Mission statement of the Molluscan Science Foundation, Inc.
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Molluscs represent over 200,000 different species which next to insects makes them the second most common family in the animal kingdom. There are seven main types of mollusca; bivalves (think of clams or oysters that we eat), univalves or gastropods (think of the coiled shells that we see on the beaches or snails found in gardens), cephalopods (shells associated with squids and octopi) and 4 other groups of less well-known families. The animal is soft (the name of the phylum is derived from the latin "malacus") and usually forms a calcified inner skeleton, the shell. Molluscs inhabit nearly every habitat, from desert to the deep sea, from tropical rain forest to arctic shores. Their occurrence is an indicator for multiple habitat factors, and changes in the molluscan fauna reflect changes of the habitat. Many molluscs produce a multitude of complex molecules, including toxins with medical properties. In many places, molluscs are the most important protein source for man. Every new species that is being discovered may yield a cure for some disease. Yet, the study and protection of the mollusca is a comparatively unpopular field of science.

Mission Statement: Our goals are to advance the study, preservation, scientific, and medical application of molluscs, and to provide an educational opportunity for discussion and direct observation in the field of malacology.

Program Activities Outline:
1. Scientific Research
    a. Taxonomy
    b. Biodiversity
    c. DNA barcoding
    d. ecology
2. Medical Research
    a. Conotoxins (pain therapeutics)
    b. Biomineralization-structural properties
    c. Bone graft substitutes and other musculoskeletal/dental applications (cement)
    d. Medical pharmacological application of isolated seashell constituents
3. Education
4. Funding for students and Expeditions

1. **Scientific Research**

a. **Taxonomy**
The field of taxonomy is a science carried out by only a few professional and amateur malacologists. New species of molluscs are discovered permanently, may be at a greater scale than in most other phyla of animal kingdom. The task of the taxonomist may seem simple at first: characterize the new species, give it a new name, differentiate it from those species that have already been named. However, it requires a broad knowledge of the field, e.g. knowing which species of a group have already been named and which are the new ones. It often requires traveling to museums to look at reference collections. As this field research is not a hi-tech modern science that makes it in the news, taxonomists are often dependent on private funding. However, the characterization of species is the most important first step, before a species or its habitat can be protected, and the species itself be investigated for its properties and possible uses, e.g. in medical research.

b. **Biodiversity**

Once the species-diversity of an area is sufficiently known and the species have been given names and a characterization, the ecological niches and habitats, as well as the geographical regions they occupy need to be investigated. With this data, a more appropriate conservation of habitats and geographical areas can be assessed.

Biodiversity studies concerning shells and molluscs have been performed to a large extent by conchologists. Many serious shell collectors have contributed greatly to the information and scientific knowledge about these different taxa, and shell collections are a documentation of the molluscan diversity that persists over centuries. The comparison of shell collections assembled in the same place at different times, therefore, also document changes that may have occurred.

Some collectors report their findings directly to agencies or biologists, but others simply store their "precious" specimens. It would be of great benefit if this stored information was disseminated so that further knowledge of many of the rarer species could be obtained to enable a better understanding about the abundance, range, habitat, and additional characteristics of certain species. In addition, tissue samples could be obtained for many studies including various types of DNA analysis. Through this foundation using its centralized database and other collaborative efforts, these goals can be achieved.

How gastropods interact in biological communities, understanding large scale global patterns, molluscan physiology, genetics, and a variety of other areas, can be accomplished where previously conchologists lacked the resources and equipment needed to achieve this. There is currently no centralized database, as there is for birds, for collectors to add information. Conchologists do have a great published forum, the *American Conchologist*, but it appears to be largely ignored by scientists (i.e. never cited in the academic journals). Most of the major molluscan journals (*Veliger, Malacologia*, etc.) do not accept faunal lists and personal observations from amateurs. Thus, this foundation will allow more global participation in our scientific molluscan knowledge.

An unprecedented biodiversity crisis caused by human activities, such as overharvesting, habitat degradation, global warming, pollution, biological invasions, and other stressors, have emerged over the past half century. (GRAY 1997, FUJIKURA et al. 2010) Thus, to access the biological diversity and further the conservation of this taxonomically muddling molluscan group, a fast and simple approach that can efficiently examine species boundaries and highlight areas of unrecognized diversity is urgently needed.

DNA barcoding has proved its effectiveness in high-volume species identification and discovery. It can be effective in species determination and can aid taxonomists by indicating useful diagnostic morphological traits, informing needful revision, and flagging unseen species. The term DNA barcoding was coined for the use of a standardized DNA region as a tag to efficiently and reliably identify known species and to aid in the discovery of undescribed species (HERBERT et al. 2003, 2010).

