

Eastern Pacific species of the venerid genus *Cyclinella* (Bivalvia)

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In spite of the number of available names, there are only three eastern Pacific species of *Cyclinella*. (1) *Cyclinella jadisi* Olsson, 1961, occurs from the head of the Gulf of California to Guayas Province, Ecuador, from the intertidal zone to 31 m. (2) *Cyclinella producta* (Carpenter, 1856) occurs from Laguna Ojo de Liebre, Pacific coast of Baja California Sur, throughout the Gulf of California, to Tumbes Province, Peru, on intertidal mudflats; *C. singlyi* Dall, 1902, is a synonym. (3) *Cyclinella subquadrata* (Hanley, 1844) occurs from Isla Cedros, Pacific coast of Baja California, throughout the Gulf of California, to Lima Province, Peru, from the intertidal zone to 75 m. *Venus kroeyeri* Philippi, 1847; *Artemis macilenta* Reeve, 1850; *Arthemis saccata* Gould, 1851; *Cyclinella galera* Pilsbry & Olsson, 1941; and *C. kroeyeri ulloana* Hertlein and Strong, 1948, are regarded as synonyms of *C. subquadrata*. Other Recent taxa that have been referred to *Cyclinella* are discussed.

[Oral presentation: General session]

Sex ratio variation among populations of the freshwater snail, *Goniobasis proxima*

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Although sexes are separate in almost all prosobranch gastropod species, very little is known regarding methods of sex determination or the sex ratios that may result. A large quantitative sample from a single population of *Goniobasis proxima* in western North Carolina included 487 individuals, the mature and unparasitized fraction showing a balanced sex ratio and no evidence of sexual dimorphism with regard to growth or survivorship. But quantitative samples of about 100 adults from 15 additional *G. proxima* populations yielded 8 populations with sex ratios significantly skewed toward the female. Female bias was not related to geography, annual water temperature, parasitism, or allozyme heterozygosity. I suggest that sex ratio variation may be an adaptive response to environments of varying harshness.

[Oral presentation: General session]

Evolutionary significance of mitochondrial 16S rRNA secondary structure in gastropods

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Gastropod phylogenetic systematics has experienced a tremendous surge of activity resulting in the virtual dismantling of the traditional classification scheme and firmly entrenched unnatural groups such as Prosobranchia and Mesogastropoda. These changes have been prompted largely by the development of new and refined morphological techniques and the use of cladistic methodology. Today, molecular data is increasingly being explored for phylogenetically informative characters to estimate evolutionary relationships among gastropods. Here we report on the use of the complete mitochondrial 16S rRNA nucleotide variation, secondary structure, and flanking gene regions to deduce a gastropod phylogeny. It is evident that structural features of molecules offer potential as phylogenetic markers.

[Oral presentation: General session]

Are polyplacophorans segmented? An ontogenetic view from muscular development

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Due to the serial arrangement of certain organ systems such as shell plates, shell musculature, and transversal nerve chords, the Polyplacophora have been regarded as the key link to the Annelida, claiming a similar kind of coelomic segmentation in a proposed “archaeomollusc”. However, multiple repetition of organs is not necessarily correlated with metamerism, as demonstrated e.g. by the presence of up to 80 pairs of ctenidia in certain chiton species or the non-metameric character of the monoplacophoran bauplan (Haszprunar and Schaefer, 1996). Here, we aim to elucidate this long-lasting dispute about the proposed primarily segmented character of the Polypacophora (and thus the Mollusca) by applying fluorescent coupled dyes for F-actin as well as electron microscopy in larvae and juveniles of the chiton *Mopalia muscosa*.

In early trochophores, a pre-trochal muscle grid similar to other “worm-like” animals is formed. Slightly later, the first fibers of the dorso-ventral shell musculature, yet not being concentrated into functional units as in the adult specimens, start to develop simultaneously and are serially arranged throughout the post-trochal larval body. Concentration of these myofibers into the characteristic seven (eight) polyplacophoran shell muscle bundles starts after the completion of metamorphosis and is thus clearly secondary. The pre-trochal muscle grid is a strict larval structure which disappears during metamorphosis. We regard this “worm grid” as a recapitulation of the body wall musculature of a proposed trochozoan ancestor of the Mollusca. The ontogeny of the polyplacophoran shell muscles infers a primary unsegmented early “pre-mollusc”.

Literature cited

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[Oral presentation: General session]

Mode of development and population structure in *Crepidula* (Gastropoda: Calyptraeidae)

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As a result of their simple shell morphology, phenotypic plasticity, and conservative anatomy, species of *Crepidula* are often difficult to diagnose on purely morphological grounds. However developmental and molecular characteristics can often be used to distinguish among morphologically cryptic species. I used DNA sequence and developmental data to examine the population structure and species status of *Crepidula* from the east coast of North America. My results show that there are actually three species currently included under the name *C. plana*, and that *C. convexa* possibly contains two cryptic species with highly structured geographic variation in haplotype occurrence.

[Oral presentation: General session]

**Comparative fine-structure of the larval protonephridia of primitive Mollusca
(Polyplacophora, Scaphopoda, Patellogastropoda)**

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The larval protonephridia of the polyplacophoran *Mopalia muscosa*, the scaphopod *Antalis vulgaris*, and the patellogastropod *Patella caerulea* were investigated by means of semithin serial sectioning, reconstruction work, and transmission electron microscopy. All species show a single pair of protonephridia behind the prototrochal region, in *Patella* alone these are asymmetrically positioned and structured.

Whereas the protonephridia of the chitons are composed of up to 20 cells, those of *Patella* consists of three (terminal, duct and aperture cell) and those of *Antalis* of two cells only (terminal cell and duct = aperture cell). Terminal cells of all species investigated show meandering ultrafiltration sites and a polyciliary flame. The duct cells of the chiton and the scaphopod (and of all other gastropods investigated) show features of ion-pumping activity, which are lacking in *Patella*, however. The huge, probably polyploid duct = aperture cell in *Antalis* combines ion-pumping, secretion and releasing function.

Although data on aplacophoran taxa are still missing, outgroup comparison leads us to the conclusion that larval protonephridia belong to the groundplan of the Mollusca. There is remarkable morphological and thus probably also functional variation among the protonephridia of the various molluscan taxa aside from deviations caused by freshwater or terrestrial habitats.

The work was financially supported by grant HA 2598/1-3 of the German Science Foundation (DFG) to G.H.

[Oral presentation: General session]

Fine structure and immunocytochemistry of a new chemosensory organ in the chiton larva (Mollusca: Polyplacophora)

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Semithin serial sectioning, scanning and transmission electron microscopy and staining by immunocytochemical fluorescence dyes and confocal laser scanning microscopy were applied to various larval and early postmetamorphic stages of several polyplacophoran species (*Chiton olivaceus*, a brooding *Lepidochitona* n.sp., and *Mopalia muscosa*). These combined studies revealed the overall existence of a larval sensory organ new to science. The cerebrally innervated, paired organ is situated dorsolaterally in the pretrochal region of the trochophore-like larva, but is clearly separated from the apical ciliary tuft or the cerebral commissure. Each organ consists of two to four sensory cells, the fine-structure of which strongly resembles the so-called “ciliary flask cells” or “ampullary cells” known from chemoreceptors of other molluscs such as the cephalic sense organ of veligers, osphradia of vetigastropods, olfactory organs of cephalopods, or of the nuchal organs of certain polychaetes. These sensory cells are stained by anti-FMRF-amide fluorescence dyes and are lost during metamorphosis.

Whereas cytological homology of the sensory cells with those of the other organs mentioned above is probable, the organ as a whole is regarded as an autapomorphy of the Polyplacophora or Chitonida. Thus, this new larval sense organ appears to be an example of a developmental module in molluscan chemoreceptive organs.

The work was financially supported by grant HA 2598/1-3 of the German Science Foundation (DFG) to G.H.

[Poster]

Changes in host-plant use of ascoglossan (= sacoglossan) sea slugs on introduced macroalgae

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On European, American, and Australasian shores, oligophagous marine herbivores associate with the introduced green macroalga *Codium fragile* ssp. *tomentosoides*. On Scottish shores, the ascoglossan sea slug *Elysia viridis* preferred to associate with and consume the introduced *C. fragile* to the native *C. tomentosum*. Growth rates and maximum body sizes of *E. viridis* on introduced hosts were greater than on natives. Although the native host *Cladophora rupestris* induced a high rate of slug metamorphosis, recently metamorphosed juvenile *E. viridis* (from *Codium fragile*-feeding parents) were generally not able to feed or grow on the native alga; in contrast, juveniles from *Cladophora*-feeding parents could eat *Cladophora*, although their performance was highly variable. Small, post-larval slugs could not effectively puncture cell walls and extract algal food from *Cladophora*; slugs fed far more readily on the thin-walled *C. fragile*. The new association on Scottish shores appears to be a host-switch such that *Codium*-feeders and their offspring had limited capacity to complete their life cycle on the native host *Cladophora*. Larval metamorphosis in *E. viridis* was greatest on potential host species, but larvae also responded to non-host macrophytes and adult conspecifics. Generality of larval settlement and metamorphosis enables oligophagous adult consumers to exploit spatially unpredictable novel hosts, to capitalize on newly available host plants, and to exhibit spatial and temporal variation in host-plant associations.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

NE Pacific ascoglossan (= sacoglossan) opisthobranchs: Review and prospectus

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The species richness and geographic ranges of the ascoglossan opisthobranch fauna have been well characterized for NE Pacific shores, particularly in the Californian province, but the ecology of these gastropods has been comparatively less well studied. At least 23 species of ascoglossans occur within the geographic region: 16 species are known stenophagous herbivores and one feeds on opisthobranch eggs. Ten species occur on cold-temperate NE Pacific shores (Alaska to Northern California), 18 species inhabit the Gulf of California and warm-temperate to tropical Pacific shores, and five species occur in both Californian and Panamic provinces. Due in part to their abundance, four of the species have been studied appreciably more than the others: *Elysia hedgpethi*, *Alderia modesta*, *Placida dendritica*, and *Aplysiopsis enteromorphae*. The paucity of study on other species is not necessarily due to low abundance. This paper will highlight the major gaps that future malacologists should seek to fill in the study of NE Pacific stenophagous gastropods.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

Biodiversity of interstitial Opisthobranchia from Bermuda

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Extensive collections of interstitial gastropods from the Bermuda Islands revealed a remarkable opisthobranch diversity in the mesopsammon. Major taxa, the Cephalaspidea (4 species), Sacoglossa (1 species), Nudibranchia (1 species), and Acochlidea (4 species) are represented, most of them new to science. All species have been observed and filmed alive prior to fixation in 4% glutardialdehyde or 95% ethanol. Among the most interesting species is the enigmatic, extremely elongated and worm-like *Helminthope psammobionta* Salvini-Plawen, 1991 (Rhodopidae?), the systematic placement of which within the Opisthobranchia is controversial. In contrast to its medium- to large-sized congeners, the new, characteristically colored, mesopsammic *Chelidonura* species (Aglajidae) from Bermuda with long bristles on its head reaches only 2 to 3 mm in length. Three further representatives of the Cephalaspidea belong to the genera *Utriculastra*, *Philine* and *Runcina*. A new *Platyhedyle* species represents the second member of the interstitial sacoglossan family Platyhedylidae, currently only known from the Mediterranean Sea. Very unusual for doridoidean nudibranchs, a new *Aegires* species could also be found in coarse sand samples. Finally, two further species of the exclusively interstitial Acochlidea were added to the single known *Unela* species from Bermuda. The collected material is the basis for histological, ultrastructural and molecular studies on these poorly known taxa that are carried out within the framework of a comprehensive approach on the systematics and evolution of interstitial gastropods.

