Marine organisms: Potential source for drug discovery

Life has originated from the oceans that cover over 70% of the earth's surface and contain highly ecological, chemical and biological diversity starting from microorganisms to vertebrates. This diversity has been the source of unique chemical compounds, which hold tremendous pharmaceutical potential. New trends in drug discovery from natural sources emphasize on investigation of the marine ecosystem to explore numerous complex and novel chemical entities. These entities are the sources of new leads for treatment of many diseases such as cancer, AIDS, inflammatory conditions, and a large variety of viral, bacterial and fungal diseases[1]. Because of the highly chemical and physical harsh conditions in marine environment, the organisms produce a variety of molecules with unique structural features and exhibit various types of biological activities. Majority of the marine natural products have been isolated from sponges, coelenterates (sea whips, sea fans and soft corals), tunicates, opisthobranch molluscs (nudibranchs, sea hares, etc.), echinoderms (starfish, sea cucumbers, etc.) and bryozoans (moss animals) and a wide variety of marine microorganisms in their tissues[2].

Sponges, the most primitive multicellular invertebrates, considered as a gold mine during the past 50 years, have fascinated scientists for isolation of promising bioactive compounds for human welfare. Published literature, patents and other scientific records on the genotoxicity and anticancer potentials of marine compounds revealed that few compounds have gone through preclinical evaluations. Interestingly, cytarabine (Cytostar-U) also known as Ara-C, a compound isolated from the Caribbean sponge *Cryptotheca crypta* currently being used with other anticancer drugs in the treatment of acute myelocytic leukaemia (AML) and lymphomas is one of the very few marine anticancer drugs studied in long-term clinical study[3]. Acyclovir, which was synthetically known as Ara-A, was modelled based on sponge-derived spongothymidine or spongouridine. Ara-A is the first sponge-derived antiviral compound in the market. Polyketide Calyculin A (a selective inhibitor of protein phosphatase 1, isolated from sponge *Discodermia calyx*), Manoalide (a potent anti-inflammatory marine natural product and a direct inactivator of venom phospholipase A2), Okadaic acid, a potent inhibitor of protein phosphatases, especially protein phosphatases 1 and 2 respectively isolated from *Luffariella variabilis* and *Halichondria okadai* has reached the market undergoing from basic research to long phases of clinical study[4,5].

Saclike filter feeder tunicates have been reported to be an importent source in drug discovery. Tetrahydroisoquinolone alkaloid 'Ecteinascidin 743' from *Ecteinascidia turbinate*, cyclic depsipeptides 'Dehydrodidemnin B and Didemnin B' from *Trididemnum solidum*, cyclic peptide 'Vitilevuamide' from *Didemnin cucliferum* and 'Diazonamide' from *Diazona angulata* are a few tunicate compounds in anticancer preclinical or clinical trials. Synthadotin and Soblidotin are two synthetic analogues of Dolastatin isolated from molluscan sp. *Dolabella auricularia* in trials. Alkylamino alcohol 'ES-285' (Spisulosine) isolated from *Mactromeris polynyma* is another compound in preclinical trial; molecular target of this molluscan compound is Rho (GTP-bp). Macrocyclic lactone 'Bryostatin 1' from bryozoan sp. *Bugula neritina*, and soft coral compounds; diterpene glycoside 'Eleutherobin' and Pyrrole alkaloid 'Lamellarin D' anticancer[6] while, anti-inflammatory compound 'OAS-100' which is semisynthetic derivative of pseudopterisone A are the hope of new effective therapeutic agents.

Study of marine organisms is a discipline, which endeavours to identify and decipher the troubles regarding not only sustainable exploitation of marine life for human health and welfare but also for marine ecology. Study of marine organisms for their bioactive potential, being an important part of marine ecosystem, has picked up the rhythm in recent years with the growing recognition of their importance in human life. This interdisciplinary study of the life in the oceans ensures an exciting new frontier of scientific discovery and economic opportunity.

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ROOPESH JAIN*
SHAILENDRA SONAWANE
NOOPUR MANDREKAR

Department of Natural Products,
Nicholas Piramal Research Centre,
Nirlon Complex, Goregaon (E),
Mumbai 400 063, India
**e-mail: roopesh.research@gmail.com*