Hence, this promising standardized molecular approach may have a role in allowing for a broad examination of species boundaries of various molluscs. DNA barcoding may be sensitive enough to reveal discrete biological entities, and allow this molecular biomarker to complement taxonomy and explore species diversity. It provides an ideal opportunity to offer fresh insights into the taxonomy and biodiversity of this poorly understood fauna.

c. **Ecology**

As food source of other organisms such as fish and crustaceans, marine gastropods and bivalves constitute an important segment of an intact ecosystem. Also, many molluscan groups are extremely sensitive to habitat disturbances such as warming temperatures and pollution. Any disturbance caused to a coral reef or sandbar, intertidally or in deep water, has an impact on the species-composition of the molluscs that inhabit these places. Depending on the species, molluscs react differently to changes in the salinity, the pH, the presence of metals, detergent, or other chemicals spilled by the activity of man. In certain molluscs, e.g. the cowries (a popular group of gastropods with a shiny shell), the shell formation is critically influenced by a variety of factors allowing for a long-term monitoring of an area simply by the study of the shells. To identify which aberration to the shell is caused by which disturbance can lead to a fine-tuned system of biomonitoring the habitats of any area inhabited by those molluscs that are suitable as bio-indicators. In England, a small parasitic snail was identified as an indicator for climate change. Interestingly, the species had never been recognized by taxonomists and had to be given a new name before further studies could be conducted (LORENZ & MELAUN 2011). The Foundation aims at supporting studies that use seashells, e.g. the shells of cowries, as bio-indicators for habitat disturbances. Also, the sampling of shells in a confined area conducted over consecutive time-steps can give insights to if and how the conditions in a habitat are changing. The Foundation is currently working on a research program providing an outline for such studies.

2. Medical Research

a. **Conotoxins**

A conotoxin is one of a group of neurotoxic peptides isolated from the venom of the marine cone snail, genus *Conus*. Conotoxins, which are peptides consisting of 10 to 30 amino acid residues, have a variety of mechanisms of actions, most of which have not been determined. However, it appears that many of these peptides modulate the activity of ion channels (TERLAU et al. 2004, OLIVERA & TEICHERT 2007, LIVETT et al.).

Pain therapeutics discovered by molecular mining of the expressed genome of Australian predatory cone snails are providing lead compounds for the treatment of neurological diseases such as multiple sclerosis, shingles, diabetic neuropathy, and other painful neurological conditions. The high specificity exhibited by these novel compounds for neuronal receptors and ion channels in the brain and nervous system indicates the high degree of selectivity that these classes of neuropeptides possess for therapeutic use in humans. A compound, ACV1 (conotoxin Vc1.1 from *Conus victoriae*), has entered Phase II clinical trials and is being developed for the treatment for neuropathic pain. ACV1 will be targeted initially for the treatment of sciatica, shingles, and diabetic neuropathy. The compound is a 16 amino acid peptide. A novel alpha-conotoxin identified by gene sequencing is active in suppressing the vascular response to selective stimulation of sensory nerves *in vivo*. [Biochemistry 42, 6904-6911], an antagonist of neuronal nicotinic acetylcholine receptors. It has potent analgesic activity following subcutaneous or intramuscular administration in several preclinical animal models of neuropathic pain [SATKUNANATHAN et al., 2005. Alpha conotoxin Vc1.1 alleviates neuropathic pain and accelerates functional recovery of injured neurons [Brain. Res. 1059, 149-158]. ACV1 may act as an analgesic by decreasing ectopic excitation in sensory nerves. In addition, ACV1 appears to accelerate the recovery of injured nerves and tissues. Every new species of cone that is being discovered yields a unique combination of concotoxins which may be of importance to medical research. During the three years of cooperation with taxonomists in the laboratory or in the field, more than 10 new species of Conidae have been discovered and made available to science, three of them have already been formally named.

b. **Biomineralization**

Biomineralization is the process by which living organisms produce minerals that harden existing tissues. Molluscs produce the carbonates that lead to the structure of seashells. The mollusc shell is a composite material that has been the subject of much interest in materials science because of its unusual properties and its model character for biomineralization. These shells consist of 95% or greater calcium carbonate by weight. The remainder is an organic component. The resultant composite has a fracture toughness which is thousands of times greater than that of the crystals themselves. These properties are conferred by the animal that directs proteins to control crystal nucleation and other properties which eventually give the shell its tremendous strength.