[Poster]

Microanatomy of *Hedylopsis* sp., a new interstitial acochlidian gastropod from the Red Sea

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This is the first report of an acochlidian gastropod species from the Red Sea. More than 20 specimens of *Hedylopsis* sp. have been extracted from subtidal coral sand near Dahab, Gulf of Aqaba. As a model organism for this poorly known, highly aberrant and enigmatic opisthobranch group, the anatomy of this new species is described in detail by using traditional and modern methods. All major organ systems, i.e. central nervous, digestive, genital and excretory system have been reconstructed from semithin serial sections. The central nervous system additionally has been studied by means of immunocytochemical staining and confocal laser scanning techniques showing even minute nerves within the body. The arrangement and structure of spicules and radula have been analyzed and SEM photographs of these acochlidian organs are presented for the first time. Our anatomical results show that the new species does not fit into any existing acochlidian genus. The question arises if some former used characters are taxonomically relevant, and if the current classification of acochlidian groups reflects natural relationships. Further studies are also needed to clarify the phylogenetic relationships between the Acochlidia and other Opisthobranchia.

[Poster]

Microanatomy and ultrastructure of the renopericardial complex of pelagic Opisthobranchia (Thecosomata and Gymnosomata)

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The microanatomy and ultrastructure of the renopericardial complex of *Creseis virgula* Rang, 1828 (Thecosomata) and *Pneumoderma* sp. (Gymnosomata) have been investigated by means of semithin serial sections, graphic reconstructions and transmission electron microscopy. The studies revealed that both species show a functional metanephridial system consisting of a heart with a single ventricle and auricle lying in a pericardium and a single kidney. Podocytes in the atrial wall of the pericardial epithelium represent the ultrafiltration-site, whereas the flat epithelium of the kidney with numerous basal infoldings and a dense microvillous border on the luminal surface serves to modify the ultrafiltrate. In *Pneumoderma* sp., additional loci of ultrafiltration with identical fine structure (meandering slits with diaphragms covered by extracellular matrix) occur in the solitary rhogocytes (pore cells). The presence of podocytes situated on the atrial wall in representatives of two higher opisthobranch taxa contradicts former ideas on the loss of the primary site of ultrafiltration in the ancestors of the Opisthobranchia.

[Poster]

Deep-sea species of *Halgerda* (Nudibranchia, Doridina) with a revised phylogeny of the genus

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Four new species of *Halgerda* from the deep western Pacific Ocean were dredged near New Caledonia, and the Philippines. The depth of these new species ranges from 90 m to 420 m. The new species differ from other *Halgerda* in several aspects of reproductive morphology. Phylogenetic analysis places these four new species in a highly derived clade, closely associated with *H. punctata* Farran, 1905. The ranges and depths of four additional, previously described *Halgerda* species: *H. brunneomaculata* Carlson and Hoff, 1993, *H. malesso* Carlson and Hoff, 1993, *H. carlsoni* Rudman, 1978 and *H. dalanghita* Fahey and Gosliner, 1999 are also extended.

A refined hypothesis of evolution is proposed for the genus. Numerous specimens from 28 species were examined anatomically. Literature from four additional species was reviewed. Fifty-three characters were considered from these examinations. The outgroup, *Asteronotus* Ehrenberg, 1831 was used to polarize the characters. The phylogeny obtained from the analysis of the characters supports the hypothesis that *Halgerda* is a monophyletic group. A species previously placed with the genus *Sclerodoris* Eliot, 1904 is examined and determined to be a member of the genus *Halgerda*. Phylogenetic analysis places this species, *H. paliensis* comb. nov. as a basal member of the genus. A new species, *H. sp. 1* is presented as the sister taxon to a basal member of the genus.

[Oral presentation: Systematics and ecology of opisthobranch gastropods / Eligible for Student Award]

Comparative ecology and conservation of the genus *Ashmunella* (Gastropoda: Pulmonata: Polygyridae) of White Sands Missile Range (NM) and Fort Bliss (NM and TX)

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The terrestrial land snails of southern New Mexico and western Texas represent a little-studied taxa and are perhaps the most poorly-understood element in the biotic communities of the Chihuahuan Desert. As a result of past geographic and climatic events, the genus *Ashmunella* has been subject to rapid speciation and a consequently high rate of endemism: The Organ and San Andres Mountains each contain four species of the genus *Ashmunella* that have their distributions restricted to these respective ranges. In addition, snails in this genus are believed to have specialized habitat needs: Most often, they are found in seams of either limestone or igneous talus bordered by a mesic vegetation composed of *Quercus*, *Garrya*, *Fraxinus* and similar deciduous species. Conservation of this unique fauna is hampered by the lack of adequate ecological data on habitat characteristics, population dynamics, diet, and dispersal. Also, as geographic distributions of select species in the genus lie entirely or in part on Department of Defense lands, a need exists for careful conservation planning to eliminate potential conflicts with DoD missions and future objectives. I sampled occupied habitat for biotic and abiotic features, including plant species, percent cover and frequency, rock size of the talus seams, ambient air temperature, soil pH, substrate type and slope. I will use principal component and cluster analysis to determine the relative importance of the habitat variables to the distribution of the individual species and to detect habitat affinities within and between species.

[Oral presentation: General session / Eligible for Student Award]

Hawaiian endemic succineid land snails: Preliminary study of phylogeny and biogeography

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The Hawaiian land snail fauna is extraordinarily diverse and unique, and an ideal model for evolutionary study. Hawaii is home to at least 750 mostly endemic non-marine snail species; unfortunately 70 % to 90 % of these are now extinct. Succineidae are among the few Hawaiian land snails that have remained relatively abundant. Succineids occur in many parts of the world but only in Hawaii have they adopted such a broad range of habitats, from xeric duneland to montane rainforest. Despite the evolutionary and ecological significance of the endemic Hawaiian succineids, almost no research on this group has been undertaken since the early 1900s. The process of evolutionary radiation in this group can be investigated by 1) constructing a phylogenetic tree of the Hawaiian Succineidae using molecular techniques and 2) evaluating range sizes of the succineid species using museum specimens and relating this to island age (older islands are hypothesized to have species with smaller ranges), in the context of the “taxon cycle” hypothesis of adaptive radiation. In this study, I examine a subset of the Hawaiian Succineidae, testing the utility of 16S rRNA and COI genes for phylogenetic reconstruction in the group. Preliminary results suggest that species on older islands do indeed have smaller ranges, but additional data are needed to confirm or reject this.

[Poster / Eligible for Student Award]

Why snails cross the Wallace line: Freshwater gastropods as model system for biogeography

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The present distributions of living organisms over the world's surface are the results of past events such as vicariance and dispersal. In reconstructing the history of taxa and areas historical biogeographers aim to synthesize systematic and geological patterns. In discerning distributional patterns of different taxa and in trying to understand how these patterns are related to the geology of the region, zoogeography has recently witnessed a growing interest over the last two decades.

A region that since A.R. Wallace's time has long intrigued biogeographers and evolutionary biologists is the Indo-Malayan Archipelago in South East Asia. It represents one of the most interesting, zoogeographically complicated and geologically complex regions in the world. Hitherto largely neglected as model system, some freshwater gastropods of the caenogastropod superfamily Cerithioidea that are currently under study exhibit fascinating distribution patterns in this region.

The distribution of Thiaridae and especially the Melanatriidae, that contain the widely distributed and very diverse *Brotia* in South East Asia as well as the highly restricted *Pseudopotamis*, span over a zone of faunal interchange called "Wallacea" between the Oriental and Australian region. Species from both families cross long discussed biogeographical delineations such as those proposed, for example, by Wallace and Lydekker. In the light of new geological evidence that has recently "set the scene", an overview of ongoing systematic studies of these limnic gastropods will be presented and their zoogeographical implications will be discussed.

[Oral presentation: General session]

**Something old, Something new...
Discrimination of two species of *Dondersia* (Aplacophora)**

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Dondersia californica was described from off southern California by Heath in 1911. Unfortunately it was mistaken for a nemertean during the collection and placed in corrosive acid as fixation which totally destroyed all traces of calcareous structures. In an ongoing investigation of the aplacophorans at the Farallon Island dumpsite four specimens of dondersiid neomeniomorphs were collected and initially identified as *D. californica*. Investigation of the spicules using scanning electron microscopy revealed, however, that the material consists of two species with different spicule morphology.

The type material of *D. californica* consists of a set of histological slides of good quality and the newly collected material was therefore sectioned for comparison of the internal anatomy. Based on the type and the new material *D. californica* is redescribed including also the calcareous spicules and is compared to the second, currently undescribed, species of *Dondersia* that occurs in the area. The position of the Californian dondersiids in relation to other dondersiid species is discussed.

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[Poster]

Sex and the banana slug: A comparison of courtship and copulation in *Ariolimax californicus* and *Ariolimax dolichophallus*

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The sexual behavior of *Ariolimax* is famous for apophallation (Heath 1916); whereby one of these hermaphrodites terminates copulation by gnawing off the penis of its partner. In an effort to clarify the function of this bizarre behavior we have initiated a laboratory study of sexual behavior in *Ariolimax* species. Both Heath (1916) and Mead (1943) focussed on *A. californicus* and reported that copulation was unilateral. Harper (1988) described simultaneous reciprocal copulation in *Ariolimax*. Our observations indicate that the species differ in that copulation; in *A. californicus* is usually unilateral whereas *A. dolichophallus* typically has simultaneous reciprocal copulation, although one slug may withdraw its penis earlier than the other. We also observed one instance of interspecific copulation between these species. An additional difference between the two species is that in *A. californicus* there may be a tendency for a pair to remain together for more than one copulation. On 3 occasions multiple, but usually brief, copulations occurred in close succession between a pair of *A. californicus*, but since these involved the same two individuals on each occasion it is not clear that this is species-typical. When simultaneous reciprocal copulation does occur in *A. californicus* it appears to be asymmetrical in that the exposed portion of one penis is much thicker than the other. Courtship behavior does not appear to differ between the two species. We have observed a unilateral apophallation in *A. dolichophallus* and a reciprocal apophallation after reciprocal copulation in *A. californicus*.

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[Oral presentation: General session]

Reproduction and brooding of a *Crepidula* species from Argentina

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The reproduction of a *Crepidula* species from Argentina, which will be described as a new species, was studied. It is an protandric hermaphrodite species with complete sex change. The males develop the gonad being mature when their shell length is 4 mm. The sex change begins around 8 mm of shell length and lasts until 11 mm, when the first previtelogenic oocytes are found. The minimum shell length for a brooding female is 15 mm, this condition is maintained until the maximum shell length (the maximum observed was 36 mm).

There is a definite seasonal reproductive cycle between August and April. The females brood between 1 and 46 egg capsules per egg mass. The intracapsular liquid is translucent and viscous in recently laid capsules but becomes less dense toward hatching. Neither nurse eggs nor cannibalism have been observed.

The total number of eggs per egg mass was 5600 ± 3300 ($X \pm SD$). The egg capsules have an average width of 2.1 mm and an average length of 2.4. Each egg capsule contains about 320 embryos. The uncleaved egg diameter is about 170 μ m. All the eggs develop synchronously in the same brood. The embryos hatch as planktotrophic veligers with a shell length of 190-230 μ m and a bilobated velum of about 160 μ m wide.

There are positive correlations between: The incubating female length (IFL) and total embryos per brood; the IFL and average embryos per egg capsule; IFL and average size of the egg capsules. Positive correlations have also been found between the average egg capsules size and the average embryos per egg capsule.

The differences with other South American *Crepidula* species are discussed.

