1991
Berkeley, CA

PROGRAM AND ABSTRACTS

JOINT ANNUAL MEETING
30 JUNE – 5 JULY 1991

Clark Kerr Campus
University of California, Berkeley

Hosted by the University of California Museum of Paleontology

JOINT ANNUAL MEETING ORGANIZERS

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Registrar ..... Henry W. Chaney
Assistant to the Registrar ..... Barbara Chaney
Field Trip committee ..... Elizabeth A. Nesbitt, David R. Lindberg, Douglas J. Long
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Photography ..... John A. Hedley
Audio Visual ..... Rex A. Hanger
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T-Shirts ..... Anne Joffee
Poster Session ..... Marta deMainetnon
Bourse ..... Anne Joffee
Joint Auction ..... Henry W. Chaney, Richard E. Petit
Council of Systematic Malacologists ..... William K. Emerson
Institute of Malacology ..... John B. Burch
Malacological Editors ..... Eugene V. Coan

Refreshments for the Auction and favors for the Closing Banquet are courtesy of the Northern California Malacozoological Club

AMERICAN MALACOLOGICAL UNION, INC.

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PAST PRESIDENTS

David K. Mulliner	1968	Vida C. Kenk	1980
William K. Emerson	1969	Carol C. Skoglund	1981
A. Myra Keen	1970	Donald R. Shasky	1982
Eugene V. Coan	1971	David R. Lindberg	1983
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James W. Nybakken	1976	Matthew J. James	1988
Helen DuShane	1977	Hans Bertsch	1989
Peter D'Eliscu	1978	Roland Anderson	1990
Barry Roth	1979		

STUDENT GRANT AWARD

The WSM student grant is given every other year in competition open to graduate students working on mollusks. The next award will be given in 1992 and announced at the annual business meeting of the society. The student grant fund is maintained through donations and the annual auction proceeds. Send requests for information to: Department of Invertebrate Zoology, Santa Barbara Museum of Natural History, 2559 Puesta del Sol, Santa Barbara, CA 93105, USA

PROGRAM SUMMARY

Clark Kerr Campus, University of California, Berkeley, 30 June – 5 July 1991

ate	Morning		Afternoon		Evening	
UN ıne 30	9:00 - 12:00	AMU Executive Council Meeting (D-1 Conference Room, Bldg. 1)	12:00 - 6:00 1:00 - 3:00 3:00 - 5:00 5:00 - 7:00 5:00 - 7:00	Registration (Lobby, Bldg. 1) Malacological Editors (D-1 Conference Room, Bldg. 1) Council of Systematic Malacologists (Room 104, Bldg.14) WSM Executive Board (D-1 Conference Room) Institute of Malacology (First Floor Lounge, Bldg. 4)	7:00 - 9:00	Presidents' Reception Garden Room & Patio (Wine and Buffet Supper)
⁄ION uly 1	8:30 - 12:00 8:30 - 8:50 8:50 - 9:20 9:20 - 12:00	Registration (Theatre lobby, Bldg. 14)) Welcome and Opening Remarks (Theatre) Introduction to Bivalve Symposium (Theatre) Bivalve Symposium (Theatre)	1:30 - 5:00 1:30 - 5:00 5:00 - 6:30	Taphonomy/paleoecology symposium (Theatre) Contributed papers Freshwater Systematics Theme Session (Room 104) Board Meeting - American Malacological Bulletin (First floor Lounge, Bldg. 4)	7:00 - 10:00	Poster Session Conservation Committee meeting (open) Slide Presentations NSF open discussion with Patricia Kelly (Theatre)
⁻UE uly 2	8:30 - 12:00 8:30 - 12:00	Bivalve Symposium (Theatre) Taphonomy/paleoecology Symposium (Room 104)	1:30 - 5:00 1:30 - 5:00	Bivalve Symposium (Theatre) Taphonomy/Paleoecology Symposium (Room 104)	5:30 - 6:30 6:30 - 8:00 7:30 - 8:00 8:00 - 10:30	Outdoor Social Hour (Great Hall Patio) California Campfire Cookout (Great Hall Patio & Great Hall) Auction Preview and Reprint Sale, and AMU/WSM Joint Auction (Main Lounge, Bldg. 4)
⁄VED uly 3	8:30 - 12:00 8:30 - 12:00	Bivalve Symposium (Theatre) Contributed Papers: Marine/Systematics Theme Session (Room 104)	1:30 - 5:00 1:30 - 5:00	Bivalve symposium (Theatre) Contributed papers: Functional Morphology, Feeding Biology, Behavior Theme Session (Room 104)	7:00 - 8:30 8:30 - 9:30	Dessert Reception, Museum of Paleontology (Foyer, Earth Sciences Bldg.) Slide Program Museum of Paleontology (Room 141, Earth Sciences Bldg.)
⁻HU uly 4	8:00 12:00 8:30 - 12:00	Biogeography symposium (Theatre) Contributed papers Molluscan Cornucopia (Room 104)	1:00 - 5:00 1:30 - 4:00 4:00 - 5:00 5:00 - 6:00	Biogeography symposium (Theatre) Contributed papers Terrestrial Theme Session (Room 104) AMU Business Meeting (Room 104) WSM Business Meeting (Room 104)	7:00 - 8:00 8:00 - 11:00	Social Hour Banquet, Great Hall, Mens Faculty Club, Berkeley Campus

FRI
July 5

Field Trips:

1. Molluscan environs of San Francisco Bay
2. Bodega Head and Bodega Marine Laboratory
3. Año Nuevo State Reserve
4. Napa Valley Wine Country
5. Open House, California Academy of Sciences

CLARK KERR CAMPUS MEAL TIMES

Breakfast (Monday – Friday): 7:30 – 8:30
Lunch (Monday - Thursday): 12:00 – 1:00
Dinner (Monday & Wednesday): 6:00 – 7:00

TO RECEIVE EMERGENCY MESSAGES

The Clark Kerr Campus office telephone number is (415) 642-6290. Messages will be posted on the bulletin board in the lobby of Building 1.

XEROXING

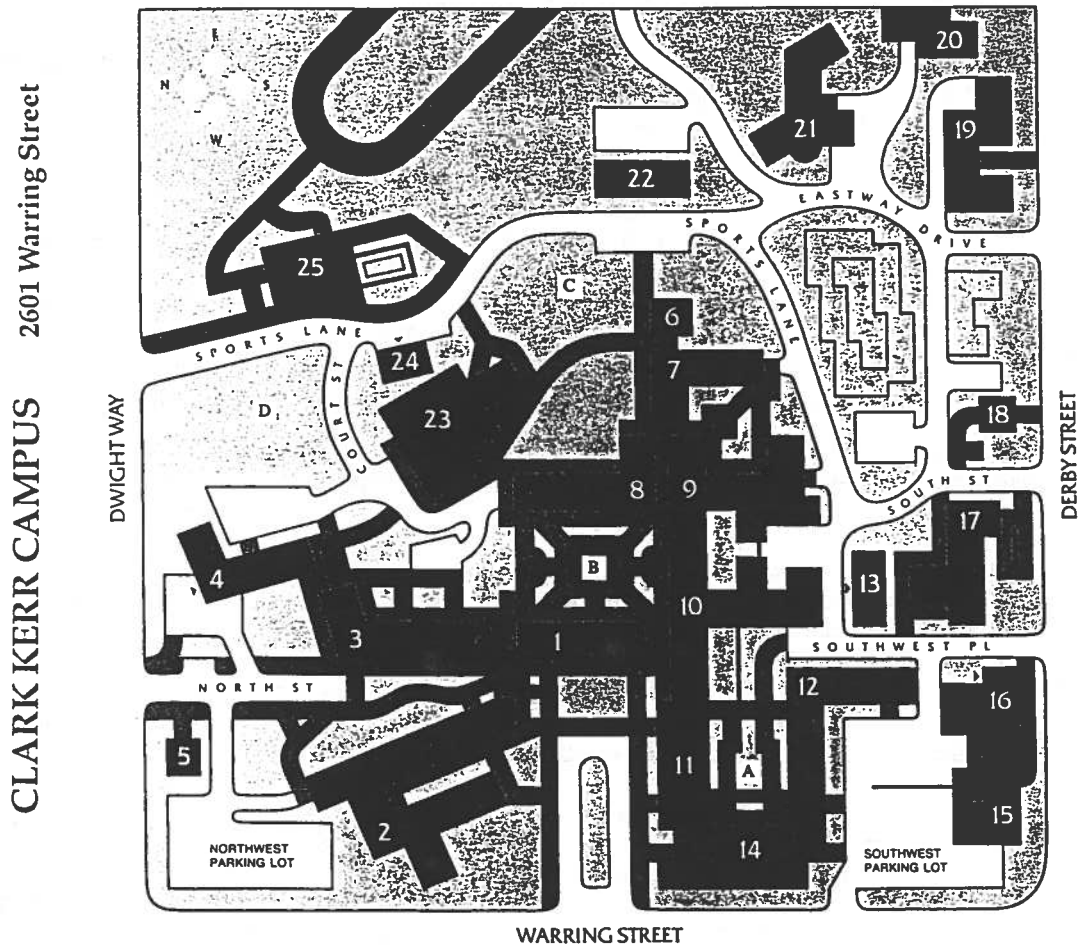
There is a copy machine in the Clark Kerr Campus office just inside the front door. The cost is $.10 per copy

MESSAGE BOARD FOR MEETING REGISTRANTS

You can leave messages for friends and colleagues in the lobby outside the Joseph Wood Krutch Theatre.

SMOKING POLICY

Smoking is prohibited in any common area (meeting rooms, hallways, lounges, restrooms, and dining rooms. Smoking is permitted in invidual rooms in suites and residence halls.



DIRECTORY

1. Clark Kerr Campus Office
   Room keys and meal cards, xeroxing, emergency phone message board
   D-1 Conference Room (downstairs)
2. Suites
4. Residence Hall
10. Dining Center
    Great Hall and Patio
    Garden Room and Patio
14. Clark Kerr Campus Center – meeting rooms
    Joseph Wood Krutch Theatre, Rooms 102, 104

A. Gingko Court
B. Grand Court

Parking. If you have purchased a parking sticker, the Northwest Parking Lot is most convenient to the Suites and Residence Hall. The Southwest lot is most convenient to the meeting rooms.

REGISTRATION

The AMU/WSM Registration table will be open from 12–6 pm on Sunday in the Lobby of the Administration Building.

CHECK-IN/CHECK-OUT

Check-in: For registrants who have purchased the Conference Housing and dining package, room keys, meal cards, and parking permits should be obtained from a conference clerk at the Conference Services Desk the Lobby of Building 1. Check-out : Check-out time on Friday, July 5, is 1:00 pm. Please return your keys to the front desk in the Administration Building. There will be a $35.00 charge for all unreturned keys.

PRESIDENTS' RECEPTION

California Wine and Buffet Supper

Don't miss this new and different and very California opening event!. All AMU/WSM registrants and their families are cordially invited to attend this year's reception in the Garden Room and Patio. Enjoy a selection of fine California wines and specially catered light supper fare while you meet new and old friends, catch up on malacological gossip, and ease yourself into the mood for a week of molluscan indulgence. And indulge yourself in deep-breaths of cool, crisp, clean San Francisco Bay air as shadows lengthen and the golden glow of sunset plays across the patio.

DEALERS' BOURSE

This year's bourse will be conveniently located in Room 102 of the Clark Kerr Campus Center, across the hall from the Joseph Wood Krutch Theatre and adjacent to the Gingko Court, where we will take our morning and afternoon Breaks. Bourse Chairperson Anne Joffee has arranged to have the sales area set up for the crowd arriving on Sunday afternoon. This is the place to hang out Sunday afternoon! For more information and bourse hours, see the flyer in your registration packet.

T-SHIRTS

Don't wait too long to purchase this year's T-shirt. It is a real collector's item. If you don't understand why at first glance, ask anyone who lives in Berkeley! These shirts are guaranteed to disappear fast.

BARBECUE

California campfire cookout

Continuing in the California Tradition, this year's barbecue will feature a campfire cookout on the outdoor grills of the Great Hall Patio. You can enjoy this event *al fresco* on the patio and get yourself real messy with barbecue sauce (eating with your fingers is in). Or you can be sedate about it: Tables will be set in the Great Hall, where you can join others who do not wish to rough it in the out-of-doors. This is nitty-gritty campfire fare: chicken and ribs, baked beans, corn-on-the-cob, potato salad, fresh garden salad, biscuits with butter, watermelon, and apple cobbler. A limited number of tickets is still available, but must be purchased on Sunday, 30 June.