The application of the study of seashell biomineralization may help in fabricating new composite materials with enhanced structural, optical, and electronic properties. The typical approach to the synthesis of materials is energy inefficient, and requires stringent conditions (e.g., high temperature, pressure, or pH) which can produce toxic byproducts. In contrast, materials produced by organisms have properties that usually surpass those of analogous synthetically manufactured materials while biological materials are assembled in aqueous environments under mild conditions by using macromolecules. The aim of biomimetics is to mimic the natural way of producing minerals such as apatites. Many man-made crystals require elevated temperatures and strong chemical solutions, whereas, the organisms have long been able to lay down elaborate mineral structures at ambient temperatures.

Various techniques including *in situ* synchrotron x-ray scattering and x-ray reflectivity studies are being used to study these biomineralization processes. So far, some authors have identified systems that mineralize in a similar manner to molluscs and are able to provide time-dependent structural information: film density, growth rate, dependence of kinetics on polymer concentration, etc. Studies along these lines should provide considerable new information about how the chemical species present can affect the kinetics of biomineralization.

c. **Bone Graft Substitutes**

Since cowries and other seashells are greater than 95% inorganic calcium apatite, they have been suggested for their suitability as a bone graft substitute. MODUPE and co-authors recently evaluated crushed cowry shells and found that they did not lead to any antigenic responses to hosts by an immune-assay (MODUPE et al. 2012). By mechanical testing, the hardness and compressive strength of the processed cowry shell was found to be comparable to that of other bone graft substitute materials in common clinical use. They found that there was integration of the materials with the bone cells at 14 days post-insertion in *in vitro* studies. They concluded that the material was found to be biocompatible with bone cells, which confirmed their use as a suitable clinical bone graft substitute.

Other studies with orthopaedic application include the analysis of cement from carrier shells which might have musculoskeletal or dental applications.

d. **Medical Pharmacological Application of Isolated Seashell Constituents**

The various chemical constituents of seashells may have multiple medical applications. The extraction of bioactive agents of seashells is one of the most intensive areas of natural product research today. A recent study showed that the presence of alkaloids, cardiac glycosides, tannins, and quinones in appreciable amounts isolated from the shells confirmed its potential use in therapy for cardiac-related diseases (OLOYEDE et al., 2008).

Many pharmaceutical products have their origin in seashells. These include Paolin (a drug made from abalone juice) for effective inhibitor of penicillin resistance. Powdered pearls from shells have been used as a topical eye medicine and it has been scientifically proven to have some anti-inflammatory effect in a painful condition called conjunctivitis. It is also used as calcium supplements in both humans and animals and has been demonstrated to be an inhibitor of cancer in mice (HELMAN et al. 2002).

3. **Education**

The foundation wants to promote the study and fascination for molluscs, and one starting point is, of course, in schools. We are currently launching a teaching unit for 6th graders to trigger fascination and the awareness for nature, with "shells in hands". Seashells are natural history objects that can be used as hand-outs in schools without risking allergic reactions or other problems encountered with other items taken from nature.

A major thrust of the foundation will be publishing new research related to the different areas that have been enumerated. To this end, two of the Board members of the foundation have been publishing ongoing work related to malacology. A large thrust of this foundation will be to encourage amateur conchologists and other contributors for research as well. The different research endeavors, as well as highlighted articles, will be featured on the abovementioned website. Not only will the website feature research from the Board members and scientific advisors, but various featured articles as well as a complete database of manuscripts will be included. These efforts will be documented not only in research articles, but in forums and posted on the website. In addition, articles and further research of interest from around the world will also be posted on the website.

The collection of seashells of the MSF yields a wealth of information and a valuable ressource to researchers. A website will allow for easy and categorized viewing of specimens. It will serve many other roles as delineated below (data-storage, interactive forum, newsletter, etc.) Presently, the website is at Michael-Mont.com and is password protected. In the future, this website will have the definitive name of the foundation and will be information rich and fluid. There will be open access for interested parties to evaluate the Foundation’s collection of shells. This can be performed by providing direct visitations to where they are stored. Visitors will be allowed to have direct observation, photographic documentation, as well as microscopic evaluation. The growing library with complete volumes of numerous malacological publications, books and a database of pdf-files will also be available to interested researchers.

4. Funding for students and expeditions

The foundation is involved in funding students of malacology in those areas where institutions fail: in providing funds for anything that takes place besides a grant or officially funded research-project. For example, the expenses for traveling to conduct research on museum collections, to meet other malacologists to cooperate on a publication, or to take a diving-course to be able to conduct field research. In one case, the foundation has provided funds to employ a person to intensify research on the DNA of cowries. The foundation has also sponsored expeditions conducted by individuals or institutions, with the benefit of adding important material to the foundation's collection, and the discovery of dozens of new species. There are multiple examples described in our newsletters.

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