[Poster]

Regeneration of the inhalant siphon of *Donax hanleyanus*, a South American Atlantic beach clam

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Donax hanleyanus Philippi 1847 is the southernmost species of the genus in the American Atlantic. It inhabits intertidal fine grain sandy in the North of Buenos Aires Province. As other species in the genus, these animals survive under certain pressure of “cropping” by fish which feed on their siphons. The inhalant siphon is a complex organ, provided in its tip of a system of branched tentacles which confer the possibility of particle selection of medium and thick grains, avoiding in this way its entrance to the paleal cavity of the animal. To estimate the regeneration speed of the amputated siphon under laboratory conditions, a study of the growth sequence after an artificial cut, in regular intervals for complete ten-days periods was performed. The observations “in vivo” under the microscope were correlated with those made by histology in the same time intervals. Results indicate that, twenty four hours after amputation, rudiments of the primary tentacles are observed, and the siphon is fully active selecting particles at the fifth day, this is, the process of regeneration of the primary, secondary and third tentacles is completed within five days approximately. After this, a period of growing and tentacle ramification follows, even though the result is a siphon with tentacles less ramified than the original.

[Poster]

What determines hatching size in caenogastropods? The importance of extraembryonic food sources

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Hatching size in caenogastropods is very variable between species and within the same species. These observed differences could be due to several factors such as egg size, female size or to the amount of food ingested by the embryos during intracapsular development in the form of nurse eggs, intracapsular liquid or cannibalism among sibling embryos, all of which represent an extra source of protein.

In order to determine which of the following parameters (1) adult size, (2) egg diameter or (3) protein available per embryo during intracapsular development, is the most determinant of hatching size, a review and comparison of the total amount of protein available per embryo was carried out for 13 species, and determined experimentally for other three (*Chicoreus brevifrons*, *Melongena melongena* and *Adelomelon ancilla*). The protein available per embryo in the egg capsule in the form of nurse eggs or intracapsular material varied between 0.64 μg (*M. melongena*) to 36,560 μg (*A. ancilla*), while their hatching sizes were 0.6 and 12.1 mm respectively.

The backward stepwise multiple regression analysis carried out in the 16 species, families Vermetidae, Muricidae, Buccinidae, Fascioliariidae, Melongenidae, Margineliidae and Volutidae, indicated that for these species, hatching length depends on the amount of protein available for the embryo ($R^2 = 0.7578$, $p < 0.01$) and not on egg diameter nor adult size. These results confirm the importance of the amount of extraembryonic food sources (as protein) for development in terms of hatching mode (veliger or crawling) and hatching size.

[Oral presentation: General session]

A phylogenetic analysis of Te's (1978) morphological data set for the family Physidae

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Physids (Gastropoda: Basommatophora) are freshwater snails distributed in North, Central, and South America as well as in Europe and have been introduced virtually around the world. Physids are often conspicuous members of temperate ecosystems and often dominate lentic habitats. Although numerous systematic studies have been conducted on physids, no modern monographic treatment exists. The most recent systematic treatment of Physidae is an unpublished dissertation by Te in 1978. The classification scheme of physids recognized today follows Te's systematic recommendations. Te's work proceeded the development of currently employed modern cladistic methodology, so it is uncertain whether his phenotypically based classification reflects phylogeny or whether it is the most parsimonious hypothesis. I reanalyzed Te's unpublished data, which comprised of 71 characters (37 shell and 34 anatomical characters) for 82 taxa using modern cladistic methodology to evaluate and compare his proposed classification with the most parsimonious cladograms generated using PAUP*. The most parsimonious phylogenies are not entirely congruent with Te's proposed classification scheme with several putative taxa not being monophyletic. In addition, we explore the degree of homoplasy in shell versus anatomical characters.

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[Oral presentation: General session / Eligible for Student Award]

***Octopus veligero*: Permanent resident or fair-weather friend?**

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During the summer of 1994 the City of San Diego's Ocean Monitoring Laboratory participated in a regional monitoring program termed the Southern California Bight Pilot Project (SCBPP), which was initiated by the EPA. The SCBPP was a cooperative effort of environmental monitoring and consulting agencies extending from Santa Barbara to San Diego. Parameters such as water quality, fish and invertebrate populations were assessed to determine the health of the Southern California Bight (SCB) as a whole. Part of this program involved the use of otter trawls to sample demersal fish and megabenthic invertebrate populations. The two common offshore octopus species that were collected were *Octopus rubescens* and *Octopus californicus*. However, a third species, *Octopus veligero*, similar in appearance to *O. rubescens*, was also discovered. Its presence in the SCB represented a northern range extension from central Baja California. Since the SCBPP program in 1994, *Octopus veligero* has continued to occur in the trawls collected by the County Sanitation Districts of Los Angeles, the City of San Diego and the City of Los Angeles Environmental Monitoring Division. Currently, two areas are being investigated: 1) The potential association of *Octopus veligero* with varying oceanographic conditions, and 2) The possibility of historical misidentification of *O. veligero* as the common local species, *Octopus rubescens*.

[Poster]

Biology, ecology, and fisheries of the volutid gastropod *Zidona dufresnei* (Donovan, 1823) from the southwestern Atlantic Ocean

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Zidona dufresnei is an endemic species of the SW Atlantic living in 40 to 60 m deep sandy bottoms, on the continental shelf fringing the Province of Buenos Aires, Argentina and Uruguay. Development of the embryosis direct, lacking a free-swimming larva; this species is not widely distributed, and its adults are commercially exploited up to numbers that reach 1,300 tons of meat per year. The most important commercial Argentinian harbors of *Zidona* fisheries are Mar del Plata, receiving 90 % of the production, and Necochea, receiving the remaining 10 %. In Uruguay the main landings are in La Paloma harbor. Given relatively high rates of exploitation, this species could be seriously endangered. Hence, studies on its biology and life cycle are important and uttermost necessary to maintain or propose new sustainable fishing policies. In this paper, we study the reproductive cycle of *Z. dufresnei* using histological techniques. The results of this study suggests that the gonad has a simple yearly cycle of gamete production with two major conditions. The maximum production period is achieved during the austral Spring (September-December), and the minimum during Fall-early Winter (April-June).

[Poster]

On the systematics of the limnic Pachychilidae: New evidence for the placement of the enigmatic *Faunus* (Caenogastropoda: Cerithioidea)

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The Superfamily Cerithioidea is a large group of ~200 genera. Although primarily marine, the group contains several lineages that have entered limnic biotopes. Previous classifications of the Cerithioidea have reflected these ecological groupings, unifying all limnic taxa in a single, presumably monophyletic, assemblage. Recently, phylogenetic relationships within the group have come under increasing scrutiny. Several cladistic treatments suggest that limnic taxa may not form a clade, but support the independent colonization of freshwater. However, relationships within and between these limnic groups remain unclear. One taxon with uncertain taxonomic composition and affinity is the Pachychilidae.

The Pachychilidae has a pan-tropical distribution with the Neotropical *Pachychilus*, *Potadoma* in Africa, *Melanatria* on Madagascar, the highly diverse *Brotia* in South East Asia and *Pseudopotamis* on the Torres Strait Islands. Anatomical investigations have revealed that members of the family possess a unique and diagnostic midgut anatomy that is highly conservative across the group. By integrating this new information with pre-existing morphological data, we will evaluate the monophyly and current systematic composition of the group. In addition, we will provide new evidence for the systematic affinity of *Faunus*, a distinct monotypic genus, hitherto placed within another limnic cerithioidean lineage, the Melanopsidae.

[Oral presentation: General session]

**Thermal influence on juvenile development in the freshwater viviparid snail,
*Campeloma decisum***

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Thermal regime can exert a very strong influence on reproductive potential in many aquatic invertebrates. The effect of temperature on juvenile output and development in the freshwater snail *Campeloma decisum* (Say 1817) was examined in laboratory and field experiments. This viviparid snail gives birth to relatively large, fully developed juveniles from a uterine brood that contains all ontogenetic stages from egg to juvenile. This character makes this gastropod an excellent test organism for developmental studies. Field collections were made monthly from June to October 1997 and a final post winter collection was made in April 1998. Field studies showed that the snails were most actively reproducing in October, but the juveniles released were generally smaller than any other time of the year. Laboratory experiments using temperatures ranging from 12 to 31 °C demonstrated that thermal regime had a profound effect upon reproductive output. Effects ranged from completely halting reproduction in cold water to inducing juvenile release spikes of small, incompletely developed individuals at warmer temperatures. The latter individuals were 1/3 the weight of “normal” individuals for the same temperature. It is possible that monitoring juvenile cohorts (size and numbers) of *Campeloma decisum* could be an appropriate tool to help in monitoring thermal regimes.

[Poster]

**Life at the edge: An examination of the northern range limit of the limpet
“*Collisella*” *scabra***

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The intertidal limpet “*Collisella*” *scabra* (Gould 1846) is found from southern Oregon to Baja California. This distribution is not concurrent with any known biogeographic province in the Northeastern Pacific, and little is known of the factors that determine its geographic limits. I surveyed the abundance and size distribution of “*C.*” *scabra* across the northern 400 miles of its geographic range. I also examined densities of four other limpet species (*Lottia digitalis*, *L. pelta*, *L. paradigitalis* and *Tectura scutum*). Abundance of “*C.*” *scabra* declined more than 100-fold across Cape Mendocino (40° 30'N). To determine whether adult *M. scabra* could survive at sites north of Cape Mendocino, I conducted transplant experiments. While survival rates were similar among snails transplanted inside and outside of the range, there were differences in growth rates of snails at different sites. Possible factors determining the northern range limit of *M. scabra* are discussed in light of this data.

[Poster / Eligible for Student Award]

Comparative sperm ultrastructure of chromodorid nudibranchs - taxonomic and phylogenetic implications

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In their recent cladistic analysis of the phylogeny of Chromodorididae *sensu* Rudman (1984), Gosliner and Johnson (1999) suggested that relationships within the family are poorly understood. In the present study, comparative sperm ultrastructure provided informative characters that have not previously been incorporated into such analyses. Examination of the acrosomal complex in a number of genera within the Chromodorididae has revealed a possible synapomorphy. Fine striations in the internal structure of the acrosomal pedestal are present in five genera (*Chromodoris*, *Hypselodoris*, *Glossodoris*, *Risbecia* and *Pectenodoris*). Preliminary examination of *Cadlina* and *Cadlinella* (both currently accepted as basal chromodorid genera) reveal marked acrosomal differences from each other and from other investigated chromodorids. As previous studies have documented the taxonomic and phylogenetic importance of acrosomal morphology in heterobranchs (Healy 1993), a reassessment of the placement of *Cadlina* in Chromodorididae is required.

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[Oral presentation: Systematics and ecology of opisthobranch gastropods / Eligible for Student Award]

Columellar muscle attachment in *Leucozonia nassa*: Implications for the interpretation of columellar fold function

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Malacologists traditionally assume that columellar folds, plications on a gastropod's inner lip frequently used in systematics, offer a functional advantage. Previous, but untested, hypotheses suggest that columellar folds guide the columellar muscle during retraction and protraction, and that folds increase the surface area of attachment increasing the animal's ability to maneuver its shell. I have begun to test these hypotheses in the fasciolariid *Leucozonia nassa* (Gmelin, 1791). The columellar muscle attachment site is far more complex than described in other gastropods. It begins at the maximum point of retraction on the shelf that separates the ultimate and penultimate whorls and extends apically along the columella and shelf for more than a whorl. The attachment is frequently destroyed when the shell is crushed for dissection or when the animal is frozen or preserved in 95% EtOH or buffered formalin. The attachment is not parallel to or coincident with the columellar folds. Rather, the muscle contacts the columellar folds briefly at only one point along the attachment. These observations suggest that columellar folds may not guide the muscle, nor do they increase the surface area for attachment. Additional work is necessary to understand the implications of this elaborate attachment, to document how universal this attachment morphology is among neogastropods, and to reveal alternative hypotheses that may correlate muscle function with the columellar folds.

