National Centre for Marine Biotechnology: An approach paper

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Need:

The marine biological wealth of India is unparalleled, with resources stretching from Andaman to Laccadives. Presently it is mainly a traditional source of food for a large fraction of the country's population. Marine organisms are turning out to be an unchartered ocean of pharmacological wealth and novel material both mineral and biological, which still need to be discovered.

India has many talented marine biologists, teaching in the universities, whose knowledge of organisms and ability to classify is unbounded. They have also trained several young people. In fact it is only the marine biologist in India who keeps alive the dying art of taxonomy very well. However, many marine biology centers in India with some exceptions have traditionally either been part of the IARI system of institutions or oceanography. There is a substantial lacuna in basic research. The research in this area is patchy and mainly related to aquaculture and or fish productivity and some biodiversity. Great field expertise, but has not been translated to good research activity. Similarly we as a country have great chemistry potential languishing in the game of follow the leader with the world's pharmaceutical industry. There is need and room for a center devoted to fundamental research and teaching devoted to marine biotechnology. We can in fact become world leaders. In a case of concerted effort Australia has recognized its marine resources potential. The core objectives will be to explore marine resources for drug discovery, materials and basic biology and should help direct the talent that is being trained by marine biology institutions to focused achievements in Marine Biotechnology.

Rationale:

The language of what I have written down as an introduction under "need" is itself wrong, so are the language of most documents produced in the context of Marine Biotechnology . They generally tend to talk about an 'exploitative' Marine Biotechnology from the very first line on unique advantages of coast length to talking about biodiversity, fish, horse she crab to sea weed, microbes or venoms from the sea….this is low return and easy pick even when the most technological inputs are brought to bear, they are like mechanization of harvesting, harvesting most without sowing at all.

What one needs to think about is a 'creative' use of marine life without ever having to disturb it…..like keeping the wild life in forests but learning from them and using their biology to our advantage without exploiting them and sucking away the life from the oceans. We must focus on learning the basic biology of marine organisms so we could develop laboratory and shore bio-industry processes to replicate marine life processes without recourse to EXPLOITING and HARVESTING. It is analogous to discovering omega 3 fatty acids in Salmon and their ability to prevent vascular disease in Eskimos, but then seeking a seed like Urid dal, which has a similar composition, and then develop technologies to grow Urid dal on industrial scale and not at all hunt Salmon ever. Another example is 'deep sequencing' one gland from a single cone snail and deconvolution of mass spectra of venom from one another single snail gland, leading to a 300-member peptide library. Now all of these 300 can be chemically synthesized form amino acids derived say from primary sources, discarded food, gobar or garbage or from Tirupati hair. Identifying and synthesizing instead of isolating and extracting is the essence. In a similar manner one must study the formation and growth of corals and shells these then may be replicated in vitro with appropriate properties of human bone or teeth. Could be grown individualized in sizes and shapes. Then frozen or killed to keep as prosthetics or given back live to the sea for conservation. . The idea hence is to develop technologies based on Molecular and Cell Biology, Chemistry and Biochemistry, Materials Science to develop products and processes inspired by marine life and marine resources but not to exploit marine biodiversity

NCMB will be a Centre to Connect Marine Biology to other disciplines including Molecular Genetics, Genomics, Cell Biology, Analytical & Synthetic Chemistry, Biotechnology, Materials Science etc.

NCMB will so aim to focus on the following areas:

1. Molecular Biology

These are necessary approaches for novel drug synthesis. Symbiotic microorganisms may produce many important marine pharmaceuticals as it is the case with tetrodotoxin. Many other chemicals and even venoms thought to be produced by animals perhaps are either themselves, or products of symbiont metabolism. However, many of these microorganisms cannot be easily cultured to produce sufficient quantities of the needed pharmaceutical compounds. Molecular genetics, will allow transfer of genetic material from one organism to another. Bioluminescence has numerous applications in cell and molecular biology, biotechnology, medical diagnosis and even environmental monitoring. Luminescent bacteria, and luminescent plankton as well as florescent organisms like Jellyfish could be useful for production of various luminescent and florescent proteins for biology research. Engineering new spectral properties and new optogenetic and diagnostic kits are to be thought of. Molecular genetic approaches will be needed for protein expression and protein engineering and will also have core analytical strengths like sequencing and DNA engineering, and mass spec capabilities; as well as cell culture and screening technologies.