JOINT AMU/WSM AUCTION

After the barbecue, mosey on over to the Main Lounge in Building 4 for the WSM Reprint Sale and a preview of all the hot items in the Auction (7:30-8 pm) This year's Auction has been designed as a Joint WSM/AMU event. To make things just a bit more interesting, we have restricted the number of items to be auctioned to approximately 100, inviting each society to contribute 50. The inimitable duo of Henry Chaney and Dick Petit will preside over this event ! Refreshments will be served, courtesy of the Northern California Malacozoological Club.

MUSEUM OF PALEONTOLOGY DESSERT RECEPTION

On Wednesday evening, come on over to the main campus for a reception in the Museum of Paleontology. The Museum houses one of the largest collections of Mesozoic and Cenozoic fossil mollusks in the world, and a type collection containing more than 1000 primary types of fossil and Recent mollusks. All meeting registrants are welcome at this event.

STUDENT PAPER COMPETITION

Both societies are presenting awards for the best paper delivered by a student at this joint meeting. Award recipients are selected by a team of judges who evaluate scientific content, adequacy of research approach, organization of the presentation, quality of visual aids, and the manner in which the presenter handles questions and answers. The twelve presentations entered in this year's competition are designated by two asterisks in the session

schedules that follow. Please make a special effort to attend student papers and offer these young malacologists your feedback and encouragement.

AMU/WSM BUSINESS MEETINGS

Both societies will hold their annual business meetings consecutively following the close of the contributed paper session on Thursday. Plan to attend and participate in the decision-making that keeps our malacological societies healthy and promotes meetings such as this.

FOURTH OF JULY CLOSING BANQUET

The social hour (cash bar) and closing banquet will be held in the Great Hall of the Mens Faculty Club on the Berkeley Campus. Built by Bernard Maybeck in 1902, the Faculty Club is one of the Bay Area's architectural treasures. Two good California wines will accompany the dinner of prime rib or poached salmon. And Terry Gosliner will provide the after-dinner malacological fireworks with one of his colorful talks. You must purchase tickets no later than noon on Monday.

FIELD TRIPS

All field trips will leave from the Northwest Parking Lot promptly at 8:30 am on Friday. All trips will be making a lunch stop and will return to the conference center by 6 pm.

DINING OUT IN BERKELEY

Berkeley is famous for its number and variety of fine ethnic restaurants and gourmet cuisine. You will find a restaurant guide in your registration packet.

BAY AREA SIGHTSEEING

Tired of listening to papers? Want to design your own field trip? Information on access to points of interest within walking distance of the conference center as well as access to attractions in the greater Bay Area is included in your registration packet.

NOTES

* – indicates author who will present paper
** – indicates candidate for best student paper award

Monday Morning, July 1

8:30 – 12:00 Registration – Lobby, Joseph Wood Krutch Theatre

8:30 Welcome and Opening Remarks – Joseph Wood Krutch Theatre
Carole S. Hickman, President of AMU
Paul H. Scott, President of WSM
Jere H. Lipps, Director, University of California Museum of Paleontology

SYMPOSIUM: MARINE BIVALVE RESEARCH IN THE NEXT CENTURY: A REVIEW OF THE CURRENT STATE OF OUR KNOWLEDGE AND DIRECTIONS FOR THE FUTURE. Joseph Wood Krutch Theatre.
Conveners: Paul H. Scott, Eugene V. Coan, Santa Barbara Museum of Natural History, Santa Barbara, California and Brian Morton, University of Hong Kong, Hong Kong.

8:50 BIVALVE SYMPOSIUM INTRODUCTION
Brian MORTON, Department of Zoology, University of Hong Kong, HONG KONG

Evolution and Systematics I

Chairperson: Itaru Hayami, University of Tokyo, Japan
Location: Joseph Wood Krutch Theatre

9:20 THE EARLIEST BIVALVES AND THEIR ORDOVICIAN DESCENDANTS.
Bruce RUNNEGAR*, University of California, Los Angeles, California, USA and John POJETA, U.S. Geological Survey, Reston, Virginia, USA

9:40 EVOLUTIONARY SIGNIFICANCE OF SHELL AND LIGAMENT MICROSTRUCTURE IN THE BIVALVIA.
Joseph G. CARTER, University of North Carolina, Chapel Hill, North Carolina, USA

10:10 BREAK

Evolution and Systematics II

Chairperson: Raymond Seed, University of Wales, UK
Location: Joseph Wood Krutch Theatre

10:35 BIVALVIAN MACROSYSTEM BASED BOTH ON CONCHOLOGY AND ON ANATOMY.
Yaroslav I. STAROBOGATOV, USSR Academy of Sciences, Leningrad, USSR

11:05 EVOLUTION OF DEEP-SEA PROTOBRANCH BIVALVES.
John A. ALLEN, University Marine Biological Station, Millport, SCOTLAND

11:30 CLADES VS. GRADES IN BIVALVE CLASSIFICATION - SOME EXAMPLES FROM THE TELLINACEA.
Phillip A. MAXWELL, Waimate, NEW ZEALAND

12:00 GROUP PHOTOGRAPH. (Grand Court)
12:15 LUNCH

Monday Afternoon, July 1

SYMPOSIUM: **MOLLUSCAN TAPHONOMY AND PALEOECOLOGY.** Joseph Wood Krutch Theatre.
Conveners: Carole S. Hickman, University of California , Berkeley, California and Michael P. Russell, California Academy of Sciences, San Francisco, California.

I. Analysis of Molluscan Fossil Assemblages and Ancient Molluscan Habitats.

Chairperson: Alan Kohn., University of Washington, Washington, USA
Location: Joseph Wood Krutch Theatre

1:30 COMPARATIVE ANALYSES OF MODERN DEATH ASSEMBLAGES AND PLEISTOCENE FOSSIL ASSEMBLAGES ON SAN NICOLAS ISLAND.
Michael P. RUSSELL, California Academy of Sciences, San Francisco, California, USA

2:00 PLEISTOCENE MARINE TERRACE ASSEMBLAGES: ARE THERE MODERN ANALOGS?
James W. VALENTINE, University of California, Berkeley, California, USA

2:30 FROM BLACK SHALES TO SEEPS: RECOGNIZING HABITATS OF CHEMOSYMBIOTIC BIVALVES FROM THE FOSSIL RECORD.
Kathleen A. CAMPBELL* and David J. BOTTJER, University of Southern California, Los Angeles, California, USA

3:00 BREAK

II. Paleoecology of drilling and boring mollusks

Chairperson: Michael Russell, California Academy of Sciences, USA
Location: Joseph Wood Krutch Theatre

3:30 RELATIONSHIPS BETWEEN DRILLING PREDATORS AND PREY IN A TERTIARY MOLLUSCAN ASSEMBLAGE FROM FIJI.
Alan J. KOHN* and Ingela ARUA, University of Washington, Seattle, Washington, USA

4:00 THE NATICID GASTROPOD PREDATOR-PREY SYSTEM: DYNAMICS AND EVOLUTION AS PRESERVED IN THE FOSSIL RECORD.
Patricia H. KELLEY*, National Science Foundation, Washington, DC, USA, and Thor A. HANSEN, Western Washington State University, Bellingham, Washington, USA

4:30 THE PALEOECOLOGY OF THE CHEMICALLY BORING BIVALVE GENUS *LITHOPHAGA* .
Debra KRUMM, University of Colorado at Boulder, Boulder, Colorado, USA

Monday Afternoon, July 1

CONTRIBUTED PAPERS: FRESHWATER THEME SESSION – Room 104

Chairperson: Robert Hershler, Smithsonian Institution, USA.

1:30 OPENING REMARKS. Robert Hershler

1:40 ELECTROPHORETIC AND ANATOMICAL DIFFERENCES IN *LAVIGERIA*: DIVERGENCE IN AN AFRICAN RIFT LAKE ENDEMIC GASTROPOD.
Ellinor A. MICHEL**. University of Arizona, Tuscon, Arizona USA

2:00 ALLOZYME AND MORPHOLOGICAL DIFFERENTIATION IN THE FRESHWATER SNAIL *VIVIPARUS GEORGIANUS*.
Masaya KATOH**, Louisiana State University, Baton Rouge, Louisiana, USA

2:20 AN UNUSUAL INSTANCE OF DISCORDANT GENETIC MARKERS IN THE FRESHWATER MUSSEL GENUS *PYGANODON* (UNIONIDAE: ANODONTINI)
Walter R. HOEH**, University of Michigan, Ann Arbor, Michigan, USA

2:40 PHYLOGENETIC ANALYSIS OF THE PULMONATE GASTROPODS AND ITS IMPLICATIONS FOR PULMONATE INVATION OF FRESH WATERS.
Richard V. LAMB**. University of Michigan, Ann Arbor, Michigan, USA

3:00 BREAK

Chairperson: Harold Murray, Trinity University, USA

3:20 GENERIC REVIEW OF THE AQUATIC SNAIL SUBFAMILY COCHLIOPINAE (GASTROPODA: HYDROBIIDAE).
Robert HERSHLER, Smithsonian Institution, Washington, D.C., USA

3:40 PHYLOGENETIC RELATIONSHIPS IN THE GENUS *BIOMPHALARIA* (GASTROPODA: PLANORBIDAE)
Susan M. BANDONI*, University of New Mexico, Albuquerque, New Mexico and Savannah River Ecology Laboratory, Aiken, South Carolina., USA, Margaret MULVEY, Savanna River Ecology Laboratory, Aiken, SC, USA, and Eric S. LOKER, University of New Mexico, Albuquerque, New Mexico, USA

4:00 INTRODUCED AMPULLARIID AND VIVIPARID AMPHIBIOUS SNAILS IN HAWAII.
Robert H. COWIE, Bishop Museum, Honolulu, Hawaii, USA

4:20 MYSTERY FLUKE IN *MELANOIDES TUBERCULATA* (GASTROPODA: THIARIDAE) IN SAN ANTONIO ZOO, SAN ANTONIO, TEXAS.
Karelyn Emily KNOTT and Harold D. MURRAY*, Trinity University, San Antonio, Texas, USA

4:40 LOOKING UP THE WRONG END: ANATOMICAL CHARACTERS OF FRESHWATER BIVALVES (MOLLUSCA, UNIONACEA).
Arthur E. BOGAN, Academy of Natural Sciences, Philadelphia, Pennsylvania, USA

Monday Evening, July 1

POSTER SESSION. Joseph Wood Krutch Theatre

7:00 – 8:30 Authors of Posters will be present to talk about their work and answer questions. Posters will remain on display in the rear of Theatre for the duration of the meeting)

CONTRIBUTED POSTERS

1. FRESHWATER MUSSELS AND FRESHWATER MITES: SYMBIOSIS AND SPECIATION.
   Ronald V. DIMOCK, Jr., Wake Forest University, Winston-Salem, North Carolina, USA

2. MODES OF REPRODUCTION AND GENETIC STRUCTURE IN AQUATIC GASTROPODS.
   David W. FOLTZ, Masaya KATOH and Li-Lian LIU, Lousiana State University, Baton Rouge, Louisiana, USA

3. THE PRELIMINARY REPORT ON THE *PHYSA* SPECIES BY USING ISOZYME TECHNIQUE.
   Hsiu-Ping LIU, University of Colorado, Boulder, Colorado, USA

4. A PRELIMINARY ANALYSIS OF A HYBRID ZONE BETWEEN *MYTILUS TROSSULUS* AND *MYTILUS GALLOPROVINCIALIS*.
   Shane K. SARVER, Louisiana State University, Baton Rouge, Louisiana, USA

5. A NEW SPECIES OF *LOTTIA* GRAY, 1833 FROM THE NORTHEASTERN PACIFIC.
   Robyn A. STUBER, University of California, Berkeley, California, USA

6. COMPARATIVE MORPHOLOGY OF THE CRANIAL CARTILAGE IN SELECTED SPECIES OF MYOPSID SQUID (CEPHALOPODA: THETHOIDEA).
   Marta J. DEMAINTENON, University of California, Berkeley, California, USA