[Oral presentation: General session / Eligible for Student Award]

Phylogenetic systematics of the genus *Platydoris* (Mollusca, Nudibranchia, Doridina)

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The genus *Platydoris* is characterized by a flat body, wide mantle margin, and elevated branchial and rhinophoral sheaths. The examination of a number of specimens and a review of the literature show that there are at least twenty valid species of the genus *Platydoris*. Fourteen of them have been previously described by other authors and six are new species. Twelve species are removed from *Platydoris*.

A phylogenetic analysis was conducted, showing the genus to be monophyletic. There was strong support for a clade of all species of *Platydoris* included except for *P. annulata* and *P. macfarlandi*, which are found in deeper water than the rest of the genus. This major clade was further divided into a clade of Atlantic and Western Pacific species and a clade of Indo-Pacific species, showing a strong biogeographical trend. Important characters separating clades include ventral pigment around the foot, large ventral spots, the presence of vaginal hooks, and whether the accessory gland enters the atrium on the side of the vagina, the side of the deferent duct, or between the two.

[Oral presentation: Systematics and ecology of opisthobranch gastropods / Eligible for Student Award]

Regulation of aluminium uptake by the freshwater bivalve *Anodonta cygnea* L.

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Although highly toxic, aluminium (Al) is considered to be relatively unavailable to aquatic organisms at neutral pH due to its insolubility. Owing to their feeding strategy, bivalves come in contact with both dissolved and particulate forms of the metal and thus are potentially more exposed to Al than other molluscs. The mechanism of Al regulation by the freshwater bivalve *A. cygnea* was investigated following exposure to two environmentally relevant concentrations (250 and 500 mg l⁻¹ added Al) for up to 15 days at neutral pH.

Shell opening time was unaffected by 250 mg l⁻¹ Al but was reduced by 50% following exposure to 500 mg l⁻¹, with little subsequent recovery. Tissue Al concentrations after 15 days exposure were up to 10 times higher in animals exposed to 250 mg l⁻¹ compared to 500 mg l⁻¹ added Al suggesting that shell closure is a short-term response to reduce Al uptake. Mussels exposed to the lower Al concentration produced pseudofaeces with significantly higher Al content than those exposed to the higher concentration suggesting that mucus production may also regulate metal uptake. In addition, lysosomal activity in digestive gland, a common detoxification mechanism in molluscs for the removal of metals was increased as a response to Al, at both exposure concentrations.

These results confirm that Al is bioavailable at neutral pH and that *A. cygnea* possess mechanisms for regulating the metal.

[Poster / Eligible for Student Award]

A new book on the marine bivalve mollusks of Western North America

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A book has just been published on the marine bivalve mollusks of western North America. Eleven years in the making, the manuscript documents and describes all bivalves from northern Baja California, Mexico, to the Alaskan Arctic, encompassing habitats from the intertidal zone down to abyssal depths of more than 4,500 meters.

The new monograph details 472 species and includes photographs and/or line drawings of each, along with a description of its shell, habitat, and ecology, and references to relevant literature. A particular effort has been made to ensure the book's utility to those outside this geographic area. In this regard, the monograph contains copiously illustrated keys and character tables, over 4,700 full bibliographic references for important literature on each family, genus, and species, and anatomical figures of most genera treated in the text.

Three new bivalve species are formally described in the book, belonging to the Thyasiridae, Tellinidae and Mactridae. Several additional new species are figured but not officially named.

[Poster]

The effects of temperature and primary productivity on the distribution of turrnellid gastropods in the Northeastern Pacific during the last 65 My

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During much of the Cenozoic, turrnellid gastropods have been a diverse and abundant component of subtidal marine communities along the California margin. All but one species of this family, however, has disappeared from this region, and the remaining species is increasingly difficult to find within its range today. Previous work on Western Atlantic and Eastern Pacific turrnellids suggests that range reductions and extinctions are related to decreases in temperature and primary productivity since the mid-Miocene (~15 Ma). Recent results from studies of sedimentological cores along the California margin support this hypothesis. The timing of range shifts and extinctions are correlated with temperature and productivity shifts throughout the Neogene, and statistical analysis confirms significant differences in midpoint ($p = 0.0356$) and in northernmost occurrence ($p = 0.0357$) for species existing under different environment regimes. There is no difference among time periods in the mean size of individual species ranges ($p = 0.288$).

These results further indicate that turrnellid species ranged farther north in the Eastern Pacific during the Eocene than at any other time in their history. Since then, the range of the family has contracted and nearly all species have become extinct. The coincidence of extinctions/range shifts and changes in temperature/productivity suggest an important link between these environmental variables and the evolution of this gastropod family in the Eastern Pacific.

[Poster / Eligible for Student Award]

Kleptoparasitism by the marine snail *Trichotropis cancellata* on tubiferous marine polychaete worms

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The marine gastropod *Trichotropis cancellata* is a facultative kleptoparasite, able to suspension feed independently or steal food from at least five species of tube-dwelling polychaete worms. Field monitoring of *T. cancellata* at sites around Friday Harbor, WA, indicate that parasitism is a dominant feeding mode of this snail. All size classes of *T. cancellata* associate with worms. The snails leave their worms to mate and lay their eggs, returning to the worms after the young are hatched. Field tethering experiments show *T. cancellata* grows faster when parasitizing serpulid worms than when suspension feeding. The five species of tubiferous worm hosts vary greatly in size. Despite this apparent difference in resource potential, the snails grow at comparable rates on the different host species during the summer, when plankton levels are high. In the winter, when plankton levels are lower, the snails grow at different rates on the different host species, but these differences seem more likely to be explained by host family rather than host size.

[Oral presentation: General session / Eligible for Student Award]

Predation by young *Cassia tuberosa* Linnaeus, 1758 (Mollusca: Gastropoda) on *Mellita quinquiesperforata* (Clarck, 1940) (Echinodermata: Echinoidea)

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In Icapuí Beach, State of Ceará, Northeast Brazil, young individuals of *Cassia tuberosa* Linnaeus, 1758 are frequently found feeding on *Mellita quinquiesperforata* (Clarck, 1940). In this study we analyzed the predatory behavior of young *C. tuberosa* on the sand dollar *M. quinquiesperforata*. The predator and prey were collected at low tide and taken to the laboratory in aerated boxes. Each *Cassia tuberosa* was placed with twenty individuals of *Mellita quinquiesperforata* in 60-liter tanks. During the experiment the number of consumed prey was noted and eaten individuals were replaced. This experiment lasted for one month at 28°C and was replicated five times. We registered the position and the dimensions of the bore holes on the sand dollars. The bore holes were complete, with 4 to 5 mm of diameter and had teeth marks of the radulae on the edges. We found, in every prey, a dark spot around the predation holes. We did not observe preference for oral or aboral sides. The defense mechanism of the prey was based on behavioral strategies.

[Poster]

Occurrence of imposex in *Thais haemastoma* (Linnaeus, 1767) (Mollusca: Gastropoda) as an indication of contamination by tributyltin (TBT) in the coastline of Fortaleza city - Ceará - Brazil

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Imposex is characterized by the development of male features in female neogastropod mollusks, namely the appearance of a non-functional *vas deferens* and a penis. The occurrence of imposex is a consequence of contamination by anti-fouling paints and, in particular, to their main biotoxic ingredient, the tributyltin (TBT). Samples of *Thais haemastoma* were collected on ten beaches of the metropolitan area of Fortaleza, State of Ceará, Brazil, and examined for the occurrence of imposex. Many examined females presented imposex. The degree of imposex was related to the distance of the beach to the city harbor, with the higher levels of contamination being presented by the samples from the Mansa and Mucuripe beaches, closest to the city harbor.

[Poster]

Land snails and slugs in Delaware, U.S.A.: Systematic survey reveals new distribution records

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Knowledge of species distributions is necessary for making informed decisions about the world. Current understanding of Delaware's terrestrial mollusk distributions is inadequate. The most comprehensive existing land snail and slug distribution maps for eastern North America report distributions to the level of county only. With only three counties in the state of Delaware, distribution resolution is very poor. Many areas of Delaware have been poorly surveyed.

In this study, we have sampled land snails and slugs from each of the 238 5x5-km squares in Delaware, giving resolution about 80 times greater than existing distribution maps. Because most species are minute, we have collected leaf litter samples to sieve later in the lab to recover small species. We have also searched visually in the field for slugs and larger snails.

We report dozens of new species records at the county and state level. We show that protected natural areas tend to have greater mollusk diversity. Species occurring in few squares include taxa on the edges of their ranges, species restricted to uncommon habitats, introduced species that have not yet spread, or species that are actually rare. As part of a larger study on land gastropods of the Delmarva Peninsula, this work will result in an atlas showing gastropod distributions in the area. The atlas will aid amateur and professional naturalists as well as workers in the fields of conservation, agriculture and ecology.

[Oral presentation: General session]

**Rates of fluid flow through the mantle cavity of the marine gastropod
*Fasciolaria hunteria***

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The functional morphology of the mantle cavity has played a significant role in the traditional theories of gastropod evolution. Our goal is to provide accurate accounts of mantle cavity structure and function that can be incorporated into modern theories of gastropod evolution. We studied the anatomy, histology, and flow characteristics of the marine gastropod *Fasciolaria hunteria*, which has a single, elongated, incurrent siphon that extends anteriorly over the head, a single monopectinate ctenidium, and a restricted region at the right posterior of the aperture that serves as the excurrent window. Analysis of videotapes of particles moving in and out of the mantle cavity using a laser as a light source indicates that incurrent velocities ranged from approximately 0.22 to 1.2 cm/sec. Excurrent velocities ranged from 0.13 to 0.86 cm/sec. These data will provide a basis for comparisons for future studies on other species of marine gastropods.

[Poster]

Phylogenetic relationships of moon snails (Gastropoda: Naticidae)

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This cladistic analysis attempts to resolve the “problematical” phylogenetic relationships among moon snails. Fifty-five extant taxa (45 naticid, 10 outgroup) and 106 characters were used to reconstruct hypotheses of relationship within the family and examine the family’s position within the Gastropoda. Because naticid shells are morphologically conservative, the analysis included opercular, radular, reproductive, and anatomical characters.

The consensus cladograms depict the higher caenogastropods (*Lamellaria* + *Trivia* + *Cypraea* + *Neogastropoda*) as the sister group to naticids. Naticids represent a monophyletic group, defined as all descendents of the common ancestor of *Eunaticina* and *Amauropsis*. The clade is diagnosed by characters derived from the sand-agglutinated egg collar, enlarged foot, and accessory boring organ on the tip of the proboscis.

Results support the placement of *Eunaticina* in Polinicinae, as in the classification of Wenz (1941), rather than in Sininae as in the classification of Marincovich (1977). Naticine polyphyly indicates that opercular calcification has arisen at least twice within the family. Monophyly is suggested for some genera and subgenera (e.g. *Amauropsis*, *Sinum*, *Eunaticina*, and *Stigmaulax*). However, many of the most familiar traditional taxa are para- or polyphyletic (e.g. *Polinices*, *Neverita*, *Natica*, *Naticarius*, and *Euspira*). Sister group relationships support a pre-Cretaceous origin for Naticidae, contrary to the recent assessment by Bandel (1999).