2. Neurobiology:

This will include behavior, anatomy, and neurophysiology of marine organisms. The nervous systems of marine animals will be useful to study as models; particular examples are the sea slug Aplysia and squid. Squid giant neurons were the beginning of our clear understanding of the basis of membrane and action potential; lampreys helped us learn about synaptic transmission, and the electric eel the first insight to neurotransmitter receptors and aplysia laid the foundations for study of learning and memory. The survival and success of animal species in its environment depend on its behavior. In the depths of oceans many common modes of communication fail and there sound and electricity become important. Electric fishes, for example, send out weak electric impulses that are used both to communicate and to detect undersea objects or cavities. It is possible slime containing chemical signals is another way of communicating. Study of such models of communication will have implications in design of new prosthetics for visually and aurally challenged. Marine animals such as slugs, lampreys with nervous system containing giant neurons and synapses could be useful models for drug testing.

3. Marine Microbiology

Many studies suggest that Oceans have millions of species of bacteria and viruses and in densities comparable to the micro biome per liter of an average mammal. Study of marine microbes should be important for fundamental understanding of issues like climate change, geochemical cycling (particularly in India with huge wash down to oceans from peninsular India) and also questions relating to ecology and evolution. Also of value to drug discovery will be marine probiotic bacteria as source of antibiotics and drugs to treat a variety of parasitic diseases. While large scale genome sequences of marine bacteria may be undertaken the center should not become a referral and collection facility. It will only develop expertise in handling the analysis of the oceanic micro biome when needed.

4. Ecology and evolution:

Study of marine biological diversity with focus on Ecology and Evolution is critical in designing optimal strategies for adapting some organisms for use in marine biotechnology. Hence fundamental studies relating to ecology including behavioral ecology relating to large changes in animal populations like spawning horseshoe crab, a valuable model to design and develop diagnostic kits or nesting sea turtles should be part of the mandate. Marine Chemical Ecology should be an important part of such studies and could in principle lead to many useful feed-ins to both materials and biomedical research.

5. Drug discovery and Biomedicine:

Development of pharmaceuticals derived from analysis of venoms of marine organisms like Marine Cone snails, Turrids, and marine snake venoms. These could be a starting point for comprehensive drug research. While identification and developments including bioassays and activity driven purification are needed the focus should be on peptide and peptide chemistry. Deep sequencing and validation by chemical and molecular genetic synthesis will be another major focus. Similarly chemicals from corals, sponges that indicate promise as a potential drug to fight breast and ovarian cancers, others shown to have potential for treating inflammation and pain, asthma etc could be identified. These will then turn the focus to organic chemical synthesis for validation and scaled up production purely on shire based inputs. Another area will be studies of the Biology of marine organisms for the design of model systems to supplant mammals in biomedical research. This also could include field and shore laboratory studies of unusual organisms like sponges and Portuguese man of war, which self organize as models for stem cell research. Several components from probiotic bacteria, bacteriophages could be of value for treatment of fungal and bacterial infections other products of value to cosmetic industry also should be identified.

6. Biomaterials:

Several interesting biomaterials can be sought from the sea. Examples that suggest themselves easily are corals grown in laboratory but derived from sea as bone replacements. It is possible if one understand how shells are made to develop in vitro technologies to grow shell like material with appropriate strength for use as prosthetics. They can be engineered for compositional and mechanical strength equivalence to bone, grown in appropriate shapes and machined for use in knee replacement surgery for example. Other materials like the glue barnacles use to stick could be strong enough to bond metals and could in principle become useful for sealing leaks in ships or closing blowouts in gas pipes since they may cure underwater. Searching or anti barnacle glue from sea fans which seem to repel barnacles will come both under purview of Chemical ecology and materials. In all cases while in the field they have to be learnt about it must be on the shore that they have to be manufactured from non-marine and renewable sources.

Substantial investment is to be made in strengthening Chemistry and Molecular Biology research inspired by Marine Biology

Facilities needed:

1. Marine Core Facility: Will provide for all types of Observational and anatomical and physiological research with marine organisms. Circulating sea water containing multiple tanks specifically designed to maintain stocks and laboratory space designed for behavior, anatomy and physiology experiments.