TAPHONOMY AND PALEOECOLOGY SYMPOSIUM POSTERS

7. DYNAMICS OF NATICID GASTROPOD PREDATION IN A LATE PLEISTOCENE FOSSIL ASSEMBLAGE FROM THE PALOS VERDES SAND FORMATION.
   Tara M. KELLY, University of California, Berkeley, California, USA

8. EXPERIMENTAL TAPHONOMY: ANALYSIS OF THE EFFECTS OF CHEMICAL DISSOLUTION AND MECHANICAL ABRASION BY SIZE CLASS IN *DONAX GOULDII*.
   Christopher J. CROSSLAND and Carole S. HICKMAN*, University of California, Berkeley, California, USA

Monday Evening, July 1

SLIDE PRESENTATIONS, OPEN MEETINGS,AND INFORMAL DISCUSSIONS.
Joseph Wood Krutch Theatre

8:30 FOSSIL LAND SNAILS IN DOMINICAN AMBER
Barry ROTH, University of California, Berkeley, California, USA

8:50 THE DOMINICAN REPUBLIC PROJECT: A PROGRESS REPORT
Peter R. HOOVER, Paleontological Research Institution, Ithaca, New York, USA

9:15 **DEMONSTRATION OF DOMINICAN REPUBLIC DATA BASE** (available for perusal and searches by meeting registrants)
Peter R. HOOVER, Paleontological Research Institution, Ithaca, New York, USA

CONSERVATION COMMITTEE MEETING (open)
Raymond W. NECK, Texas Parks and Wildlife Department, Austin, Texas, USA

NATIONAL SCIENCE FOUNDATION FUNDING FOR MOLLUSCAN RESEARCH.
An open discussion/question-and-answer session.
Patricia H. KELLEY, National Science Foundation, Washington, DC, USA

TREATISE ON INVERTEBRATE PALEONTOLOGY: CAENOGASTROPOD VOLUME
Informal discussion and update on funding and completion plans.
Warren D. ALLMON, University of South Florida, Tampa, Florida, USA

Tuesday Morning, July 2

SYMPOSIUM: MARINE BIVALVES (Cont.) – Joseph Wood Krutch Theatre

Evolution & Systematics III

Chairperson: Yaroslav I. Starobogatov, Academy of Sciences, USSR
Location: Joseph Wood Krutch Theatre

8:30 SYSTEMATICS, EVOLUTION AND GEOGRAPHICAL DISTRIBUTION OF THE GENUS *MYTILUS*.
Raymond SEED, University of Wales, Bangor, Menai Bridge, Gwynedd, UK

9:15 MITOCHONDRIAL DNA DIVERSITY IN BRITISH COLUMBIA POPULATIONS OF THE PACIFIC OYSTER.
John D.G. BOOM* and A.T. BECKENBACH, Simon Fraser University, Burnaby, British Columbia, CANADA

9:40 A NEW APPROACH TO THE STUDY OF BIVALVE EVOLUTION.
Mary Ellen HARTE, Rocky Mountain Biological Laboratory, Crested Butte, Colorado, USA

10:10 BREAK

Evolution & Systematics IV

Chairperson: Eugene V. Coan, California Academy of Sciences, USA
Location: Joseph Wood Krutch Theatre

10:35 WHAT DO WE KNOW ABOUT CRETACEOUS PACIFIC SLOPE VENERID BIVALVES?
L. R. SAUL, Natural History Museum of Los Angeles County, Los Angeles, California, USA

10:55 CLADISTIC PHYLOGENY OF THE CARDIID BIVALVES.
Jay A. SCHNEIDER**, University of Chicago, Chicago, Illinois, USA

11:25 THE AUSTRALASIAN PROTOCARDIINAE REVISITED.
Jean-Maurice POUTIERS, Laboratoire de Biologie des Invertebres marins et Malacologie, Museum National d'Histoire Naturelle, Paris, FRANCE

11:40 SYSTEMATICS AND GEOLOGICAL HISTORY OF THE SUBFAMILY CLINOCARDIINAE (BIVALVIA: CARDIIDAE)
Alexander I. KAFANOV, Laboratory of Ecosystem Dynamics, Petropavlovsk-Kamchatsky, USSR

12:05 LUNCH

Tuesday Morning, July 2

SYMPOSIUM: MOLLUSCAN TAPHONOMY AND PALEOECOLOGY (cont.) – Room 104.

III. Paleoecology and Taphonomy of faunas: Large-Scale Patterns

Chairperson: Dana Geary, University of Wisconsin, USA
Location: Room 104.

8:30 A ROLE FOR TAPHONOMY IN AN EVOLUTIONARY PALEOECOLOGY OF MOLLUSKS: AN EXAMPLE FROM THE FLORIDA PLIO-PLEISTOCENE".
Warren D. ALLMON, University of South Florida, Tampa, Florida, USA

9:00 PALEOECOLOGY OF THE EARLY ALBIAN RUDIST REEFS FROM THE ALISITOS FORMATION, BAJA CALIFORNIA, MEXICO.
Reese E. BARRICK, University of Southern California, Los Angeles, California , USA

9:30 FINE SCALE DIVERSITY PATTERNS IN FRESH-WATER MOLLUSCAN FAUNAS: A TOOL FOR ASSESSING MASS EXTINCTIONS.
Paul J. MORRIS, Harvard University, Cambridge, Massachusetts, USA

10:00 BREAK

IV. Paleoecology and Taphonomy of Taxa

Chairperson: Alison Kay, University of Hawaii, USA
Location: Room 104

10:30 ONTOGENY AND ECOLOGY OF MARGINELLID GASTROPODS FROM THE NEOGENE OF THE DOMINICAN REPUBLIC
Ross H. NEHM* and Dana H. GEARY, University of Wisconsin, Madison, Wisconsin, USA

11:00 SHAPE, DRAG AND POWER IN AMMONOID SWIMMING
David K. JACOBS, University of California, Berkeley, CA, USA

11:30 NASSARIID GASTROPODS AS DESTRUCTIVE AGENTS IN MARINE FISH TAPHONOMY
Douglas J. LONG, University of California, Berkeley, California, USA

12:00 LUNCH

Tuesday Afternoon, July 2

SYMPOSIUM: MARINE BIVALVES (Cont.) – Joseph Wood Krutch Theatre

Evolution & Systematics V

Chairperson: LouElla Saul, Natural History Museum of Los Angeles County, USA
Location: Joseph Wood Krutch Theatre

1:30 *MEIOCARDIA* OF THE INDO-WESTERN PACIFIC AND THE WESTERN ATLANTIC.
Akihiko MATSUKUMA, Kyushu University, Fukuoka, JAPAN

1:50 PRELIMINARY REVIEW OF HOLOCENE AND PLEISTOCENE NORTHEASTERN PACIFIC *GLYCYMERIS*.
Charles L. POWELL, II, U.S. Geologic Survey, Menlo Park, California, USA

2:10 A TAXONOMIC REVIEW OF THE NORTHEASTERN PACIFIC BIVALVIA: THE UNANSWERED QUESTIONS.
Eugene V. COAN* and Paul H. SCOTT, Santa Barbara Museum of Natural History, Santa Barbara, California, USA

2:25 KEEPING UP TO DATE ON PANAMIC PROVINCE BIVALVE LITERATURE.
Carol SKOGLUND, Santa Barbara Museum of Natural History, Santa Barbara, California, USA

2:35 FUNCTIONAL MORPHOLOGY OF THE STOMACH IN THE BIVALVE *LYONSIA HYALINA* CONRAD, 1831.
Kenneth A. THOMAS**, University of Rhode Island, Kingston, Rhode Island, USA

2:55 BREAK

Evolution & Systematics VI

Chairperson: John A. Allen, University Marine Biological Station, Millport, SCOTLAND
Location: Joseph Wood Krutch Theatre

3:30 THE "YOYO CLAMS" OF FLORIDA, AND A DISCUSSION OF SYSTEMATIC CHARACTERS IN THE GALEOMMATIDAE.
Paula M. MIKKELSEN*, Harbor Branch Oceanographic Museum, Ft. Pierce, Florida, USA and Rüdiger BIELER, Field Museum of Natural History, Chicago, Illinois, USA

4:00 EVOLUTION OF THE BIVALVE GENUS *LASAEA*.
Diarmaid O'FOIGHIL, Simon Fraser University, Burnaby, British Columbia, CANADA

4:20 SEASONAL VARIATIONS IN BROOD SIZE AND LARVAL SIZE OF *LASAEA* CF. *UNDULATA* (BIVALVIA) IN HONG KONG.
Brian MORTON, University of Hong Kong, HONG KONG

4:40 REPRODUCTIVE ECOLOGY OF THE ANTARCTIC PHILOBYRID BIVALVES.
Robert S. PREZANT, Indiana University of Pennsylvania, Indiana, Pennsylvania, USA

Tuesday Afternoon, July 2

SYMPOSIUM: MOLLUSCAN TAPHONOMY AND PALEOECOLOGY (Conclusion)
Room 104.

V. Readings from the Taphonomic Palempsest

Chairperson: David Bottjer, University of Southern California, USA
Location: Room 104

1:30 THE INFLUENCE OF ECOLOGY AND BEHAVIOR ON THE TAPHONOMY OF STROMBID GASTROPODS.
Dana H. GEARY* and Bryan E. BEMIS, University of Wisconsin, Madison, Wisconsin, USA

2:00 INTERPRETING THE SEPARATE TAPHONOMIC FATES OF TURBINID SHELLS AND OPERCULA IN FOSSIL MOLLUSK ASSEMBLAGES
Carole S. HICKMAN, University of California, Berkeley, California, USA

2:30 MARINE MOLLUSKS OF THE URVINA BAY UPLIFT, GALAPAGOS ISLANDS.
E. Alison KAY, University of Hawaii, Honolulu, Hawaii, USA

3:00 BREAK

Tuesday Evening, July 2

BARBECUE AND AUCTION

5:30 Social Hour — Great Hall Patio

6:30 California Campfire Cookout — Great Hall Patio

7:30 Auction preview and WSM reprint sale — Main Lounge, Building 4

8:00 AMU/WSM Joint Auction — Main Lounge, Building 4

Wednesday Morning, July 3

SYMPOSIUM: MARINE BIVALVES (Cont.) – Joseph Wood Krutch Theatre

Biology

Chairperson: Diarmaid O'Foighil, Simon Fraser University, CANADA
Location: Joseph Wood Krutch Theatre

8:30 SETTLEMENT AND METAMORPHOSIS OF MARINE BIVALVES.
Thomas H.J. GILMOUR, University of Saskatchewan, Saskatoon, Saskatchewan, CANADA

9:00 PRISMATIC SHELL FORMATION IN TEMPORARILY OPEN EXTRAPALLIAL SPACES: EXPLICABLE?
Melbourne R. CARRIKER, University of Delaware, Lewes, Delaware, USA

9:20 BLUE MUSSEL (*MYTILUS EDULIS*) MORTALITY IN BRITISH COLUMBIA: COMPARISON OF PACIFIC AND TRANSPLANTED ATLANTIC MUSSELS.
Glen S. JAMIESON, Pacific Biological Station, Nanaimo, British Columbia, CANADA

9:40 PARALYTIC SHELLFISH POISONING TOXINS AS A CHEMICAL DEFENSE IN THE BUTTER CLAM (*SAXIDOMUS GIGANTEUS*).
Rikk G. KVITEK, Moss Landing Marine Laboratories, Moss Landing, California, USA

10:10 BREAK

Ecology

Chairperson: Thomas H. J. Gilmour, University of Saskatchewan, CANADA
Location: Joseph Wood Krutch Theatre

10:35 THE ROLE OF BIVALVE BEDS AND REEFS IN COASTAL ECOSYSTEMS.
Richard F. DAME, University of South Carolina, Coastal Carolina College, Conway, South Carolina, USA

11:05 A RE-EVALUATION OF THE ROLE OF *MYTILUS CALIFORNIANUS* IN A ROCKY INTERTIDAL COMMUNITY.
David P. LOHSE**, University of California, Santa Barbara, California, USA

11:30 NATICID GASTROPOD PREDATION ON CORBULID BIVALVES: PHYSICAL AND BIOLOGICAL CONTROLS.
Laurie C. ANDERSON**, University of Wisconsin-Madison, Madison, Wisconsin, USA

12:00 LUNCH

Wednesday Morning, July 3

CONTRIBUTED PAPERS: TAXONOMY, CLASSIFICATION AND PHYLOGENY OF MARINE MOLLUSKS THEME SESSION - Room 104.