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[Oral presentation: General session]

Malacology at the Carnegie Museum of Natural History and opportunities for collection-based research

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Over 100 years ago, The Carnegie Institution was established by a gift from Andrew Carnegie to the people of Pittsburgh. The Carnegie Museum of Natural History is one of the four original components of the Institution. Since its inception, malacology has been an important aspect of the study of the life sciences at the Museum.

The malacology collection is built around the early donations and collections of H. H. Smith, George Clapp and Victor Sterki. Ortman, Brooks, McMillan and Parodiz, curators of malacology, have augmented the collection through their collecting activities. Additional accessions from other museum scientists, outside agencies and the amateur community number in the hundreds. The collection is currently comprised of some 94,000 lots representing several million specimens. The collection is especially strong in the freshwater mussels (Unionacea), sphaerid clams and terrestrial and freshwater gastropods, especially of North and South America. The type collection contains over 1,200 lots.

This presentation will feature further aspects of the history of the collection, its curators, and a detailed analysis of the holdings in the research collection. Opportunities for research based upon the strengths of the collection will be discussed. Though the Section does not currently have a full time malacologist on staff, requests for information and for loans can be made to the authors.

[Poster]

Survey and status of terrestrial slugs in North America

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The status of the invasive terrestrial slug fauna needs revision for several reasons. The United States Department of Agriculture, Animal and Plant Health Inspection Service, (USDA, APHIS), intercepts slugs on various commodities at international ports. A mission of APHIS is to prevent the importation of exotic plant pests. Unfortunately, a fair number of slug specimens intercepted at ports-of-entry are immature and are difficult to identify using morphological or anatomical methods. One goal is to develop molecular methods for taxonomic purposes to distinguish naturalized from exotic slug species.

However, current knowledge of slug species thought to be established in North America is assumed to be incomplete as the last thorough survey was limited to the northeast 30 years ago. Therefore, it is difficult to evaluate species that pose a risk to American agriculture, managed and natural ecosystems; versus species of no concern (*i.e.* those already established). With recent increases in commerce and reduced trade restrictions, these same concerns are impacting other countries, especially those of Europe.

Preliminary surveys have shown us that the existing slug fauna is not thoroughly recorded. Laboratory colonies have been established as a result of these collections. These populations will allow us to better address molecular issues, and are available for ecological or applied studies. We are requesting your help and can reciprocate with identifications. A contact Information Sheet is provided on the poster.

[Poster]

**Mitochondrial DNA and morphological differentiation of the land snail
Hemiphaedusa in Taiwan: A derivative phylogeography event**

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The land snail genus *Hemiphaedusa*, despite its restricted geographical distribution, exhibits an extreme degree of morphological differentiation in Taiwan. Twenty-two representatives of 18 species, include 5 unknown ones, were studied with a combined approach using mitochondrial DNA and qualitative morphological data. Mitochondrial DNA were analyzed by sequencing a PCR-amplified mitochondrial DNA fragment of the large rRNA subunit gene.

Qualitative morphological characters on shell were examined in seventeen items. Maximum parsimony and neighbor-joining phylogenetic analyses demonstrate different relationships not only within but also between genetics and morphology. There is considerable variation of genetic distance within species. In the phylogenetic tree, it appears that the phylogenetic relationships do not correlate well with current taxonomy, but exhibit biogeographical distribution. The genus of closely related species were divided into three clusters: North, center and southeast. There is a certain relationship of distance within one cluster but not among the clusters. Small- and large- scale evolutionary events can be deduced. According to our analysis, we suggest that there was an early and rapid differentiation of *Hemiphaedusa* groups in Taiwan followed by dispersal and local speciation in confined geographical areas.

[Poster]

Documenting Neogene invasion of the eastern Pacific with species-level venerid phylogenies

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Many genera of the venerid subfamily Chioninae had their origins in the Early Oligocene-Early Miocene of the tropical western Atlantic. These genera are present today in the tropical eastern Pacific; in fact several are now extinct in the western Atlantic. Invasion of the eastern Pacific occurred via the Panama Seaway and must have taken place prior to uplift of the Isthmus and final Seaway closure (approximately 3.1 Mya). Phylogenetic patterns of invading taxa promise to shed light on the still poorly known and understood dynamics of the invasion. Important questions remain unanswered, such as: (1) Was invasion episodic or continuous? If episodic, are episodes of invasion coincident among different clades? (2) What oceanographic and geological conditions may have promoted invasion? (3) Were any episodes bidirectional?

Answering these questions requires a good fossil record and species-level phylogenetic analyses of target clades. Chionine genera have excellent records on both sides of the Americas, though the record in the eastern Pacific is not as well documented. Species-level phylogenies do not exist for any of these genera. Phylogenetic analysis at that level, with the inclusion of fossil taxa, requires the analysis of characters that can be described for those taxa. The present study combines discrete conchological characters with morphometric developmental characters, and the combination is proving sufficient to resolve relationships among extinct and extant, and Atlantic and Pacific species within individual genera. For example, analysis of the genus *Chione* reveals that at least two distinct subclades invaded the eastern Pacific.

[Oral presentation: General session]

Systematic review and phylogenetic analysis of the nudibranch genus *Melibe* (Opisthobranchia: Dendronotacea) with descriptions of three new species

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Three new species of the genus *Melibe* are described from the Philippines and Okinawa. Specimens of *Melibe engeli* Risbec, 1937 are recorded and described from the Hawaiian Islands and the Philippines and an additional photo is noted from southern Japan. These represent the first published records of this species since its original description. The anatomy of an additional nine species of *Melibe* is re-examined. These include: *M. australis* (Angas, 1864), *M. bucephala* Bergh, 1902, *M. leonina* (Gould, 1852), *M. liltvedi* Gosliner, 1987, *M. megaceras* Gosliner, 1987, *M. papillosa* (de Filippi, 1867), *M. pilosa* Pease, 1860, *M. rosea* Rang, 1829 and *M. viridis* (Kelaart, 1858). Consistent anatomical differences suggest that *M. pilosa* and *M. papillosa* represent distinct species. This review of the morphological variability within the genus provides the basis for a phylogenetic analysis of the group. *Melibe* is shown to represent a monophyletic clade. Members of the genus *Tethys* represent the sister group of *Melibe*.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

Vetigastropod relationships revisited

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The current study addresses the relationships within Vetigastropoda *sensu stricto* (Fissurellidae, Haliotidae, Lepetodrilidae, Pleurotomariidae, Scissurellidae, Trochidae) and Vetigastropoda *sensu lato* (Vetigastropoda *ss*, Melanodrymia, Neomphalidae, Peltospiridae, Seguenziidae). The three genes Cytochrome B, Cytochrome Oxidase subunit I, and Histone 3 are used. The phylogenetic hypotheses allow to address questions regarding the evolution of size and the vertical colonization of the ocean.

[Oral presentation: General session]

ABMAP: Abalone distribution on the Web

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A new web site on the server of the Natural History Museum of Los Angeles County details the distribution of world-wide abalone (Gastropoda: Vetigastropoda: Haliotidae). The site provides dot maps for each species, supplies all the specimen information, provides illustrations of all species, and gives the latest state of the nomenclature. Additional records are being sought and can be provided by anybody through a form interface. The user can not modify any information, which insures quality data being provided. ABMAP is an example, how up-to-date information can be provided at low cost and distributed world-wide. Some construction details with DreamWeaver 2 are described. The site is demonstrated with a computer.

[Poster]

**A morphometric comparison of two species of land snails (Pulmonata: *Polygyra*)
from Val Verde County in southwest Texas**

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A morphometric analysis was carried out on thirty shells of polygyrid land snail collected from Devil's River State Natural Area, Val Verde County, Texas. Specimens examined include shells conforming to the descriptions of *Polygyra texasiana texasensis*, *Polygyra tamaulipasensis* and some that display mixed characteristics of each species. Twenty-four shell characters were measured and a principal component analysis (PCA) was performed. The PCA scores were then analyzed using a multivariate analysis of variance (MANOVA), which indicated that there is no significant difference between these groups. Continuous variation was observed in all characters examined between the two species. These results would appear to support a re-examination of these two taxa of land snails.

[Oral presentation: General session / Eligible for Student Award]

**The natural history of *Doriopsilla gemela* at Bahía de Los Ángeles,
Baja California, México**

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Doriopsilla gemela is one of the most common subtidal nudibranchs at Cuevitas and Punta La Gringa, Bahía de Los Ángeles, Baja California, México. It occurs on its prey item, pink masses of *Pseudosuberites pseudos*, or on a yellow sponge (that may be a different color form or species). It has an annual cycle, and lays its direct development eggs on algae (e.g. *Colpomania*) that break off and are carried by the currents. The nudibranch's dispersal mechanism utilizes floating algae. Statistical analyses of these aspects of *Doriopsilla gemela*'s life history will be presented, along with comparisons of its ecology in southern California, U.S.A.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

Provisioning for offspring: Histochemical and biochemical analyses of the egg masses of two congeneric populations of *Costasiella* (Opisthobranchia: Ascoglossa) with different developmental modes

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Egg masses of two populations of the ascoglossan genus *Costasiella* with different developmental modes were examined. Adults of the two populations were separable by habitat but could not be distinguished by external morphology. Both feed solely on the green siphonalean alga *Avrainvillea nigricans*. *Costasiella ocellifera*, an encapsulated developer that hatches in 12 days, were collected at Geiger Key, Florida, a well-flushed location where algae are short and sparsely distributed. *Costasiella* sp., which hatches as a veliger in 6 days, were collected at Lake Surprise, Key Largo, Florida, where *A. nigricans* is taller, found in high densities and tidal flushing is limited. Histochemical examination of extra-embryonic intracapsular vesicles from the egg masses of *C. ocellifera* revealed the contents to be glycoprotein. No inclusions were visible in the capsular fluid of *Costasiella* sp. Egg masses from the two populations differed significantly in the amount of TCA-soluble carbohydrate, lipid, and NaOH-soluble protein per egg and per milligram dry weight of egg mass. By provisioning the embryo with the appropriate quantity and quality of resources largely by modifications of accessory structures, *C. ocellifera* might achieve encapsulated development without production of a large yolky egg. The advantage of hatching out directly onto a suitable food source that is temporally persistent but patchily distributed might have provided the selective pressure to achieve extended intracapsular development. These results support the idea that some ascoglossans have the potential to achieve more than one developmental pattern, but selective forces constrain expression to a single pattern.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

Phylogeny, biogeography and evolution of color in the genera *Hypselodoris* and *Thorunna* (Nudibranchia: Chromodorididae)

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Phylogenetic reconstruction is the only testable means by which evolutionary relationships between taxa can be examined. The resulting hypothesis of relationship is used to answer questions broader than who is related to whom. Phylogenies have been used to trace the evolution of different traits, to test the appropriateness of group names and to understand biogeographic events. Here questions regarding the evolution of color pattern in similarly colored sympatric nudibranchs and the geographic distribution of different species are addressed in light of phylogenetic hypotheses. Three phylogenies are presented: A preliminary phylogeny of the family Chromodorididae and complete phylogenies of the genera *Hypselodoris* and *Thorunna*. It is immediately apparent from the phylogeny of the Chromodorididae that similar color patterns have evolved multiple times in distantly related, sympatric taxa. In examining the other more detailed species level phylogenies we find there is no one pattern to explain the evolution of color in these nudibranchs. Biogeographical patterns found in the Indo-Pacific and Eastern Pacific species of *Hypselodoris* are also discussed.

[Oral presentation: Systematics and ecology of opisthobranch gastropods / Eligible for Student Award]

Development patterns in the sacoglossan *Elysia patagonica* Muniain and Ortea, 1997 from Argentina

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There is limited available information on spawning behavior and development patterns in sacoglossan opisthobranchs. These characteristics have only been completely studied in some species.