Professional associations and proactive scientists

Scientists could be proactive[1] by institutionalizing their roles through professional associations (PAs) or societies. PAs broadly refer to a formal organization of professionals who are practitioners of a given profession uniting together by mutual consent to deliberate, determine and act jointly for a purpose. This is the case whether the PA is that of dentists, cardiologists, pharamocologists, soil scientists, plant breeders, lawyers, economists or other professions. PAs have largely emerged through voluntary action, largely with a view to establishing the identity of increasingly specialized groups to promote the subject/discipline in which these groups have a common interest. PAs are largely self-supported and carry out their activities with funds raised through subscription/membership fee, voluntary contribution of time by office bearers, etc. They are also often eligible to receive small grants from the State or Central Government, which enables them to organize various activities such as annual symposia, workshops, seminars, etc. along with the publication of their own disciplinary journals/proceedings. PAs are an important component of the R&D system because they provide an opportunity outside the public system and assume a role which is complementary to the well-defined and well-structured role of the public R&D. They are different from other organizations in the R&D sector as their central concern is about furthering the interests of the profession and its social relevance, and are not tied to any patron (state/private/civil/legal entity), and can legitimately reflect upon the status/evolution of the profession, in order to strengthen their professional identity. This voluntary nature of PAs gives them the inherent convening power and drive, a unique position and flexibility to play a key role in innovations with broader goals relevant to the society.

Most scientists are part of one or more PAs/societies in India. But they have hardly been mentioned as important actors in the larger R&D system. Scientists, who are part of PAs, mostly get coloured by the organizational and disciplinary constraints of the R&D system and do not use the flexibility they can have due to their position. These scientists can work proactively through the PAs and use them as a platform to contribute to the public domain. This will help in bridging the gap between science and its public understanding and bringing its social relevance to the society. The disconnect between the science that they pursue and its societal relevance is quite evident through the absence in public debates on relevant issues.

These PAs are present in almost all the fields of science, but have played little role in linking the knowledge that they have with societal issues. It is important to recognize their role and leverage their roles and capacities. For example, there are more than 50 PAs in agricultural sciences, but they have hardly contributed to the public domain. These PAs often work independently and mostly in strict disciplinary modes. Organizations like the National Academy of Agricultural Sciences, like the academies in America or other parts of the world, could facilitate networking among PAs in agricultural sciences and other relevant stakeholders to help facilitate ongoing scientific disciplinary goals as well as broader societal goals to enlighten the public domain. There is a need now to recognize at least the presence of PAs as important actors in R&D and intervention points that could leverage their roles.

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SUNITA SANGAR

Innovation, Technology and Society,
International Development Research Centre,
Regional Office for South Asia,
208, Jor Bagh,
New Delhi 110 003, India
e-mail: ssangar@idrc.org.in

Virtual water trade

The article on ‘Status of virtual water trade from India’ by Vijay Kumar and Jain (*Curr. Sci.*, 2007, **93**, 1093–1099) gives a table, according to which the virtual water content of crops like millet, sorghum, lentil and oilseeds is higher than that of paddy and sugarcane. The authors define virtual water as, ‘The amount of water consumed in the production process of an agricultural or Industrial product’. In simple terms, I guess virtual water indicates water-efficiency of a crop or a product. The authors further mention that the virtual water content of a product tells something about the environmental impacts of consuming the product.

According to conventional wisdom, paddy and sugarcane are more water-intensive than crops like millets, sorghum, lentils and oilseeds. The latter category crops can grow with little water and are called dry-land crops. Nutrition and agricultural scientists urge farmers in the dry-land area to diversify from paddy and sugarcane to horticulture, millets and pulses, since these crops are more nutrient-dense and consume less water. The farmers mindlessly use bore-well water to cultivate paddy, which the authors refer to as a ‘water-guzzling crop’. Would such a diversification strategy mean more stress on the water system? Are we justified in advocating diversification from paddy and sugarcane to dry-land crops (sorghum, millets, oilseeds) in the hope of saving precious groundwater? It is also interesting to note how water-intensive coffee is compared to tea, and maybe coffee drinking should be discouraged in a water-stressed country like India. Not a palatable thought for South Indians, who relish coffee.

MAHTAB S. BAMJI

No. 211, Sri Dattasai Apartments,
RTC Cross Road,
Hyderabad 500 020, India
e-mail: msbamji@gmail.com

Response:

For an agriculture crop, virtual water is calculated as the ratio of the water required (m/crop period) to the crop yield (t/sq. m). Note that the virtual water content of a crop is not the same as water-efficiency of a crop. The crop water requirement, crop yield and the resulting virtual water content of paddy, wheat, millet, sorghum and sugarcane is given in Table 1 (ref. 1).

As shown in Table 1, the water requirement is high for sugarcane followed by paddy, wheat, sorghum and millet. Sorghum and millet have low water requirement compared to sugarcane and paddy, but as their yield is less, the virtual water content is high.

As also mentiond in our article, Chapagain and Hoekstra[1] have calculated the water requirement using the CROPWAT model of FAO and considering a country’s average climate data. Some of the data used are of the capital city of the country (e.g. New Delhi for India). Since there are large variations in climatic conditions and crop yields in India, there will be significant intra-country variations in virtual water content of various crops. Recently, we have done more literature survey on this topic and have