Chairperson: Gary Rosenberg, Academy of Natural Sciences of Philadelphia, USA
Location: Room 104

8:30 OPENING REMARKS. Gary Rosenberg

8:40 MOLLUSCA-ANNELIDA-ARTHROPODA: A PHYLOGENETIC ANALYSIS OF SPIRALIANS FROM MORPHOLOGICAL AND 18S rRNA SEQUENCE DATA.
Douglas J. EERNISSE* and James S. ALBERT, & Frank E. ANDERSON, University of Michigan, Ann Arbor, Michigan, USA

9:00 THE APLACOPHORA AS PROGENETIC ACULIFERA.
Amelie H. SCHELTEMA, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

9:20 PHYLOGENETIC SYSTEMATICS OF THE RECENT SUBFAMILIES OF VOLUTIDAE (GASTROPODA: PROSOBRANCHIA).
M.G. HARASEWYCH, Smithsonian Institution, Washington, DC, USA

9:40 PHYLOGENETIC RELATIONSHIPS IN THE SUBFAMILY ODONTOCYMBIOLINAE (GASTROPODA: VOLUTIDAE): PRELIMINARY RESULTS.
José H. LEAL, University of Miami, Miami, Florida, USA

10:00 BREAK

Chairperson: Jerry Harasewych, Smithsonian Institution, USA
Location: Room 104

10:20 PRELIMINARY IDEAS TOWARD A REVISION OF THE OVULIDAE (GASTROPODA: CYPRAEACEA)..
Gary ROSENBERG, Academy of Natural Sciences, Philadelphia, Pennsylvania, USA

10:40 THE UTILIZATION OF GROWTH TRENDS IN SHELL DEVELOPMENT TO STUDY STROMBID PHYLOGENY AND SYSTEMATICS.
David HARGREAVE, Western Michigan University, Kalamazoo, Michigan, USA

11:00 PATTERNS AND PROBLEMS IN THE CLASSIFICATION AND PHYLOGENY OF THE NATICIDAE (GASTROPODA).
Alan R. KABAT, Smithsonian Institution, Washington, DC, USA

11:20 ANATOMY AND PRELIMINARY GENERIC REVIEW OF THE *BITTIUM* GROUP.
Richard S. HOUBRICK, Smithsonian Institution, Washington, DC, USA

11:40 POTENTIAL PYRAMIDELLID PARADIGMS.
John B. WISE**, Smithsonian Institution, Washington, DC, USA

12:00 LUNCH

Wednesday Afternoon, July 3

SYMPOSIUM: MARINE BIVALVES (Conclusion) - Joseph Wood Krutch Theatre

Biogeography / Ecology I

Chairperson: Rudo von Cosel, Museum National d'Histoire Naturelle, France
Location: Joseph Wood Krutch Theatre

1:30 CRYPTIC PROPEAMUSSIIDS AND OTHER BIVALVES FROM A SUBMARINE CAVE OFF OKINAWA, SOUTH JAPAN.
Itaru HAYAMI*, University of Tokyo, Bunkyo-ku, Tokyo, JAPAN and Tomoki KASE, National Science Museum, Shinjuku-ku, Tokyo, JAPAN

2:00 PATTERNS OF DISTRIBUTION OF OSTREOID BIVALVES ALONG THE WESTERN COASTS OF AUSTRALIA.
Shirley M. SLACK-SMITH, Western Australian Museum, Perth, Western Australia, AUSTRALIA

2:30 TEMPORAL CHANGES IN THE ABUNDANCE OF THE CLAM *MACOMA BALTHICA* ON AN INTERTIDAL MUD FLAT IN PORT VALDEZ, ALASKA.
A.S. NAIDU, H.M. FEDER, University of Alaska, Fairbanks, Alaska, USA and Nora R. FOSTER*, University of Alaska Museum, Fairbanks, Alaska, USA

2:50 BREAK

Biogeography / Ecology II

Chairperson: Shirley Slack-Smith, Western Australian Museum, Australia
Location: Joseph Wood Krutch Theatre

3:15 SIZE FREQUENCY DISTRIBUTION IN A DEAD BIVALVE ASSEMBLAGE AND THE LIVING SOURCE POPULATION IN HAWAII (BIVALVIA).
Beatrice L. BURCH* and Thomas A. BURCH, Bernice P. Bishop Museum, Honolulu, Hawaii, USA

3:45 BIOGEOGRAPHICAL PATTERNS OF WEST AFRICAN MARINE BIVALVES.
Rudo von COSEL, Laboratoire de Biologie des Invertebres marins et Malacologie, Museum National d'Histoire Naturelle, Paris, FRANCE

4:05 BIVALVE SYMPOSIUM SUMMARY - "DIRECTIONS FOR THE FUTURE" (Panel of session chairpersons)

Chairperson: Melbourne R. Carriker, University of Delaware, USA

Wednesday Afternoon, July 3

CONTRIBUTED PAPERS: MOLLUSCAN FUNCTIONAL MORPHOLOGY, FEEDING BIOLOGY, AND BEHAVIOR THEME SESSION - Room 104.

Chairperson: Dianna Padilla, University of Wisconsin, USA

1:30 OPENING REMARKS. Dianna Padilla

1:40 PROSOBRANCH FUNCTIONAL MORPHOLOGY: WHAT'S AFOOT IN A SEA OF SLIME?
Janice VOLTZOW, University of Puerto Rico, Rio Piedras, Puerto Rico, USA

2:00 RADULAR VARIABILITY IN THE HERBIVOROUS MESOGASTROPOD *LACUNA*: INTRA- AND INTERSPECIFIC PATTERNS.
Dianna K. PADILLA, University of Wisconsin, Madison, Wisconsin, USA

2:20 A COMPARISON OF OPISTHOBRANCH, PROSOBRANCH, AND CRUSTACEAN FEEDING ON GREEN ALGAE.
Cynthia D. TROWBRIDGE, Oregon Institute of Marine Biology, Charleston, Oregon, USA

2:40 RADULAR STRUCTURE OF *SMARAGDIA* (GASTROPODA: NERITIDAE), A CYTOPLASM-FEEDING SEAGRASS ASSOCIATE.
Catherine UNABIA**, University of Hawaii, Honolulu, Hawaii, USA

3:00 BREAK

3:20 COMPARATIVE.FEEDING BIOLOGY OF *ACTEOCINA CANALICULATA* (SAY, 1826) (OPISTHOBRANCHIA: CEPHALASPIDEA).
Charles M.CHESTER**, University of Rhode Island, Kingston, Rhode Island, USA

3:40 STALKS, SLOPES, AND TRAILS: THE EFFECT OF CONFLICTING DIRECTIONAL CUES ON THE ORIENTATION OF THE MARSH PERIWINKLE *LITTORINA IRRORATA*.
Richard A. Tankersley**, Wake Forest University, Winston-Salem, North Carolina, USA

4:00 AGGRESSIVE AND REPRODUCTIVE BEHAVIOR OF CAPTIVE *OCTOPUS BURRYI* (MOLLUSCA: CEPHALOPODA).
William K. MACY, University of Rhode Island, Narragansett, Rhode Island, USA

Wednesday Evening, July 3

MUSEUM OF PALEONTOLOGY RECEPTION AND SLIDE LECTURE

7:00 Dessert Reception, Foyer, Museum of Paleontology, Berkeley Campus.

8:30 FIRST RECONNAISSANCE EXPEDITION TO ROCAS ALIJOS, BAJA CALIFORNIA, MEXICO.
Robert W. Schmieder, Cordell Expeditions, Walnut Creek, CA , USA

Thursday Morning, July 4

SYMPOSIUM: HISTORY OF THE NORTH PACIFIC MOLLUSCAN FAUNA.
Conveners: David R. Lindberg, University of California, Berkeley, California, USA, and Geerat J.Vermeij, University of California, Davis, California, USA.
Joseph Wood Krutch Theatre.

Chairperson: David Lindberg, University of California, Berkeley, USA
Location: Joseph Wood Krutch Theatre

8:00 INTRODUCTORY REMARKS
Geerat J. VERMEIJ, University of California, Davis, California, USA

8:15 TECTONIC SETTING OF THE NORTH PACIFIC MOLLUSCAN FAUNA.
Richard E. THOMS, Portland State University, Portland, Oregon, USA

8:45 LATE CENOZOIC PALEOOCEANOGRAPHY OF THE NORTH PACIFIC.
Jere H. LIPPS, University of California, Berkeley, California, USA

9:15 ORIGIN AND INTERCHANGE OF COLD-ADAPTED NORTH PACIFIC MOLLUSCAN FAUNAS.
Geerat J. VERMEIJ, University of California, Davis, California, USA

9:45 LATE CENOZOIC EVOLUTION AND DEVELOPMENT OF THE NORTH PACIFIC MOLLUSCAN FAUNA.
Louie MARINCOVICH, Jr., U.S. Geological Survey, Menlo Park, California, USA

10:15 BREAK

Chairperson: Gary Vermeij, University of California, Davis, USA
Location: Joseph Wood Krutch Theatre

10:30 FAUNAL HISTORY, BIOGEOGRAPHIC PATTERNS AND DIVERSITY IN THE MARINE FAUNA OF THE CENTRAL PACIFIC.
E. Alison KAY, University of Hawaii, Honolulu, Hawaii, USA

11:00 PLEISTOCENE EVOLUTION OF THE NORTH PACIFIC MOLLUSCAN FAUNA.
David R. LINDBERG, University of California, Berkeley, California, USA

11:30 MARINE MOLLUSKS OF ROCAS ALIJOS.
James H. MCLEAN* and Eugene V. COAN, Los Angeles County Natural History Museum Los Angeles, California, USA

12:00 LUNCH

Thursday Morning, July 4

CONTRIBUTED PAPERS: MOLLUSCAN CORNUCOPIA - Room 104.

Chairperson: Roland Anderson, The Seattle Aquarium, USA.
Location: Room 104

8:30 INCIDENCE OF THE NORTH PACIFIC GIANT SQUID, *MOREOTEUTHIS ROBUSTA* (VERRILL, 1876) IN PUGET SOUND.
Roland C. ANDERSON, The Seattle Aquarium, Seattle, Washington, USA

8:40 AQUARIUM MAINTENANCE OF THE SEPIOLID SQUID *ROSSIA PACIFICA* BERRY, 1911.
Roland C. ANDERSON, The Seattle Aquarium, Seattle, Washington, USA

9:00 STUDIES ON THE SHALLOW WATER POLYPLACOPHORA OF NUEVA ESPARTA, VENEZUELA.
Robert C. BULLOCK*, University of Rhode Island, Kingston, RI, USA, and Craig J. FRANZ, LaSalle University, Philadelphia, Pennsylvania, USA

9:20 COMPARATIVE ANATOMY OF *MYCETOPODA* AND *ANODONTITES* (MYCETOPODIDAE) FROM CENTRAL AMERICA WITH *MUTELA* (MUTELLIDAE) FROM EAST AFRICA.
Clifton C. CONEY, Los Angeles County Museum of Natural History, Los Angeles, California, USA, and A. LOPEZ, University of Central America, Managua, NICARAGUA

9:40 PATTERN FORMATION IN CYPRAEID GASTROPODS: SUPPORT FOR DIFFUSION-REACTION MODELS.
C. Porter MEYER, University of California, Berkeley, California, USA

10:00 BREAK

10:20 THE INTERTIDAL: PHYSICAL AND BIOLOGICAL INFLUENCES ON SPECIES COMPOSITION, ABUNDANCE AND RECRUITMENT PATTERNS IN THE NORTHEAST PACIFIC OCEAN.
Glen S. JAMIESON and Donald J. NOAKES, Pacific Biological Station, Nanaimo, British Columbia, CANADA

10:40 SAN NICOLAS ISLAND MACROINVERTEBRATES: PAST AND PRESENT.
Kelly A. ROSSBACH, NAS, Pt. Mugu, California, USA

11:00 RECONSTRUCTING THE HISTORICAL BIOGEOGRAPHY OF *FISSURELLA* (*FISSURELLA*) BRUGUIERE, 1789: A PHYLOGENETIC APPROACH.
Robyn A. STUBER, University of California, Berkeley, CA, USA