Elysia patagonica Muniain and Ortea, 1997 is the first sacoglossan species described from Patagonia (Argentina). Specimens were maintained in controlled conditions of temperature, food and water quality, from fertilization to metamorphosis. This species has planktotrophic development. Egg masses contain multiple embryos per capsule (1-8) and the mean capsule diameter is 148 x 119 μm (1 embryo) to 230 x 300 μm (> 4 embryos). The veliger larvae have a large bilobed velum and a coiled larval shell (Type 1). The average length of larvae is 96 μm to 320 μm (larva 10 days post hatched).

In the present study we describe the copulation and spawning behavior, number and size of the egg capsules in the mass, embryo per capsule, and the development type. We compared and discussed the results found in other species of *Elysia*, a genus in which the poecilogony phenomenon, as an intraspecific variation in the mode of larval development, has been stated by some authors.

[Poster]

Chemical ecology of opisthobranchs mollusks from Argentina and comparison to adjacent regions

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The biochemistry of marine mollusks has been intensively investigated in recent years, leading to the discovery of a variety of novel molecules. These studies have been particularly intensive in opisthobranch gastropods compared to studies of other groups of mollusks.

In most gastropods, the principal function of the shell is protective. The opisthobranchs constitute one of the best examples of marine animals where chemical products have replaced the shell in the function of primary defensive mechanism.

A review of the main natural products of opisthobranchs from the South Atlantic and adjacent regions (Pacific Magellanic Province and Antarctic Province), based on bibliographic references and our own studies has been carried out. The presence of similar secondary metabolites in different groups of mollusks, the probable origin (diet or biosynthesis) and the location (mantle or digestive gland) are discussed.

[Poster]

Contribution to the knowledge of the taxonomy, ecology and geographic distribution of opisthobranch gastropods from Argentina

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A systematic revision of the opisthobranch mollusks from Argentina has been recently completed. A commented checklist based on bibliographic references, museum material and personally collected specimens compiles the opisthobranch fauna from the three biogeographic regions present in Argentina: Argentinian, Magellanic and Antarctic Provinces. A great deal of confusion existed among the species recorded, mainly because the anatomy and the external morphology of the living animals were poorly known. The list includes synonyms, references and geographic ranges for the species belonging to the most problematic and representative genera.

Preliminary ecological studies on predator-prey relationships, defense strategies and reproductive aspects have been carried out in carnivorous and herbivorous opisthobranchs, principally in nudibranchs and sacoglossan from the Magellanic Province.

[Oral presentation: Systematics and ecology of opisthobranch gastropods]

Geographic range extension of *Isognomon alatus* Gmelin (Bivalvia, Isognomonidae) in the Brazilian coast

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Isognomon alatus has been reported to occur in the Brazilian coast up to Santa Catarina State (South of Brazil - 27° 20' S, 48° 30' W). However, this species has been recently observed up to Rio de Janeiro State, with high densities on rocky shores. In this study we estimated the percentage of coverage of this species at three rocky shores, exposed to different oceanographic conditions in the Cabo Frio upwelling area (22° 47' 5'' S, 42° 05' W), Rio de Janeiro, State. Larval concentration in the water column was also measured near the rocky shore and related to the presence of settlers on the shore. The results show that *I. alatus* can reach up to 100% of coverage in the intertidal zone, replacing the bivalve *Perna perna*, an important commercial species in the region, in several areas. The presence of primary prodossoconch larvae of *I. alatus* shows that this species can complete its life cycle in the environmental conditions of the study area. There are many reports on the occurrence of this species in several areas between Santa Catarina State and Cabo Frio region, which suggests that this species has already extended its original distribution range throughout the south and southeast of the Brazilian coast. The ecological consequences of the dominance of this species in the intertidal zone of the rocky shore in the Brazilian coast need to be evaluated.

[Oral presentation: General session]

The conservation of regulatory genes and the evolutionary diversification of molluscs

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While bilateral symmetry make up the bauplan of the basal forms of molluscs, the gastropods have undergone a great deal of change leading to both symmetrical and asymmetrical body forms. We will attempt to ascertain how this evolutionary diversification has taken place by studying regulatory gene pathways. We are particularly interested in examining mesoderm formation and differentiation. In dueterostomes, it has been well demonstrated that the same set of highly conserved regulatory genes control mesoderm determination. We have isolated some of these genes by the polymerase chain reaction (PCR) in molluscs, demonstrating their antiquity. By the use of *in situ* hybridization we will determine how these genes interact with one another in the formation and differentiation of mesoderm leading to the various frameworks of gastropods.

[Oral presentation: General session]

What sort of bilaterian ancestor gave rise to Mollusca (and ourselves)?

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Recent phylogenetic analyses of morphological and 18S rDNA data sets have revealed overall congruence in recognizing three main groups of bilaterian animals. These new groupings are very different from conventional views. Mollusca is presently viewed as a member of the clade, Lophotrochozoa (or Eutrochozoa), along with annelids and other protostome animals with spiralian development, and also lophophorates (e.g. brachiopods and phoronids). This grouping does not include arthropods, which are no longer considered sister taxon of annelids but instead are members of Ecdysozoa, along with nematodes and other protostome animals that molt their exoskeleton. A third major clade of bilaterian animals, Deuterostomia, is now restricted to chordates (ourselves), echinoderms, and hemichordates. This presentation will focus on the rooting of Bilateria, which is a problem because only relatively distant outgroups such as cnidarians and ctenophores are available, but remains an extremely important obstacle to accurate reconstruction of bilaterian ancestry. For example, recent analyses have favored a basal position for acoe flatworms within Bilateria, and this would have critical implications for understanding the polarity of embryonic and larval evolution within Bilateria. Evidence will be presented that leads to a different interpretation for these results, suggesting that the rooting at acoe flatworms is an artifact of spurious attraction to distant outgroups. When acoe flatworms are removed from the data set, 18S rDNA estimates agree largely with morphological estimates, with a more conventional split between deuterostome and protostome bilaterians. Moreover, it appears increasingly likely that spiralian development is derived from a deuterostome-like ancestor.

[Oral presentation: General session]

Spatial and temporal growth patterns in the phenotypically variable *Littorina saxatilis*: Surprising patterns emerge from chaos

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Intraspecific variation may have many causes - genetic, developmental and environmental - and understanding those causes is a major theme in biology. *Littorina saxatilis* continues as a model system for studying intraspecific variation because the shells are variable and response is tied to environmental conditions along the near-shore (e.g. ecotype). Although most research has focused on disentangling genetic-environmental interactions, *L. saxatilis* is an excellent system to study developmental shifts that lead to adult ecotypic variation because the shells contain a full record of development. However, *L. saxatilis* is an indeterminate grower and shells wear at the apex, making inference more challenging. In this study we ask: 1) Can we infer ANY pattern given indeterminate growth. 2) If yes, then between and within groups, are growth patterns similar or different? 3) Are changes in development built by temporal shifts (heterochrony), spatial shifts (heterotopy) or both? Is it the same for all groups?

In order to construct ontogenetic trajectories, we performed an eigenshape analysis of the *L. saxatilis* whorls. Eigenshape analysis calculates angle change around each object and then summarizes differences across all objects. We sampled whorls from seven different lots (34 total shells) representing five different ecotypes. Results show all individuals in five of the seven lots have similar growth stopping-points. In one lot, all individuals add an extra quarter-whorl but have similar spatial patterning. In another, growth is truncated very early but also follows a completely different trajectory. Thus both spatial and temporal shifts lead to morphological differences in the ecotypes.

[Oral presentation: General session]

**Feeding specialization and diversification patterns in the eastern Pacific
Patellogastropoda**

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The role of feeding specialization in both clade diversification and mode of speciation within eastern Pacific Patellogastropoda is examined using sterols incorporated into the shell and body tissues as dietary indicators. A molecular phylogeny of the eastern Pacific Patellogastropoda is constructed using DNA sequences from two mitochondrial genes - the large ribosomal subunit (16S) and cytochrome oxidase subunit I (COI). The phylogeny includes both unique taxa that are apparent feeding specialist as well as taxa that feed broadly in the mid to high intertidal zone. Initial field data collected on habitat type and feeding substrate suggest that there is a large diversity of feeding specialists. Preliminary data collected using shell and tissue biomarkers that reflect dietary preferences further support this conclusion. Additional phylogenetic analyses were performed to determine whether these feeding specialists have distinct evolutionary trajectories within Patellogastropoda. Phylogenetic comparative methods are used with the molecular phylogeny of the eastern Pacific Patellogastropoda to test whether a correlation exists between feeding specialization and clade diversification. Ecological characters, such as modern day taxon distributions, are also examined in a phylogenetic context to identify possible modes of speciation.

[Poster / Eligible for Student Award]

The phylogenetic history of *Monadenia fidelis*

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Monadenia fidelis is a widespread west coast land snail taxon that ranges from Alaska to central California. Although this group is as morphologically uniform as other recognized land snail species, it contains nine described geographic subspecies. Furthermore, because *M. fidelis*'s range is several orders of magnitude larger than the ranges of other taxa within *Monadenia*, a phylogenetic investigation is warranted to determine the validity of geographically distinct infraspecific phylogenetic units. The phylogenetic history of the *M. fidelis* species complex is derived from the partial DNA sequences of two mitochondrial genes, cytochrome oxidase I (COI) and the large subunit ribosomal RNA (16s). The monophyly of the group is tested and the phylogeography is evaluated to determine if vicariance predominantly explains the distribution patterns observed. Reproductive morphological characters and shell characters, traditionally used in determining the classifications within this group, are mapped onto the phylogeny to test their relative levels of informativeness.

[Oral presentation: General session]

Native predators limit the abundance of a subtidal whelk in a recently invaded habitat

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Species that invade new regions and habitats often experience ecological release due to the absence of coevolved natural enemies. This release can lead to invader population explosions and result in significant direct and indirect impacts on invaded communities. The recent expansion of Kellet's whelk (*Kelletia kelletii*) into central California added a novel species to kelp forest communities. These whelks act both as important predators of native prey species and as a novel prey resource for native predators (primarily sea otters, but also crabs and drilling gastropods). Field experiments in Monterey Bay identified potential predators of the whelk and determined types and frequencies of shell damage. Results indicate that invasive whelk populations in central California are severely impacted by native predators that are either absent or uncommon in southern California. In Monterey Bay, high levels of predation on the whelk by native predators and an apparent failure of local reproductive effort suggest that this is a whelk population "sink" which may become locally extinct. Such an extinction would represent a rare marine example of native predators controlling an invader.

[Poster / Eligible for Student Award]

The changing ranges of eastern Pacific marine invertebrates: The influence of oceanographic and anthropogenic mechanisms

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I report recent range extensions or revisions for 12 species of intertidal or shallow subtidal marine invertebrates (11 mollusks and 1 ophiuroid) along the California coast. Ten range extensions were northward and two southward. Six potential mechanisms causing these range extensions are considered: 1) climate change; 2) El Niño Southern Oscillation (ENSO) events; 3) thermal refugia; 4) search artifacts; 5) anthropogenic effects; and 6) unpublished data. Search artifacts account for the discovery of seven extralimital species, anthropogenic thermal refugia facilitated two extensions, and the 1997–98 ENSO transported only one species beyond its typical northern limit, although previous ENSO events presumably contributed to the remaining northward extensions. Additionally, unpublished museum material further extended the range endpoints of six species. While climate change and global warming are consistent with patterns of northward expansion, and 10 of 12 species did expand northward, other mechanisms can also explain both ephemeral range anomalies and long-term range expansions. The ability to distinguish among the many mechanisms that alter geographic range in marine systems is an important first step towards understanding the ecological consequences of biotic rearrangement due to climate change and species introductions.