2. Marine Microbial Facility: for growth of microorganisms including those that need "extreme" growth conditions like at high temperatures, high anaerobicity, saline concentrations as well as hyperbaric conditions. All forms of biochemical analysis should be possible to be done routinely and where necessary containment for safety and quarantine facility should also be built.

3. Chemistry and Biochemistry Lab: Major investment should be made on a very sound Chemical laboratory including peptide and organic synthesis for validation and development of future industrial processes. This will include many centrifuges, tissue culture facility, HPLC, GC/MS (several of these), and NMR. IR UV spectrophotometers, analytical equipment other than these for inorganic and organic analysis.

4. Molecular Biology Laboratory: in addition to some of the above like Centrifuges, HPLC's and FPLC's, and spectrophotometers, should also have equipment like Capillary DNA sequencers Real-time thermo cyclers and Robotic liquid handling stations. Routine DNA Sequencing, Plasmid Purification, Genotyping, Clone Library Construction should be possible

5. Microscopy Laboratory: Inverted Microscope, Upright Microscope Fluorescence DIC Phase contrast and perhaps an Electron microscope should form the bulwark of a microscopy laboratory

6. Neuro-Physiology Laboratory: should be set up to do electrophysiology of high quality and all types of electrical recording should be possible.

7. Underwater Lab: A good section on teaching diving, maintenance of diving equipment and underwater photography

8. Boat: In addition at least one boat capable of onboard chemical and biochemical analysis containing many portable battery operated equipment like microscopes and spectrophotometers, HPLC/GC/MS, Electrophoresis and DNA sequencers and a few other equipment as above should also be thought of as either hired or in association with other institutions.

Some General Ideas:

Access to airport to get quickly supplies and consumables that may need delivery in special storage, convenience of maintenance of equipment, and in general access to various facilities for faculty and students has to be matched with access to marine organisms and ability to maintain and culture organisms in marine environment. It may be worth while considering splitting the lab to two components. A shore laboratory that should house the major environmental and growth facilities listed as 1 and 2 in facilities with appropriate equipment for on shore studies and use of marine animals for drug testing etc. It will also house several portable equipments which could be used both on shore on coastal surveys and on shore. This also should be the base camp for the possible boats for off shore collections and analysis. The near city component should focus on molecular biology, materials and chemistry. All faculty and students will use both facilities and only a skeletal administrative and facilities staff ill have to be placed in specific locations.

Place:

Any place from Kaiga to Honavar where one can get land close to sea is ideal for this.... islands across.....generally calm seas unlike east coast access to both Mangalore and Goa international airports in a couple of hours. On the Konkan rail route and main West Coast Highway to Bombay. Ghats and forests close by. Power and water supply assured because of the Kaiga atomic power plant and many west flowing rivers and the major Kadra dam close by. Among coastal states Karnataka alone probably does not have a Marine Biology research center

SOME THINGS YOU DON'T WANT TO DO:

Some aspects of Marine Biotechnology that IMBI should not pursue and perhaps are handled better by excellent faculty present in places like CAMB Annamalai, CMFRI, CIFE, NIO, NIOT, CIFA, Central Salt and Marine Chemicals Institute etc

Areas to be avoided are:

1. Many basic studies relating to reproduction, endocrinology, genetics, early development, nutrition, growth and disease in marine and estuarine fish and shellfish or prawns etc.

2 Aquaculture including seaweed and prawn farming and fisheries biotechnology development of genetic and molecular genetic approaches to improved quality of prawns etc

3. Study of fish viruses, viral pathogenesis and development of vaccines for fish and prawn diseases. Other areas to do with oceans as a source of food and improving catch and purely biology of marine organisms including taxonomy, survey etc including catch size and weather related changes.

4. All taxonomic and survey studies including research on distribution. Issues relating to conservation and management etc whether of fish or marine mammals are better addressed by other institutions.

5. Collection and maintenance of stocks or marine animals or library of brood stocks for the sake of exchange or conservation

6. Studies of marine microalgae as a source for renewable biofuels, marine chemistry particularly relating to chemicals that are isolated from seawater by evaporation and fractional crystallization etc or chemicals, dyes, fish oils of value for textile and other industries isolated from marine animals.

7. Finally education in the forms of undergraduate or maters programs should not at all be mandated. The aim should be to generate top quality research and this needs pools of strictly selected graduate students and an International pool of post doctoral trainees, not necessarily only qualified in marine biology. The teaching should come as natural corollary to the graduate studies program.