11:20 ASPECTS OF THE LIFE-HISTORY OF A MINUTE, OVOVIPAROUS BIVALVE, *GONIOCUNA DALLI* (BIVALVIA: CONDLYOCARDIIDAE) FROM THE NORTHERN GULF OF MEXICO.
Carol M. CLEVELAND, University of Southern Mississippi, Hattiesburg, Mississippi, USA

12:00 LUNCH

Thursday Afternoon, July 4

SYMPOSIUM: HISTORY OF THE NORTH PACIFIC MOLLUSCAN FAUNA
(conclusion) — Joseph Wood Krutch Theatre

Chairperson: Janet Voight, Field Museum, USA.
Location: Joseph Wood Krutch Theatre

1:00 NORTH PACIFIC APLACOPHORA.
Amelie H. SCHELTEMA, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

1:30 BIOGEOGRAPHY AND TAXONOMIC COMPOSITION OF NORTHEASTERN PACIFIC POLYPLACOPHORA.
Douglas J. EERNISSE, University of Michigan, Ann Arbor, Michigan, USA

2:00 VICARIANCE RELATIONSHIPS OF THE NORTH PACIFIC OPOSTHOBRANCH GASTROPODS.
Terrence M. GOSLINER, California Academy of Sciences, San Francisco, California, USA

2:30 PACIFIC OPISTHOBRANCH ZOOGEOGRAPHY: BIODIVERSITY AND ENDEMISM
Hans BERTSCH, California Academy of Sciences, San Francisco, California, USA

3:00 BREAK

Chairperson: Amelie Scheltema, Woods Hole Oceanographic Institution, USA
Location: Joseph Wood Krutch Theatre

3:15 DEVELOPMENT OF THE LAND MOLLUSK FAUNA OF THE NORTHEAST PACIFIC RIM.
Barry ROTH, University of California, Berkeley, California, USA

3:45 NORTH PACIFIC CEPHALOPODS, ESPECIALLY THE GONATIDAE.
Janet R. VOIGHT, Field Museum of Natural History, Chicago,IL, USA

4:15 BIVALVE EVOLUTION IN THE NORTH PACIFIC.
Alexander KAFANOV, Laboratory of Ecosystem Dynamics, Petropavlovsk-Kamchatsky, USSR

4:45 CLOSING REMARKS.
David R. Lindberg, University of California, Berkeley, California, USA

Thursday Afternoon, July 4

CONTRIBUTED PAPERS: TERRESTRIAL THEME SESSION — Room 104.

Chairperson: Emmett Evanoff, University of Colorado Museum, USA
Location: Room 104

1:30 OPENING REMARKS. Emmett Evanoff.

1:40 PALEOCLIMATIC IMPLICATIONS OF LATEST EOCENE AND EARLY OLIGOCENE LAND SNAILS (PULMONATA: STYLOMMATOPHORA) FROM EASTERN WYOMING.
Emmett EVANOFF, University of Colorado Museum, Boulder, Colorado, USA

2:00 BIOGEOGRAPHY AND SYSTEMATICS OF *POLYGYRA*, LAND SNAILS FROM WESTERN MEXICO AND SOUTHERN USA.
Timothy A. PEARCE, University of Michigan, Ann Arbor, Michigan, USA, and Edna NARANJO-GARCIA, Universidad Nacional Autonoma de México, MEXICO

2:20: LEAF LITTER MALACOFAUNA OF A TROPICAL RAIN FOREST. PRELIMINARY RESULTS.
Edna NARANJO-GARCIA, Universidad Nacional Autonoma de México, MEXICO

4:00 - 5:00 Annual Business Meeting, American Malacological Union (Room 104)

5:00 - 6:00 Annual Business Meeting, Western Society of Malacologists (Room 104)

Thursday Evening, July 4

CLOSING BANQUET

6:00 - 7:00 Social Hour (Cash Bar) — Great Hall, Men's Faculty Club, Berkeley Campus.

7:00 - 10:00 Banquet, Great Hall, Men's Faculty Club.

Banquet Address: FROM SNAILS TO SLUGS: PARALLEL SLIME TRAILS ON THE EVOLUTIONARY TREE
Terrence M GOSLINER, California Academy of Sciences, San Francisco, CA, USA

THE EVOLUTION OF DEEP-SEA PROTOBRANCH BIVALVES

ALLEN, John A., University Marine Biological Station, Millport, Scotland, KA28 0EG.

The evolution of the deep-sea Protobranchia is considered in relation to their feeding strategies. One of the cornerstones of their success in colonizing abyssal soft sediments lies in their ability to digest extracellularly organic materials in low concentration. The time needed to digest such material contained in a column of sediment is maximized by the possession of a much elongated hindgut, the progression of material within it being controlled by the muscular compression of the bulbous stomach. Elongation of the hindgut has been accompanied by a variety of configurations of its course. These maximize the length of tube that can be accommodated within the space of the visceral mass. It would appear that this has been the major evolutionary concern within the deep-sea protobranchs.

A ROLE FOR TAPHONOMY IN AN EVOLUTIONARY PALEOECOLOGY OF MOLLUSKS: AN EXAMPLE FROM THE FLORIDA PLIO-PLEISTOCENE

ALLMON, Warren D., Department of Geology, University of South Florida, Tampa, FL 33620

Taphonomic analysis can serve at least two roles in providing a basis for an understanding of the ecological context of evolutionary change: 1) at a small scale, it provides information on the nature of the preserved fossil record, allowing for estimates of time and habitat averaging and information loss; 2) by determining how densely fossiliferous deposits form, specifically the relative roles of biological productivity and biostratinomic processes, it can assist in the recognition of high-productivity environments. Productivity may be of considerable evolutionary importance in controlling patterns of origination and extinction.

Plio-Pleistocene deposits of southern Florida include densely shelly sands that may contain as many as 1200 species of mollusks. This time interval spans a period of major evolutionary and biogeographic change in the Caribbean basin and Gulf of Mexico and Florida's mollusks appear to reflect these changes. Highest diversity correlates with periods of apparently high productivity, possibly associated with upwelling. The late Pliocene western Atlantic regional mass extinction, documented by Stanley, may be related not only to temperature change but also to collapse of productivity in the area, possibly associated with closure of the Panamanian isthmus.

NATICID GASTROPOD PREDATION ON CORBULID BIVALVES: PHYSICAL AND BIOLOGICAL CONTROLS.

ANDERSON, Laurie C., Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, WI 53706

Naticid gastropod predation on corbulid bivalves is said to be anomalous in a number of ways. The preferred hypothesis for anomalous predation is the presence of distinct conchiolin (organic) layers within corbulid valves. This explanation, however, is incompatible with the mechanics of shell penetration in drilling gastropods. In addition, the presence of conchiolin layers appears to be characteristic of corbulids, although anomalous predation is not. Because anomalous predation is not universal in or limited to corbulid prey, less inclusive hypotheses are needed. This study documents the occurrence of anomalous predation in several corbulid species as a means to formulate alternative hypotheses. I tested for prey-size selectivity, borehole-site selectivity, and differences in proportions of bored, incompletely-bored, and multiply-bored valves. Predation is site- and size-selective in most species, and there are significant differences in proportions of bored valves between species, environments, and regions, but not over time. Differences in proportions of incompletely- and multiply-bored valves between species, regions, and over time did not yield significant results. Possible explanations for most cases of anomalous predation include small sample size, variable prey-shell thickness, and environmental factors. Conchiolin layers may have some effect on naticid predation, but are not the only cause of anomalous patterns.

AQUARIUM HUSBANDRY OF THE SEPIOLID SQUID ROSSIA PACIFICA (BERRY,1911)

ANDERSON, Roland C., Puget Sound Biologist, The Seattle Aquarium, Pier 59, Seattle, WA. 98101

The stubby squid, Rossia pacifica, has been on public display at the Seattle Aquarium almost continually for eight years. A brief description of the animal is given along with its life history, field aspects, and previous cultivation efforts. The history of its aquarium maintenance is detailed with aspects of its public display, collecting techniques, commonalities of collection sites, and feeding regimens.

OCCURRENCE OF THE NORTH PACIFIC GIANT SQUID IN PUGET SOUND, WA.

ANDERSON, Roland C., Puget Sound Biologist, The Seattle Aquarium, Pier 59, Seattle, WA. 98101

The North Pacific giant squid, Moroteuthis robusta (Verrill,1876), is commonly caught by trawlers over its range in the North Pacific from 100-600 m deep. It is considered a rarity to find it in Puget Sound, which has sills and reduced salinity, and as such is reported as an oddity to the press or institutions such as the Seattle Aquarium. Reports of the animal collected over the years indicate it is a more frequent visitor than previously thought. Little is known of their habits, migrations, or food, although one animal donated to the Aquarium from the Gulf of Alaska was caught with Atka mackerel, a pelagic greenling, which is a probable food source. It has been speculated that they follow salmon migrations into Puget Sound.

PALEOECOLOGY OF LOWER ALBIAN RUDIST REEFS FROM THE ALISITOS FORMATION, BAJA CALIFORNIA, MEXICO.

BARRICK, Reese E., Department of Geological Sciences, University of Southern California, Los Angeles, CA 90089-0740

Mid-Cretaceous bioherms of rudistid bivalves (Hippuritacea) occur in the predominantly volcaniclastic Alisitos Formation in localities from Punta China to the Vizcaino Peninsula . The Alisitos consists of strata related to a marine arc formed during the eastward subduction of an ocean plate beneath the southwestern margin of North America. These bioherms formed along a very narrow carbonate bank at varying distances from the volcanic arc with the northern localities being more distal and the southern localities more proximal to the arc. The structure and composition of the Alisitos bioherms are most similar to those of the Antillean islands.

Individual bioherms are generally tabular and discontinuous and range from less than 1 m to 10's of meters in thickness. The bioherms are autochthonous/parautochthonous representing reef and back reef lagoonal depositional environments and vary in diversity between bioherms. The rudist fauna consists of Caprinuloidea, Agriopleura, ?Caprinula, Toucasia, and Monopleura. In a number of bioherms, these genera colonized hermatypic coral horizons and eventually excluded the corals. Reefal bioherms become dominated by Caprinuloidea. Bioherm termination have been related to 2 main factors: volcaniclastic events and oceanographic events.

Results from this study of Alisito's bioherms indicates faunal associations not previously known from other Gulf Coast or Caribbean mid-Cretaceous rudistid bioherms. Although these occurrences represent some of the northernmost rudist paleocommunities of the mid-Cretaceous, these bioherms show normal rudist diversity for the Albian. Future work on systematics may yield important biogeographic information as the bioherms contain unidentified rudist species from a period in which rudists were rapidly radiating throughout the world.

PHYLOGENETIC RELATIONSHIPS IN THE GENUS BIOMPHALARIA (GASTROPODA: PLANORBIDAE).

BANDONI, Susan M.,[1,2] MULVEY[2], Margaret, & LOKER, Eric S.[1] (1) Department of Biology, University of New Mexico, Albuquerque, NM, 87131, and (2) Savannah River Ecology Laboratory, Aiken, SC, 29802

Freshwater snails in the genus Biomphalaria transmit Schistosoma mansoni in Africa and the neotropics. Systematic relationships among the species remain poorly known, and most studies to date have emphasized regional faunas. Twenty-five populations representing seven neotropical and four African species were compared using starch gel electrophoresis. Twenty-five enzyme loci were scored. A phylogenetic analysis was performed on the electrophoretic characters. Sixty equally parsimonious trees were obtained, each with a consistency index of 75.9%. Most of the 60 trees represented rearrangements of the populations of only 3 species. There were only 6 arrangements of the remaining 8 species. In all of the trees obtained the four African species formed a monophyletic group but the neotropical species did not. When either African or neotropical species were analyzed alone, larger numbers of trees were obtained, indicating that further comparisons of the species from both hemispheres will be of considerable utility.

PACIFIC OPISTHOBRANCH ZOOGEOGRAPHY: BIODIVERSITY AND ENDEMISM.

BERTSCH, Hans, Invertebrate Zoology, California Academy of Sciences, San Francisco, CA 94118

Although much alpha-level taxonomy remains to be described throughout the Pacific basin, our knowledge of opisthobranch natural history reveals some distinct zoogeographic trends.

This presentation will summarize patterns of species' distributions in various regions of the northern and tropical eastern Pacific, examining different provincial levels of biodiversity and endemism.

