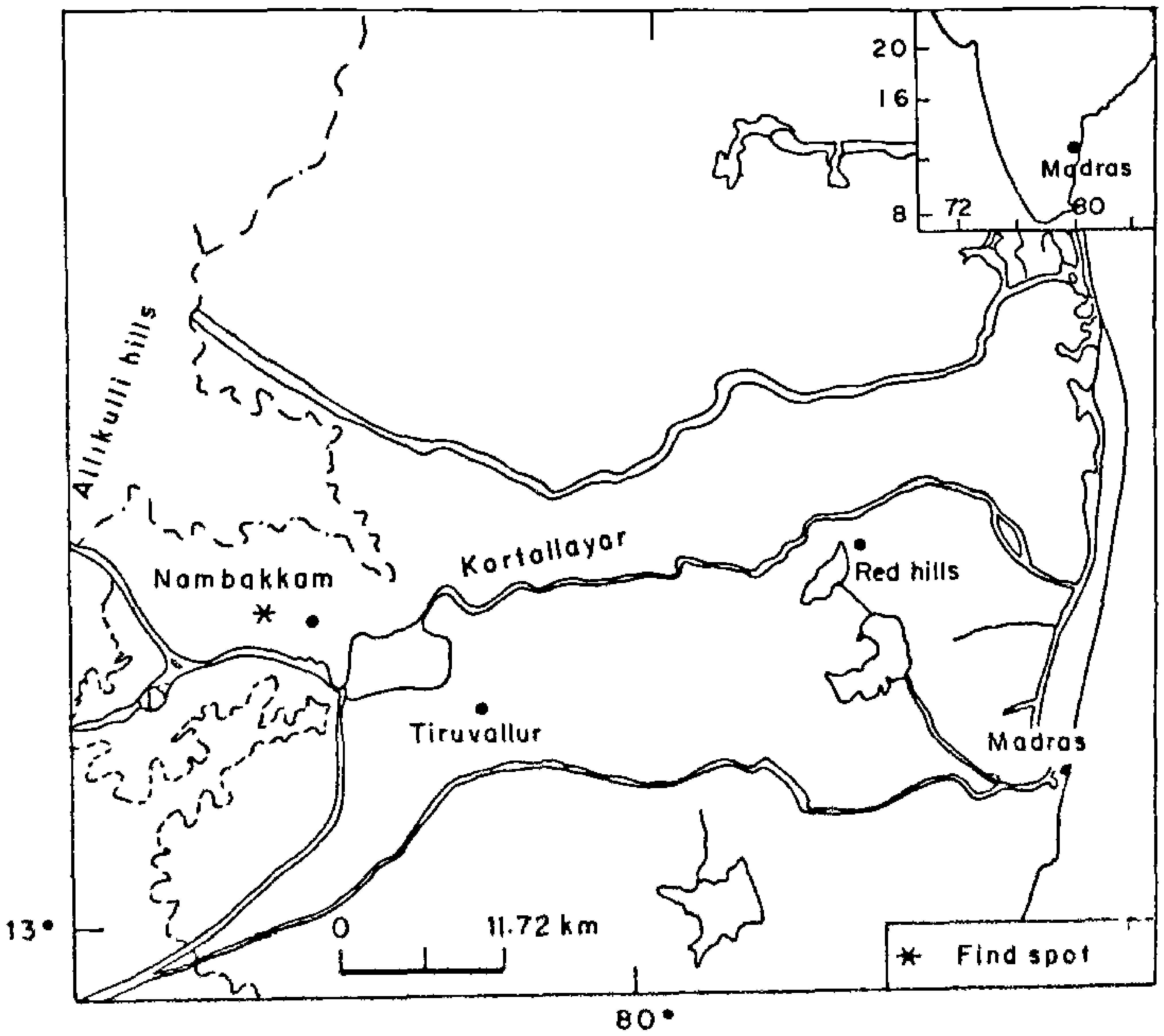

Figure 1. Location of fossil bone, Tiruvallur taluk, Chingleput district, Tamil Nadu

Ever since the discovery of the first palaeolithic artifact at Pallaveram in Tamil Nadu[4], the Kortallayar basin has been an important centre for prehistoric research in India. More than sixty Lower, Middle and Upper Palaeolithic and Megalithic sites have been discovered here. Recent investigations in order to reconstruct the Quaternary palaeoenvironment and human settlement patterns are being conducted by the first author in the upper Kortallayar basin, in the light of new theoretical and methodological advances. However a major lacuna in the understanding of past ecology lies in the absence of a suitable sample of Quaternary fossils. The earliest discovery of a fossil in this region was made by R. B. Foote in 1863, in the Attrambakkam nullah (Tiruvallur taluk, Chingleput district), which was apparently washed out of the 'lateritic conglomerate' and which was associated with palaeoliths. It was identified by Busk and Boyd Dawkins as possibly forming a part of the human tibia with the platycnemic deformation found in people given to squatting on the ground. However due to the loss of articulations and imperfect condition this was not confirmed. The fossil was subsequently misplaced[5].

As part of the field exploration undertaken by the first author, a fossil bone was discovered in the canal cutting forming part of the Telugu Ganga project located near the village of Nambakkam (79° 53' E; 13° 14' N). The bone was located in compact Holocene clay at a depth of 1 m below the surface The compact clay extends for a depth of 2 m and overlies the Upper Gondwana shales. It is capped in turn by ferricrete lag (Figure 2) In general, the composite stratigraphic sequence in this region