[Oral presentation: General session / Eligible for Student Award]

Molluscan shell pigments

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In 1949-1951 Alex Comfort identified porphyrins as molluscan shell pigments, but did not determine the cause of colour in shells without porphyrins. Later workers identified carotenoids and other compounds as pigments, but most search certain compounds, rather than identify pigments. We have an incomplete result: We know whether a compound is present or absent, but hardly whether it causes the shell to be coloured. Furthermore, for example porphyrins are very diverse compounds (including chlorophyll and hemoglobin) and the term 'porphyrin' is scarcely more informative than 'carbohydrate.' We examine shells with Raman spectroscopy to identify the pigments. This approach is very gentle, as the shell is not dissolved, exposed to high temperatures, or other harmful conditions; Raman spectra are collected with visible light under a microscope in a normal laboratory setting. The method is very sensitive and capable of collecting data from very small sample volumes (down to 1-2 cubic micrometer). This allows us to collect data from several sites, to see the difference between closely spaced pigmented and white sectors, and whether 'black' and 'brown' are due to different pigments or to different concentrations of the same compound. Raman spectroscopy is highly reproducible and very sensitive to minor differences in molecular structure. It is also a new technique without comprehensive databases of spectra, and we often have to produce our own reference spectra. This will be a short introduction to the technique and a brief discussion of our preliminary data.

[Oral presentation: General session]

Toward a phylogeny of North American unionids

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The greatest diversity of freshwater unionid bivalves occurs in North America, which has nearly 300 recognized unionid species. Regrettably, nearly 75% of all unionids are considered extinct, endangered, threatened, or of special concern, making unionids the most imperiled group of animals in North America. Unfortunately, a well-corroborated phylogeny of unionids is lacking hindering conservation efforts to federally protect species as endangered or threatened. Here I present a molecular phylogenetic hypothesis of North American unionids based on mitochondrial gene sequences and compare and contrast these findings with previously published studies.

[Oral presentation: General session / Eligible for Student Award]

Pulmonate Mollusca persisting in California delta marshes with high tidal and physical/chemical extremes

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Several marshes along the outer San Joaquin/Sacramento River Delta have been monitored for years as some have been restored to higher tidal action, after levies largely isolated these sites from San Francisco Bay tides and from the outer River Delta. As a result, salinities and other environmental parameters have often changed with tidal action. Among restored and reference sites, winter salinities ranged 0.5~10 ppt (2~30% seawater) and summer salinities ranged 1~20 ppt (3~60% seawater). Temperatures in these shallows ranged 10~25 °C near the Bay and 5~30 °C further (~20Km) from the Bay. Water clarity was only 5~15 cm in each marsh.

Marsh benthos yielded live Mollusca that represent bivalves and pulmonate gastropods, with almost no other Mollusca. A freshwater pulmonate snail, *Physella integra*, was the most abundant mollusk (year-round) at both restored sites fed by a reclaimed water marsh. Other invertebrates and fishes also were most abundant there, where salinities were lowest, ranging 0.9~2.2 ppt (brackish), water clarity was down to 5 cm, and temperatures were extreme. The other low-salinity site had more variable salinity, low pulmonate population densities, but high abundances of *Macoma balthica* bivalves. Pulmonate slugs were detected at even saltier marshes (~5 ppt), with higher temperature extremes. Based on nearby sediments, bivalves including Asian clams, *Potamocorbula amurensis*, once were common near most sites.

Thus, these several Mollusca persist among extreme conditions in brackish marshes, while prosobranch gastropods and other Mollusca are virtually absent, despite abundant, other Mollusca only seaward or only up river.

[Oral presentation: General session]

Population dynamics of the Jurassic oyster *Gryphaea*: Insights on the role of preservational and collection biases

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The first quantitative morphometric and paleoecological analyses of North American representatives of the Jurassic oyster *Gryphaea* indicate that this model taxon exhibits different life strategies than previously recognized. While well-studied European *Gryphaea* species have been interpreted to exhibit low mortality rates of skeletonized juveniles, assemblages of *Gryphaea nebrascensis* from the Sundance Formation of north-central Wyoming exhibit very high levels of juvenile mortality. Since ecological strategies and environmental conditions have been invoked to explain evolutionary patterns of *Gryphaea*, our study may have implications for previous evolutionary studies of this important molluscan lineage.

There are statistically significant differences between assemblages found in museum collections, float samples, and bulk *in situ* samples. Specifically, juvenile-dominated assemblages are only present in bulk samples while the largest individuals are only present in museum and float assemblages. These differences could be a result of natural factors such as lateral and/or temporal variability between paleo-populations, fluctuating paleoenvironmental conditions, modern weathering and hydrodynamic conditions, and bioturbation. However, human-introduced collection and curation biases may also play a large role in producing these statistically significant differences. Because these differences could result in disparate interpretations regarding the mortality rates, ecological strategies, and population dynamics of this species, future paleoecological studies of fossil molluscs should carefully examine preservational and collection biases.

[Oral presentation: General session]

Evolution of ecomorphic variation in the gastropod clade *Littorina*: A case study of new methods of quantifying shell shape in gastropods

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The littorinid gastropods are a model system for studying phylogenetic, ecomorphic, and developmental data at different hierarchical levels. This group has taxa both with and without ecomorphic variation in shell morphology and a phylogenetic hypothesis with which to test the polarity of evolutionary events. Ecomorphic variation in littorines has often been studied within a single species. However, an exclusively microevolutionary view is potentially limiting. This study provides a macroevolutionary perspective using a clade level approach, generates new hypotheses about the evolution of ecomorphy in *Littorina*, and addresses the applicability of recent morphometric methods to gastropod shells.

Shell shape variation was quantified for 15 taxa from the clade *Littorina* using Relative Warp Analysis (RWA) and Eigenshape analysis. Results from RWA, a landmark-based method, and Eigenshape analysis, an outline-based method, were compared, and the relative strengths and weakness of each method as applied to coiled gastropod shells were examined. Results suggest that non-ecomorphic taxa occupy a limited morphospace when compared to ecomorphic taxa, and that the more recently diverged ecomorphic taxa have expanded the range of morphospace along a similar trajectory. This result, combined with the current phylogeny for the group, suggests that ecomorphy evolved only once in *Littorina*. A comparison of landmark-based and outline-based analyses reveals the specific challenges that gastropod shells present when using modern morphometric methods, and therefore encourages the use of multiple approaches.

[Oral presentation: General session / Eligible for Student Award]

**Morphological systematics of the Mactridae (Bivalvia:
Mactroidea): A research proposal**

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Mactrid bivalves are important components of estuarine and high-energy, shallow-water marine communities. However, little is known about their systematic relationships and comparative biology. In addition, only a few works were published on their anatomy, functional morphology, or development. The Mactridae are loosely defined in the literature as bivalves displaying chondrophore ligament with triangular resilifer, well-developed and inverted V-shaped left cardinal tooth, lateral teeth elongate, fused siphons usually covered by a periostracum sheath. Previous studies on functional anatomy indicate that some mactrids have type 5 stomach, but the number of sorting areas is reduced in relation to the Mesodesmatidae (herein considered as sister-group to the Mactridae). The traditional taxonomy of the Mactridae accounts for about 20 genera distributed in 4 subfamilies: Mactrinae, Lutrariinae, Pteropsellinae, and Zenatiinae. A cursory examination of specimens and literature shows that distribution of the above mentioned “mactrid characters” is not consistent among the genera traditionally included in the group. Furthermore, all generic allocations at present are based solely on shell morphology and, in some cases, “genera” are defined by single shell characters. These inconsistencies in the traditional systematic treatments of the Mactridae indicate that a reappraisal of mactrid systematics is called for. The proposed study aims, through phylogenetic analyses of morphological data obtained from fresh and preserved (museum) specimens, to define the relationships between the major groups traditionally included in the Mactridae.

[Poster]

Seasonal effects of a digenetic trematode parasite on feeding and reproduction of the snail *Elimia flava* (Lea)

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Snails in the genus *Elimia* (Gastropoda: Prosobranchia), common intermediate hosts for digenetic trematodes, have shown a variable capacity to control periphyton in streams of the southeastern United States. The purpose of this study was to assess effects of trematode parasitism on feeding and related physiology of this ubiquitous stream grazer. *E. flava* was collected seasonally from a naturally infected population in Choctafaula Creek, SE g, from fall 1998 to summer 1999. Grazing on algae-covered tiles and ammonia excretion were measured for each snail, after which individuals were dissected to quantify parasites. Infections were ~ 0 to 700 sporocysts/snail, with 40-80% of the sampled population infected. Parasitized snails consumed less periphyton than non-parasitized snails in fall but consumed more in summer. Parasitized snails excreted more ammonia than non-parasitized snails in fall, spring, and summer. I also examined the potential effects of parasitism on reproduction of *E. flava* by relating parasite load to degree of gonadal development. Trematode infection negatively influenced gonadal development in both sexes, with high infections resulting in apparent chemical castration of the host. Parasitism therefore appears capable of altering the feeding, physiology, and reproduction of this snail, and may contribute substantially to the high variation in density and grazing ability reported for this important stream grazer.

[Oral presentation: General session / Eligible for Student Award]

Molecular phylogeny and the evolution of Patellogastropoda aperture morphology

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Phylogenies reconstructed from partial sequences of 12S and 16S genes are currently being made available for Patellogastropod limpets. Relationships between species suggested by these studies do not necessarily conform to prior relationships implied by traditional taxonomy based on morphological data. This study re-evaluates existing hypotheses regarding morphological evolution and biogeography in an attempt to reconcile this data with the molecular data. To examine phylogeny and ecology as mutually exclusive properties is to run the risk of confusing convergence with common ancestry. This study reassesses past interpretations of Patellogastropoda shell shapes, often rooted in ideas of function and convergence, by considering the possibility that shell shapes may be a result of constraint (common ancestry) and their current distributions due to interchange rather than being products of adaptations to more recent conditions. Specifically, the relative differences in shell aperture (measured by perimeter crenulations) are associated with phylogenetic similarity within patellid limpets worldwide from collections in the Museum of Paleontology at UC Berkeley. Under the null model that changes in shell shape and degree of relatedness are non-correlated, a preponderance of positive difference in shell aperture should be associated with increasing relatedness no more often than negative difference using Stearn's subtraction independent comparison tests. Conversely, if species that are more distantly related are consistently similar, the possibility that there is some pattern between the history (spacial and/or temporal) and shell shape will not be rejected in favor of randomness.

[Poster / Eligible for Student Award]

**An introduction to the Patellogastropoda of the Northeastern Pacific, or forget
(almost) every binomial name you ever learned for this group**

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The Pacific coast of North America is world renowned for its patellogastropod fauna. Over 26 living species occur between the Bering Straits and Cabo San Lucas Baja California Sur, Mexico. This diversity is not the evolutionary product of a single recent radiation as earlier workers thought, but rather an amalgamation of immigrants, relicts from the Tertiary, and several distinct radiations within the indigenous clade. From the North Pacific, this clade has successfully moved north through the Bering Straits and into Arctic Canada, and eventually into the North Atlantic. They have also moved eastward into the northwestern Pacific. While most are nearshore species, and intertidal in distribution, several species occur to depths more than 1000 m. While the living diversity appears extremely high, fossil representatives of two additional clades, the pectinodontids and cellanids, are known from the Tertiary of the Oregon and Washington. The living taxa and their ranges are reviewed.