It will also describe differences in the presence of higher-level taxa, and variation in the proportionate representation of species with different feeding (prey) preferences.

LOOKING UP THE WRONG END: ANATOMICAL CHARACTERS OF FRESHWATER BIVALVES (MOLLUSCA, UNIONACEA)

BOGAN, Arthur E. Department of Malacology, Academy of Natural Sciences, 1900 Benjamin Franklin Parkway, Philadelphia PA 19103-1195.

Early work on the recognition of higher taxa within unionaceans was done by Lea, Rafinesque, Say, Conrad, Agassiz, and von Ihering. Simpson continued this endeavor using the marsupial structure of demibranchs as a basis of classification. Ortmann finally developed a classification of Unionacea using a suite of anatomical characters. Several unsatisfactory classifications have been proposed based on a single character or limited suite of characters. Davis and Fuller tested Ortmann's classification with biochemical techniques and concluded that it was basically sound. A constant criticism is the apparent lack of usable anatomical characters for analysis of the relationships among taxa. The rectal area of bivalves has been overlooked by most authors describing bivalve anatomy. At least 12 new anatomical characters are identified from this area. Rectal characters are analyzed and the resulting tree is compared with the tree developed from the Davis and Fuller data. The two data sets are combined and that tree is presented. Although these preliminary analyses use only a portion of the diversity of North American unionids; this new data set adds a new dimension to the development of a phylogeny for North American Unionacea.

MITOCHONDRIAL DNA DIVERSITY IN BRITISH COLUMBIA POPULATIONS OF THE PACIFIC OYSTER

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The Pacific Oyster, *Crassostrea gigas*, was first introduced to British Columbia coastal waters from Japan in 1912. While conditions for growth and survival can be found in most areas, conditions favoring spawning are not widespread. This has led to the establishment of a discreet subset of populations which reproduce on a regular basis. We are analysing the mitochondrial (mtDNA) genomes of these populations to determine (i) the effective genetic population size of British Columbia oyster populations; (ii) whether any differences in genetic population structure exist between these populations, and; (iii) possible levels of inbreeding in hatchery propogated stocks. This research is supported by British Columbia Science Council Funding to A.T.B.

STUDIES ON THE SHALLOW WATER POLYPLACOPHORA OF NUEVA ESPARTA, VENEZUELA.

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Collections of Polyplacophora from Isla de Margarita and shallow water dredging near Isla Coche, Nueva Esparta, Venezuela, have greatly increased the number of chiton species recorded from this area. We now report 17 species including: significant range extensions of Callistochiton portobelensis Ferreira, 1976, previously known only from the Caribbean coast of Panama, and Ischnochiton papillosus (C. B. Adams, 1845), reported previously only from the Greater Antilles; two undescribed species of Lepidochitona; and an undescribed species of Acanthochitona. The presence of Acanthochitona rhodea (Pilsbry, 1893) and A. pygmaea (Pilsbry, 1893) in Venezuelan waters is confirmed. Chaetopleura apiculata (Say, 1834) known from the eastern coast of the United States, commonly occurs in the shallow waters of Isla de Margarita.

SIZE FREQUENCY DISTRIBUTION IN A DEAD BIVALVE ASSEMBLAGE AND THE LIVING SOURCE POPULATION IN HAWAII (BIVALVIA)

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A series of catastrophic southerly storms eradicated extensive beds of Pinna muricata on the leeward side of Oahu, Hawaii. These vast beds constituted an important ecological environment for numerous mollusks and other invertebrates. A study was undertaken to compare size frequency distributions of both the living source populations and dead assemblages of bivalve mollusks. Samples were dredged in different areas, depths, and environments in Mamala Bay, Oahu, Hawaii before, during, and after the series of storms.

The bivalves studied were: Cardiidae, Nemocardium thaanumi; Condylocardiidae, Carditella hawaiensis; Lucinidae, Ctena bella; Semelidae, Ervilia bisculpta & E. sandwichensis; Tellinidae, Elliptotellina euglypta, Tellina oahuana & Tellina robusta.

FROM BLACK SHALES TO SEEPS: RECOGNIZING HABITATS OF CHEMOSYMBIOTIC BIVALVES FROM THE FOSSIL RECORD

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Modern chemosymbiotic bivalves include solemyids and some modiolids, vesicomyids, lucinids and thyasirids. These bivalves occupy a variety of habitats typically characterized by relatively high organic content. In the geologic record, related fossil bivalves are preserved in several types of paleoenvironments that were likely conducive to chemosynthetic adaptation. These fossils are associated with: 1) pillow basalts and sulfide minerals (hydrothermal vents); 2) *in situ* masses of microbial carbonates (cold seeps); 3) laminated to partially bioturbated black shales (stagnant basins); 4) marine mammal bones (microenvironments where bivalves existed on decaying organic matter); and 5) strata deposited in certain nearshore settings (marine grass banks). Not every occurrence of these fossil bivalves is restricted to one of the above paleoecologic associations. Nonetheless, such associations may have utility for increased understanding of the nature of possible chemosymbioses in now-extinct bivalves. For example, a chemosymbiotic life habit has been postulated for members of the Mesozoic Inoceramidae that are found in laminated black shales. However, for at least one example where fossil cold seep carbonates are found in black shales (Tepee Buttes of the Pierre Shale, Upper Cretaceous, Colorado), lucinids predominate in the "core" seep carbonates whereas the less abundant inoceramids are generally restricted to the shaley seep margins. If black shale inoceramids had the same type of bacterial chemosymbiosis as do lucinids, they would be expected to be abundant in the carbonates. Inoceramid scarcity in these deposits, however, implies that their trophic strategy was of a different sort.

PRISMATIC SHELL FORMATION IN TEMPORARILY-OPEN EXTRAPALLIAL SPACES: EXPLICABLE?

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Many aspects of molluscan biomineralization, such as control of polymorphic type and form of microstructures, yet remain unexplained. A comparison of formation of prismatic shell in two species of bivalves is presented that suggests, as indicated by one current hypothesis, that soluble organic matrix precedes and regulates the type and form of biocrystals. In Mytilus edulis Linne prisms develop at the shell margin in an extrapallial space continuously closed to seawater by the emerging periostracal sheet, the mantle margin remaining in place. In Crassostrea virginica (Gmelin), however, margins of mantle lobes frequently withdraw into the mantle cavity, exposing prismatic surfaces to seawater. Prism-secreting cells, even though they could be precisely repositioned over growing prisms, probably do not control the form of these prisms; rather, once nucleated in the soluble matrix, each biocrystal with its accompanying matrix probably mediates mineralization and shape of that prism and subsequent prisms in the prismatic column. Thus, after the secreting epithelium is reestablished over prisms, bathing them in extrapallial fluid, growth is resumed without deformation.

EVOLUTIONARY SIGNIFICANCE OF SHELL AND LIGAMENT MICROSTRUCTURE IN THE BIVALVIA.

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Shell and ligament microstructure can be misleading with regard to phylogenetic relationships in the Bivalvia unless one's database includes both ancient and modern taxa. Shell and ligament microstructure is commonly convergent at the family and superfamily level among Jurassic - Recent representatives of lineages which had become distinct by late Paleozoic time. Unraveling these convergences suggests that: 1. Some early Nuculanoidea and Solemyoidea were nacreous or at least partially nacreous. 2. The ancestral nuculoid ligament was simple arched or simple planar *sensu* T.R. Waller, and very weakly mineralized or unmineralized. 3. The Arcoida and Pterioida are ancestrally nacreous with a very weakly mineralized or unmineralized and at least superficially duplivincular ligament. 4. The divided fibrous ligament in the Arcidae is not primitive within the Arcoida, but evolved from the united fibrous ligament of the Parallelodontidae. 5. The Triassic arcoid *Pichleria* may be closely related to the Paleozoic cyrtodontids. 6. The Triassic pterioid *Cassianella* differs from most other pterioids but resembles *Pichleria* in having a wholly aragonitic nacroprismatic shell in some species, without calcite in the outer shell layer. 7. The immediate common ancestor of the Dimyidae, Plicatulidae and Ostreidae is probably a nacreous *Lopha*-like species more closely related to the Pterineidae and Malleidae than to the Pseudomonotidae. 8. The Pectinoida is ancestrally nacreous, but most if not all Triassic pectinoid families had already replaced nacre with porcelaneous and/or foliated microstructures.

COMPARATIVE FEEDING BIOLOGY OF ACTEOCINA CANALICULATA (SAY, 1826) AND HAMINOEA SOLITARIA (SAY, 1822) (OPISTHOBRANCHIA: CEPHALASPIDEA).

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The feeding biology of two southern New England cephalaspid species, Acteocina canaliculata (Say, 1826) and Haminoea solitaria (Say, 1822) was examined. Acteocina canaliculata fed on bivalves (including Gemma gemma (Totten, 1834)) and three suborders of foraminiferans: Textulariina, Miliolina, and Rotaliina. The proportion of miliolid forams in the diet of Acteocina decreased while bivalves increased with increasing size of Acteocina. In addition no bivalves were found in the guts of snails < 5.0 mm in shell length, probably reflecting an inability of small snails to ingest large prey. The snails appeared to locate prey with the aid of Hancock's organ and senscry patches situated along the anterior edge of the cephalic shield and foot. Individual prey were grasped with the radula and pulled whole into the buccal cavity. Sediment appeared to be passively removed by the jaws.

Haminoea solitaria ingested sediment containing diatoms, unidentified algae, and detritus. Snails appeared to feed indiscriminately on food items in proportion to their relative abundance in the environment. Hancock's organ and sensory patches did not aid in the selection of specific food particles, but may be involved in locating areas where diatoms and algae are abundant.

ASPECTS OF THE LIFE-HISTORY OF A MINUTE, OVOVIVIPAROUS BIVALVE, GONIOCUNA DALLI (BIVALVIA: CONDYLOCARDIIDAE) FROM THE NORTHERN GULF OF MEXICO.

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Goniocuna dalli (Vanatta, 1904) is a minute ovoviviparous bivalve found along the northern Gulf of Mexico between the Mississippi River and Apalachicola Bay, Florida. Very little is known of the ecology, physiology, or morphology of this clam. To study several aspects of the life-history of G. dalli, collections were made on West Ship Island, Mississippi between August 1990 and April 1991. Length, sex, and reproductive data were recorded. Clam length rarely exceeds 2.5mm and young are released at a length of approximately 0.3mm. A greater fraction (>60%) of large (>1.5mm) clams were found to be brooding females . The overall population's male/female ratio was very low (1:4); however this ratio increased (1:2) in smaller size classes. Brood size increased considerably with female sizes above 2.0mm. The average brood size was 10 in clams less than 2.0mm, and in larger clams the average brood size was 25. Two developmental stages were recognized within the broods: unshelled and shelled. Data from August 1990 suggests that the brood stage is not dependant on parental size and that broods are sequential, both stages can be found in a single female.

A TAXONOMIC REVIEW OF THE NORTHEASTERN PACIFIC BIVALVIA: THE UNANSWERED QUESTIONS

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Work in progress on a volume on the bivalves of the northeastern Pacific serves to highlight many unresolved taxonomic problems. It also illustrates the need for much greater international communication and collaboration, and the importance of undertaking work on taxonomic problems on a multi-disciplinary basis.

COMPARATIVE ANATOMY OF MYCETOPODA AND ANODONTITES (MYCETOPODIDAE) FROM CENTRAL AMERICA WITH MUTELA (MUTELIDAE) FROM EAST AFRICA.

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Scanning and transmission electron microscopy and histology were employed to investigate the external and internal anatomy of the ctenidia, the external structure of the oral and aboral surfaces of the labial palps and the ciliation of the incurrent and excurrent siphons of Mycetopoda siliquosa (Spix, 1827), Anodontites nicaraguae (Philippi, 1848), and A. montezuma (Lea, 1841) of the Central American Mycetopodidae and Mutela nilotica (Cailliaud, 1823) of the East African Mutelidae. The unique circulatory system of the mycetopodid ctenidia and ctenidial ciliation are described in detail. The bizarre theca containing the developing frontal cilia of the ctenidia of Mutela nilotica are described from early development to maturation. The surfaces of the labial palps, as well as the ciliation of the incurrent and excurrent siphons, are compared. These results confirm the higher level classification erected by Parodiz and Bonetto in their landmark contribution of 1963.

BIOGEOGRAPHIC PATTERNS OF WEST AFRICAN BIVALVES

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In the course of preparation of a comprehensive identification guide of the bivalves of tropical west Africa (427 species treated, ca. 10.000 lots examined of which 5000 collected during extensive field work), I found the distributions of the species to be essentially coincident with the major hydrographic features of the west african shelf:

- northern zone of permanent upwelling, from Morocco to the Sahara
- northern zone of seasonal upwelling, from Cape Blanc to Guinea
- tropical zone, from southern Guinea to Gabon
- southern zone of seasonal upwelling, from Gabon to northern Angola
- southern zone of permanent upwelling, from southern Angola to Namibia

A rather high number of species show a disjunct distribution: these occur either in both areas of permanent upwelling, or in both areas of seasonal upwelling. Vicarianist vs. dispersalist interpretations of such patterns are discussed.

INTRODUCED AMPULLARIID AND VIVIPARID AMPHIBIOUS SNAILS IN HAWAII.

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At least six species of the prosobranch families Ampullariidae (one Pila sp. and four Pomacea spp.) and Viviparidae (one Cipangopaludina sp.) have been introduced to Hawaii. These snails are amphibious, breathing with gills when underwater but using the modified mantle cavity as a lung when out of water or when using the inhalant siphon as a snorkel. They can withstand long periods out of the water. Viviparids bear their young live; ampullariids lay large egg masses, often up to 10 cm above water on emergent vegetation.

Cipangopaludina and Pila are Asian genera, the latter distinguished from Pomacea, which is essentially Neotropical, by having a calcified rather than horny operculum. All have been deliberately introduced to Hawaii for one or both of two reasons: 1) for harvesting, or even culture, for food, and 2) as domestic aquarium snails. They are recorded from the islands of Oahu, Kauai, Maui and Hawaii. While some see their culture in positive terms as a source of revenue, others complain that taro crops are being damaged by increasing populations of the snails. The snail farmers insist that their snails cannot escape and pose no problem.

Thus far, little concern has been expressed over other more fundamental ecological problems these snails might cause, such as destruction of native freshwater habitat, competition with native freshwater snails, disease transmission, etc.

EXPERIMENTAL BIVALVE TAPHONOMY: ANALYSIS OF THE EFFECTS OF CHEMICAL DISSOLUTION AND MECHANICAL ABRASION BY SIZE CLASS IN *DONAX GOULDII* DALL, 1921.

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Studies of well-preserved fossil bivalve populations frequently assume a lack of significant taphonomic bias. Most taphonomic experiments have been designed to generate results in which destruction is obvious. This study compares the less obvious taphonomic effects of experimental physical abrasion and chemical dissolution on three size classes of a Holocene population of *Donax gouldii* Dall, 1921. It is designed to provide a framework for assessing more subtle forms of taphonomic alteration in fossil bivalve populations.

Shells of three size classes of live-collected animals from Newport Beach, California, were subjected to three experimental treatments: (1) abrasion in sandy water on on a rocking intertidal-simulation table, (2) dissolution in an acidic solution mimicking conditions that valves might experience in natural pre-burial or post-burial settings, and (3) dissolution in an acidic solution following abrasion on the rocking table. Data indicate a tendency for greater percent weigth loss in the small shell size classes. Although shells remained intact through all treatments, scanning electron microscopy shows dramatic differences between the surfaces of fresh shells, abraded shells, and dissolved shells.

Although this study does not generate a full classification of dissolution and abrasion features, it does demonstrate the potential of experimental taphonomy for detailed reconstruction of post-mortem history of fossil bivalve populations.

THE ROLE OF BIVALVE REEFS AND BEDS IN COASTAL ECOSYSTEMS.

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In shallow coastal waters and estuaries, dense bivalve assemblages, primarily oyster reefs, mussel beds and cockle beds, form major structural features. Studies over the past 10-years indicate these bivalve systems also play a major role in the functioning of coastal ecosystems. they remove large quantities of suspended particulate material including inorganic sediments, phytoplankton, organic detritus and zooplankton from the surrounding water column. Dissolved substances like amino acids, sugars, heavy metals, etc., are also actively removed. Some of these materials are utilized as food yielding metabolic waste such as ammonium and orthophosphate. Because these systems enriched the surrounding sediments, other dissolved substances are released as a result of benthic bacterial decomposition.

Based on their filtration capabilities bivalve reefs and beds have been touted as eutrophic control mechanisms, increasing sedimentation, and limiting phytoplankton productivity. Their high material release rates have been speculated to increase phytoplankton production and nutrient recycling. Recent manipulation experiments on whole ecosystems support some these claims, but point to water residence time as a major contributing factor.

COMPARATIVE MORPHOLOGY OF THE CRANIAL CARTILAGE IN SELECTED SPECIES OF MYOPSID SQUID (CEPHALOPODA: TEUTHOIDEA).

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Cephalopodan endoskeletal cartilages, despite their apparent presence across many of the extant taxa and functional convergence with the vertebrate skeleton, have largely escaped notice and description in the scientific literature. A review of what little is known of these structures indicates that they vary in form, composition, and pattern of occurrence across different taxa; however a cranium is usually present. The results of a principal component analysis of cranial morphology in selected species of myopsid squid suggest that cranial form is conservative within the suborder Myopsida, and that interspecific variation is influenced primarily by the configuration of the brain and by environmental factors; greater variation in cranial morphology and cartilage composition appears to be present at the ordinal level. Such variation is potentially valuable in the study of cephalopodan relationships and phylogeny, and should be evaluated further as a tool in revising cephalopod classification.

FRESHWATER MUSSELS AND FRESHWATER MITES: SYMBIOSIS AND SPECIATION.

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The cosmopolitan water mite family Unionicolidae includes numerous species occurring as 'temporary' or 'permanent' symbionts of unionid mussels. Recent taxonomic revision has revealed a plethora of unionicolid species from North American unionids. Unionicola formosa is reported from at least 12 species of anodontine mussels. In North Carolina it occurs principally with Anodonta cataracta and A. imbecilis. Populations of this mite from these mussels cannot reliably be separated on morphological criteria. However, mites from the two mussel species, even from sympatric host populations, differ significantly with respect to several aspects of their population ecology, as well as host-influenced and host-oriented behavior. In addition to these ecological and behavioral differences, an electrophoretic analysis of 19 enzyme loci from four populations of U. formosa from A. imbecilis and two from A. cataracta revealed significant differences in the population genetic structure of mites from these two species of mussels. Coupled with assumptions regarding this mite's reproductive biology, these data suggest that these host-specific populations may constitute sibling species. Thus, taxonomic issues regarding this symbiotic taxon may be more complicated than currently recognized.

BIOGEOGRAPHY AND TAXON COMPOSITION OF NORTHERN PACIFIC POLYPLACOPHORA

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About one fifth of the more than 800 chiton species worldwide inhabit the warm temperate to subpolar northern Pacific. This study uses newly developed software for automated global mapping and distributional tallies, combined with a current database of worldwide nominal chiton taxa. The northern Pacific chiton fauna is examined with respect to its taxonomic composition, diversity relative to global chiton distributions, reported trans-Pacific distributions, boreal affinities of northern Pacific and Atlantic faunas, and species range limits relative to bathymetric distributions. Supraspecific taxonomic diversity is only moderate, but some taxa are speciose and largely restricted to the northern Pacific. Chitons may show more restricted representation than other molluscan groups because all chitons have nonfeeding larvae that are able to assume a benthic lifestyle within about a week. Reports of wide species ranges are exceptional, often based on unconfirmed reports or questionable synonymies, although some rafting of juveniles and small adults almost certainly occurs.

MOLLUSCA-ANNELIDA-ARTHROPODA: A PHYLOGENETIC ANALYSIS OF SPIRALIANS FROM MORPHOLOGICAL AND 18S rRNA SEQUENCE DATA

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Shared segmentation of annelid and arthropod body plans has led to the conventional hypothesis "Articulata." Conflicting embryological and larval characters support an alternative annelid-mollusk grouping. The first published cladogram of metazoans accompanied by an explicit matrix of morphological characters (Meglitsch & Schram, 1990: *Invertebrate Zoology*, 3rd Ed.) depicts support for the "Articulata" hypothesis. Reanalysis of this matrix, however, fails to repeat this result. Instead, 1422 trees of one fewer step were found, whose strict consensus lacked resolution for spiralian taxa. Our independent study of a larger matrix for 17 phyla of morphological data combined with, or analyzed separately from, available 18S ribosomal RNA sequence data also fails to support "Articulata." Rather, weak evidence supporting a "Eutrochozoa" clade, excluding arthropods, is presented.

PALEOCLIMATIC IMPLICATIONS OF LATEST EOCENE AND EARLY OLIGOCENE LAND SNAILS (PULMONATA: STYLOMMATOPHORA) FROM EASTERN WYOMING

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The White River Formation near Douglas, Wyoming, contains 13 genera (13 spp.) of land snails. All are referable to modern families and most to modern genera. The formation was deposited continuously across the Eocene-Oligocene boundary, and includes the upper Eocene Chadron and lower Oligocene Brule members.

A major change in land snail faunas occurs at the Chadron Brule contact. Chadron land snail faunas are characterized by taxa now living in the Central Mexican Plateau and the southern-most Rocky Mountains (Ashmunella, Holospira, and a n. gen. closely related to Humboldtiana). Brule land snail faunas include genera now living in southern California and northern Baja California (Xerarionta, Micarionta) and taxa now living in the southern Rocky Mountains (Ischnopupoides Gastrocopta, Radiocentrum). Large-shelled Xerarionta are abundant in the lower Brule, but are less abundant than the microshelled taxa Ischnopupoides, Gastrocopta and Radiocentrum in the middle Brule. This change reflects a decrease in available leaf litter shelter, associated with increased drying. A land snail fauna within a middle Brule paleovalley fill contains a normal Brule fauna with the addition of Polygyrella, Mesomphix, and Mesodon(?). These snails indicate a local increase of moisture and leaf litter habitats. The distribution of modern analogue taxa provides estimates of climatic parameters such as mean annual temperature and precipitation.

MODE OF REPRODUCTION AND GENETIC STRUCTURE IN AQUATIC GASTROPODS

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The population genetic structure of aquatic molluscs is determined by life history factors as well as by possible differences in selection pressures in heterogeneous environments. In gastropods, one important influence on genetic differentiation is the potential for long-distance dispersal of eggs or larvae. The available data suggest that, for marine gastropods, free-spawning species with planktonic larvae (e.g., Stramonita, some Littorina) exhibit levels of genetic differentiation that are 10-100 times lower than the differentiation over compar-able geographic scales for related brooding species (e.g., Nucella, some Littorina). Among freshwater gastropods, free-swimming larval stages do not occur, but there are still differences among taxa in dispersal potential. Freshwater prosobranch molluscs produce eggs that are either brooded or deposited in large capsules, which restricts dispersal compared with pulmonate molluscs, which produce smaller eggs that are capable of at least passive dispersal. Available data suggest that these differences in dispersal potential between prosobranch molluscs (e.g., Viviparus, Campeloma) and pulmonate molluscs (e.g., Lymnaea) are also associated with differences in amount of genetic differentiation of populations.

THE INFLUENCE OF BEHAVIOR AND SHELL FORM ON THE TAPHONOMY OF STROMBID GASTROPODS.

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Strombid gastropods exhibit several behaviors that are unusual among molluscs, most notably their tendency to be gregarious and the frequency with which they bury themselves, particularly as juveniles. The gregarious behavior of most strombid species means that fossil aggregations of these gastropods may represent biological rather than physical accumulations. Living juveniles and adults sometimes congregate separately, so that even size sorting may have a biological component. Most strombid species exhibit characteristic burial behaviors, where individuals, particularly juveniles, spend considerable amounts of time buried in the substrate. This behavior discourages the growth of epibionts and/or boring organisms. The position and abundance of epibionts and boring organisms holds considerable information about the taphonomic history of the individual shell and the deposit as a whole.

Strombids are also unusual among gastropods in that shell growth is determinate: adults of most species are characterized by a thickened, flaring lip, which is lacking in juveniles. Flume experiments demonstrate that adult and juvenile shells of S. floridanus exhibit characteristically different hydrodynamic behavior. Adult shells generally become oriented with their coiling axis roughly normal to a current, with the relatively shallow slope of the flared lip directed upstream, while juvenile shells more commonly orient with the apex of the shell downstream. Strombids should have a tendency to be found aperture-down in current-deposited strata, unless they were buried quickly while infaunal (i.e. in lip-up position).