[Oral presentation: General session]

The burying behaviors of *Euprymna scolopes* Berry, 1913

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Sepiolid squids are known for burying in the sand during daylight hours. The burying activity of the Hawaiian dumpling squid, *Euprymna scolopes*, is examined here to determine how it breathes while buried, how it sees while buried, how it behaves under threats, and how it avoids burying in intertidal sand. In a laboratory setting at the Hawaii Institute of Marine Biology, *E. scolopes* were allowed to bury in four different substrates. Inking behavior, time to settle, latency to bury, time to bury, method of burial, breathing while buried, and response to a threat were noted. There were significant differences between the organic content and granulometry of the substrates tested, and in burying times and activities in the different substrates, indicating that the squid can distinguish the difference between intertidal and subtidal substrates. They used a fixed routine in burying themselves. They formed two small breathing holes in the substrate and may have formed a mucus-lined breathing chamber. In face of a continuing threat, the squid first blew water out a breathing hole, then water and sand, then a diffuse ink, and then a concentrated ink blob, indicating they can change the consistency of their ink and may make active choices of responses.

[Oral presentation: General session]

The intermediate disturbance hypothesis does not work for Western Stream Mollusks

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The Intermediate Disturbance Hypothesis (Connell, 1975, 1978; Petraitis *et al.*, 1989) has become a truism of modern ecology, so much so as to be termed “one of the success stories of ecological science” (Rosenzweig, 1995). As applied to streams, it is often coupled with river classification schemes like that of Illies and Botosaneanu (1963). The IDH proposes that diversity (usually defined as gamma diversity) in a non-equilibrium system is greatest in an intermediate disturbance regime. For streams, this generally implies that gamma diversity will be greatest in the mid-portion (rithron) and will decline both toward the headwaters (crenon) and lowest segment (potamon). Plots of any such system will thus be unimodal curves. Survey of the Sacramento River system freshwater mollusk fauna (California) indicates that the IDH is inadequate to explain the observed mollusk diversity. Here, both alpha and gamma diversity peak in the crenon (large limnocrenes; springs generally). Other western US streams follow the same pattern: Diversity peaks in habitats with relatively little small-scale disturbance. Further, greatest sympatric diversity and endemism peak in the same habitats. Hydrobiid dominance may be a partial explanation. Eastern US unionid faunas may fit the traditional picture better, although the relative scarcity of crenon taxa, here due to virtual exclusion of fish larval hosts from the crenon of many streams, perhaps renders comparison moot.

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[Oral presentation: General session]

Fact, theory and tradition in the study of molluscan origins

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Discussions of phylogenetic relationships and origins often use figures called “archetypes,” or “reconstructed common ancestors.” Here we discuss one such creature, the hypothetical ancestral mollusk or HAM. HAM first appeared in 1853 as T. A. Huxley’s archetypal mollusc and has speciated often since then. Radiations have occurred within both paleo and Recent taxa (from the paleontological and neontological literature, respectively). Eight species have appeared in the last 25 years alone and six species remain extant today.

We performed both phenetic and cladistic analyses of the character states present in these figures. Our best approximation of the phylogeny of HAM (based on known ancestor - descendant relationships and stratigraphy) requires 28 more steps than the most parsimonious tree found by cladistic analysis. Phenetic trees based on neighbor joining and UPGMA analyses require one and ten more steps, respectively. The evolution of HAM exhibits all the typical processes and developmental heterochronies thought to encompass organic morphological evolution and both phenetic analysis and cladistic analyses have problems relating paedomorphic taxa.

HAM has not aided evolutionary biologists or paleontologists in solving problems, but has had the opposite effect, by requiring that theories be treated within its framework. Often real data end up being “tested” against a hypothetical anatomy to determine whether a hypothesis shall be accepted or rejected. It has been argued that HAM serves a valuable role as a pedagogical teaching aid. Unfortunately, these imaginary animals do not come clearly labeled with warnings about the harm that they might do if mistaken for real organisms.

[Oral presentation: The place of malacology in comparative biology]

Tracking a marine specialist in geological time: Deciphering confounding patterns of migration, colonization and physiological change

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Specialist herbivores rare in marine systems, and often specialist species thought to be more likely to become extinct. Marine sea grass limpets first appearance in the Eocene of the Paris Basin with a high morphological diversity that is correlated with fossil sea grass leaf widths. Today there are 4 species in North Pacific, 1 extinct species in Northwestern Atlantic, and 1 species in Australia. In the North Pacific the distribution of plants and limpets are not congruent. There are two patterns: In the North - *Lottia alveus* and *Lottia angusta* track northern range of *Zostera marina*, while in the south - *Lottia depicta* occurs only on southern populations of *Zostera marina* and *Lottia paleacea* occurs on southern populations of *Phyllospadix* spp. A molecular phylogeny of these taxa was necessary to resolve relationships because of possible homoplasies in sea grass morphology. Both COI and 16s rDNA genes produce a phylogeny that suggests two distinct radiations of sea grass limpets in North Pacific - *Lottia alveus* in the North and *Lottia depicta* and *Lottia paleacea* in the south. The lineage of *Lottia depicta* and *Lottia paleacea* was tropical and present in the continuous Panamic - Caribbean region. The ancestral clade is likely represented in the Miocene - Pliocene fossils of the Dominican Republic and shell structure data connects these taxa back to the Eocene Paris Basin fauna. Without phylogeny the ecological scenario of adaptive radiation associated with habitat diversification would have remained plausible, but untested.

[Oral presentation: The place of malacology in comparative biology]

More than just a shell: Malacologists in Hawaii 1850-1950

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At least ten malacologists, among them D. D. Baldwin, C. M. Cooke, W. H. Dall, A. Garrett, J. T. Gulick, W. H. Pease and H. A. Pilsbry, dominated the molluscan literature of the Hawaiian Islands and other Pacific islands between 1850 and 1950. In that period they described more than 1,500 species of mollusks. The major questions in biology of that era were about distribution in a world divided into realms, provinces and regions; mechanisms of dispersal, whether by rafting, drifting in currents, or a continent bridging the Pacific; the nature of species and varieties; and the origin of species. The collections amassed during those years of species description provide answers to some of the questions, as Garrett and Pease focused on mollusk distribution, Pilsbry and Cooke espoused a continent to explain distribution and utilized anatomy for both classification and phylogeny; and Gulick proposed isolation as a major factor in speciation.

[Oral presentation: The place of malacology in comparative biology]

Species description in malacology and elsewhere - not “just descriptive” but a framework of hypothesis

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Systematists are often confronted with the view of non-systematists - but sometimes also of colleagues - that species descriptions are “purely descriptive” or “lack a causal framework” and thus are of minor scientific impact. Contrary to that general point of view the present contribution argues that a well-done description of a new species - let’s say in malacology - is a framework of three major types of hypothesis: (1) The specimens under investigations represent at least one of several species concepts which is new to science. (2) The placement of the new species in the “natural” (i.e. phylogenetic) system implies several hypothesis of monophyly. However, in particular the implied creation of a paraphyletic status of established taxa by erecting a new taxon is often neglected by scientists. (3) Each application of each special term within the species description reflects a hypothesis of homology, which may be trivial but is highly problematic in many cases. These three types of hypothesis are outlined by actual examples from the field of malacology. The given framework of hypothesis, on which each species description is based, links taxonomy with phylogeny and thus with evolutionary biology - there is nothing like “purely descriptive”.

[Oral presentation: The place of malacology in comparative biology]

Monographic revision of the pleurocerid genus *Lithasia*

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Lithasia is one of seven recognized genera of the freshwater gastropod family Pleuroceridae. *Lithasia* is distributed in rivers and streams of Kentucky, Tennessee, and Northern Alabama, although a few species occur disjunctly in Illinois and Indiana, and Mississippi. *Lithasia* exhibits a high degree of shell variation, which has prompted authors to describe a number of species and subspecies. Here, I review the currently recognized taxonomy and distribution of *Lithasia* and provide the results from a survey of anatomical and shell variation among species. In addition, I offer a molecular phylogenetic hypothesis based on mitochondrial cytochrome oxidase c (COI) DNA sequences. The morphological and molecular-based phylogenies are compared and the conservation status of the species is discussed.

[Oral presentation: General session / Eligible for Student Award]

Diffuse comments on mollusks, paleontology and evolution

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Although Darwin's work "On the Origin ..." was discussed by paleontologists in America almost as soon as it was published, for generations little was written on the subject of evolution by invertebrate paleontologists concerned with mollusks. For a century, the prime effort of most invertebrate paleontologists was devoted to relative dating of rocks and to the description of faunas to support that effort. After the era of American patriarchs in this field, paleontologists began to specialize and a few are properly classified as paleomalacologists. Gastropods and pelecypods do not change dramatically through time, in contrast to the geologic record of the cephalopods. For the first half century after Darwin, Hyatt, who specialized in the study of fossil cephalopods, was the only American paleomalacologist who wrote extensively on evolution. In the mid-part of the 20th Century slightly more interest was shown in evolution, drawing to some extent on the impressive data base of Mesozoic and Cenozoic mollusks which had been documented. Report on *Neopilina* transferred interest to the Paleozoic record of mollusks and especially the early Paleozoic. For the last quarter of the 20th Century, emphasis has shifted dramatically from biostratigraphy to paleobiology, so much so that many paleontologists are identified by the problems of concern rather than by the fossil group of interest. Some of the current leaders in various evolutionary studies began their career as paleomalacologist.

[Oral presentation: The place of malacology in comparative biology]

Molluscan contributions to comparative neuroethology and general biology

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Best known are the many studies of membrane biophysics in the propagation of nerve impulses in giant axons of squid and the studies of learning in ganglia of *Aplysia*, both having advanced to the molecular level. Many other contributions will be reviewed, from cephalopods, nudibranchs, pulmonates, pteropods, pelecypods and even chitons, ranging from microanatomy and ethology to higher integrative physiology, brain waves and pharmacology.

[Oral presentation: The place of malacology in comparative biology]

Chemical defense in opisthobranch molluscs: From comparative chemistry to comparative biology

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Opisthobranch molluscs play a relevant role in marine ecology. They apparently lack any protection against predators, their shell being either reduced or completely absent. However, in spite of this, they are rarely victims of predators. In fact, these molluscs have elaborated a series of very effective defensive strategies which include the use of chemical compounds. Probably, the chemical protection has favoured a widespread colonization of opisthobranchs in very distinct ecological niches where they exhibit highly selective dietary habits, eating algae, sponges, bryozoans, tunicates, soft corals, hydroids and also infaunal organisms.

Our interest in opisthobranchs started almost twenty years ago. Our chemical studies have favoured the construction of a general chemical scenario. Now it is possible, knowing the chemical structure of a compound present in the extract of an unknown opisthobranch, to suggest the order, and sometimes even the family or the genus of the mollusc. The credibility of this chemical scenario is supported by the substantial correspondence of the data recorded by all chemical groups interested in investigating opisthobranchs.

The contribution of the study of marine opisthobranchs to comparative chemistry can be extended to other marine organisms. Chemical compounds present in molluscs can be derived from their habitual diet. The chemistry of opisthobranchs is very often the chemistry of sponges, algae, soft corals, tunicates and so on. However, not all secondary metabolites from opisthobranchs have a dietary origin. In fact, some species are able to modify dietary metabolites whereas others are able to biosynthesize *de novo* their chemical arsenal. Surprisingly, chemical compounds constructed by mollusc very often exhibit structural features closely related to those possessed by common dietary secondary metabolites.

All these topics will be discussed in detail for the main orders of the Opisthobranchia: Cephalaspidea, Sacoglossa, Anaspidea and Nudibranchia, trying to construct an ideal bridge between comparative chemistry and comparative biology.

[Oral presentation: The place of malacology in comparative biology]

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