SETTLEMENT AND METAMORPHOSIS OF MARINE BIVALVES

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Methods for the chemical induction of settlement and metamorphosis of bivalve larvae would be useful both for aquaculture and for the study of development. Early studies on the environmental cues responsible for spatfall suggested that settlement of Crassostrea virginica could be induced by copper carried into estuaries by freshwater. Later studies on American and European oysters provided evidence that metamorphosis was stimulated by factors which could be extracted from the tissues of adult bivalves. Recent work has suggested that substances secreted by bacteria may be involved in the step-wise stimulation of settlement behaviour and metamorphic processes.

Settlement behaviour of pacific oysters and Ctenoides scabra is stimulated by ammonia generated by the titration of ammonium chloride with sodium hydroxide. Supernatants from a strain of bacterium containing similar levels of ammonia can also stimulate settlement behaviour. Epinephrine bitartrate solutions which induced metamorphosis when they were titrated with sodium hydroxide also generated ammonia.

It has been suggested that once settlement behaviour of pacific oyster larvae has been initiated by ammonia secreted by bacteria living on the sediment interface the larvae are exposed to other contact-dependent and soluble cues. The induction of metamorphosis can be stimulated by L-DOPA which may be secreted by bacteria.

Vicariance Relationships of the North Pacific Opisthobranch Gastropods

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The opisthobranch mollusk fauna of the North Pacific consists of several distinct components: temperate western Pacific fauna, temperate eastern Pacific fauna, Panamic tropical eastern Pacific fauna and Indo-Pacific fauna. There are endemic components to all of these faunas. The species level and generic phylogeny of most opisthobranch taxa is poorly known. Nevertheless, examining the sister group relationships for taxa where some phylogenetic information is available sheds light on their biogeogarphy. All evidence suggests that each of these faunas has historical relationships to several different geographical regions and that the origins of the present faunas are extremely complex.

PHYLOGENETIC SYSTEMATICS OF THE RECENT SUBFAMILIES OF VOLUTIDAE (GASTROPODA: PROSOBRANCHIA)

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Character states for 27 characters of shell morphology, ultrastructure, anatomy and reproductive biology are described and tabulated for 22 genera representing all ten subfamilies of Volutidae that have Recent representatives. Characters are polarized on the basis of outgroup comparison, and a phylogenetic hypothesis of the relationships of these taxa proposed. Data from these analyses are used to reassess the higher taxa in the family, and to shed light on their relative age and biogeography.

A NEW APPROACH TO THE STUDY OF BIVALVE EVOLUTION.

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Radio-immuno-assay (RIA) measures genetic distance between taxa by measuring how much antibodies made against proteins of one species binds with proteins of another. The resulting immunological distances correlate highly with DNA hybridization results. RIA is unique in that it can extract information from proteins preserved in fossil and recent calcareous matrices. Since most molluscan collections consist predominantly of dry shells, for any studies of their evolution, RIA could be very important. It has been used in evolutionary studies of fossil or recent mammals, reptiles, amphibians, birds, brachiopods, coelenterates, plants, and algae. I am using RIA to study parallel evolution in the Veneridae, and to develop a phylogenetic outline of the family. Taxonomy of the family is currently based on obvious malacological similarities, but preliminary results suggest that such similarities are often the result of parallel evolution. A more accurate classification may need to depend more strongly on anatomical, biomolecular and biogeographical data.

THE UTILIZATION OF GROWTH TRENDS IN SHELL DEVELOPMENT TO STUDY STROMBID PHYLOGENY AND SYSTEMATICS.

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Using computer simulations, Harasewych and others have shown that the helically coiled growth plan of gastropod shells can be approximated by a series of points each describing a logarithmic spiral in a plane perpendicular to the coiling axis while undergoing exponential translation in a direction parallel to that coiling axis; the many variations in shell shape being a function of (a) the generating curve defined by the points at any moment in time, (b) the rate of spiral expansion, and (c) the rate of exponential translation. While members of the Strombidae family exhibit these general gastropod growth features, it has been observed that, among all recent and fossil taxa studied to data, there exist predictable ontogenetic changes in both the rate of spiral expansion and the rate of exponential translation. In addition, these taxa produce axial and spiral sculptural features that also exhibit predictable ontogenetic changes. These ontogenetic "signals" are being studied to determine their usefulness in separating Strombid taxa and delineating evolutionary lineages.

The paper will focus on the techniques used to identify and express these ontogenetic signals, the potential uses of the information obtained, and the difficulties and limitations associated with the technique.

CRYPTIC PROPEAMUSSIIDS AND OTHER BIVALVES FROM A SUBMARINE CAVE OF OKINAWA, SOUTH JAPAN

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A cryptic molluscan fauna, including Neritopsis radula, was discovered from the totally dark inner part of a submarine cave off Ie-jima Island, Okinawa. The cave is a nearly horizontal tunnel (ca. 30 m long) open to the outer slope of a barrier reef with an entrance about 10 m below the sea level. The wall of the inner part is also inhabited by Parvamussium n. sp. and Carditella n. sp. Numerous dead shells of about 20 bivalves (mostly new species) were found from the calcareous mud on the bottom of this cave. They include Arcidae (2 species), Philobryidae (4 species), Mytilidae (2 species), Propeamussiidae (4 species), Limidae (2 species), Nucinellidae, Carditidae, Crassatellidae, Montacutidae, Vesicomyidae, Kelliellidae and Cuspidariidae? (1 species for each). The propeamussiids are Parvamussium n. sp., Cyclopecten n. sp. A and B, and Chlamydella cf. favus (Hedley).

This bivalve fauna shows unusual features such as: 1) Presence of Nucinellidae, Philobryidae, Propeamussiidae and Kelliellidae, the distribution of which had been almost restricted to deep seas, 2) Very small adult shell-size of each species (length commonly less than 4 mm), 3) Persistent provinculum until adult stages in most species, indicating paedomorphic evolution, 4) Large (and often hat-shaped) prodissoconch I, which appears not only in philobryids but also in many other species, suggesting nonplanktotrophic development and K-strategy.

Although the origin of this fauna is still difficult to explain, low predation pressure in the lightless and poorly nutritious conditions seems to have permitted the survival of such peculiar bivalves.

GENERIC REVIEW OF THE AQUATIC SNAIL SUBFAMILY COCHLIOPINAE (GASTROPODA: HYDROBIIDAE).

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The Cochliopinae (= Littoridininae of authors) is a large (31 genera and over 270 species), predominantly New World subfamily of aquatic prosobranchs found in diverse nonmarine waters. Shell and anatomical study of at least one species in each genus has been completed by us and is the basis for this generic review. Results are discussed, with emphasis on clarifying nomenclature, assessing phylogenetic relationships among the genera, and examining zoogeographic patterns in a preliminary fashion.

INTERPRETING THE SEPARATE TAPHONOMIC FATES OF TURBINID GASTROPOD SHELLS AND OPERCULA IN FOSSIL MOLLUSK ASSEMBLAGES

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Because of the marked difference in size and shape of turbinid shells and opercula, the two skeletal elements are easily separated by taphonomic processes involving transport. In addition, they are differentially susceptible to diagenetic alteration. Their separate taphonomic fates enhance rather than detract from the quality of the gastropod fossil record.

Samples from 87 Neogene localities in the northern Dominican Republic contain abundant shells and/or opercula of turbinid gastropod species. Opercula are more abundant than shells at most localities, and while the majority of shells show moderate to considerable breakage, opercula are intact and well preserved. Seven distinct opercular morphologies are present in 130 lots containing a total of approximately 1500 opercula. Initial observations suggest that opercula can provide better estimates of population size structure than shells and that estimates based on shells alone will be skewed toward smaller sizes than estimates based on opercula. Results of analyses from 25 localities where shells and opercula were recovered from bulk samples demonstrate the feasibility of species matching and the feasibility of determining shell size accurately from operculum size. Analysis of a locality preserving both shells and opercula of two species of *Turbo* illustrates the method of analyzing separate taphonomic fates and confirms the prediction that opercula provide a better estimate than shells of population structure.

Supported by grants from the Swiss National Science foundation and the Committee on Research, University of California, Berkeley.

AN UNUSUAL INSTANCE OF DISCORDANT GENETIC MARKERS IN THE FRESHWATER MUSSEL GENUS PYGANODON (UNIONIDAE: ANODONTINI)

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The degree of correlation between mitochondrial DNA (mtDNA) phylogeny and organismic phylogeny is of great importance to evolutionary biologists using mtDNA phylogeny as an estimator of organismic phylogeny. Investigation of biological systems that exhibit discordance between mtDNA and nuclear DNA-based characteristics should offer insight as to the factors responsible for the observed discordance. Multiple studies are necessary to assess the generality of the assumption that mtDNA phylogeny and organismic phylogeny are highly correlated. When observed, the discordance between mtDNA patterns and nuclear-encoded characteristics is usually accounted for by hypothesizing: 1) introgressive hybridization, 2) stochastic sorting out of ancestral mtDNA polymorphisms, or 3) mtDNA rate heterogeneity. This study reports recent work on an unusual discordance between allozymic and mtDNA markers in the freshwater mussels Pyganodon cataracta and P. fragilis. Two conditions, 1) knowledge of the taxic and phylogenetic distribution of the mtDNA markers, and 2) a hypothesis of evolutionary relationships for the pertinent taxa (based on nuclear-encoded characteristics), permit discrimination among the alternative hypotheses.

THE DOMINICAN REPUBLIC PROJECT: A PROGRESS REPORT

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The continuous and faunally diverse Neogene marine sequences of the Cibao Valley in the northwestern Dominican Republic allow close examination of total assemblages and their relation to paleoenvironment and time. Field work started in 1978, and the introductory publication appeared in the *Bulletins of American Paleontology* in 1986. Since then a series of nine faunal monographs, including four on mollusks, have appeared. Three additional manuscripts, one on mollusks, are being processed, and at least fifteen more are expected in the next few years. All published data and, in some cases, additional unpublished data on the lithology, stratigraphy, and fauna of the nearly one thousand collecting localities have been entered into a dBASEIV database, which may be searched on any field and/or portions or combinations thereof.

ANATOMY AND PRELIMINARY GENERIC REVIEW OF THE BITTIUM GROUP.

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The anatomy of seven members of the Bittium group is described, clarifying the status of the genus-level taxa comprising it. Bittium reticulatum, the type species of Bittium Gray is described in depth, thereby establishing a criterion for other component taxa. The type species of Stylidium Dall and representatives of Bittiolum Cossmann, Cacozeliana Strand and Bitinella Dall are examined and compared with Bittium, s.s. Results reveal five different anatomical groups indicating that the Bittium-group should be divided into five genus-level taxa under subfamily Bittiinae Cossmann.

Synonymies of the higher taxa and representative species examined are presented.

SHAPE, DRAG AND POWER IN AMMONOID SWIMMING

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Drag measurements were used to calculate drag coefficients and the power required for swimming at a variety of sizes and velocities in a series of ammonoid shells of variable lateral compression. The results indicate that the shell shape that confers optimal swimming efficiency is highly dependent on the Reynolds number of operation. Laterally compressed forms, such as oxycones, long thought to be the most efficient swimmers are only more efficient at high Reynolds numbers. At lower Reynolds numbers, likely to be typical of ammonoids of modest size swimming at moderate velocities, less compressed forms will have the advantage of lower drag and power requirements. Thus optimal shell form depends on size and swimming behavior.

Swimming velocity should increase with increasing size. Reynolds number is a function of both velocity and size and should increase by three orders of magnitude during the ontogeny of the average ammonoid. Therefore, if ammonoids are adapted for efficient swimming from hatching onwards, their shell shape should become more laterally compressed through ontogeny. Examination of data from the literature suggests that this is the case. Ammonoids hatch at a millimeter in size and are nearly spherical in shape. Once they reach one centimeter in size they are more compressed; width of the whorl is often less than half of the radius of the coil.

Nautilids hatch at a much larger size than ammonoids. Hydrodynamic influences on the smaller juveniles of ammonoids may account for differences in coiling parameters and differences in the evolutionary tempo of the two groups.

BLUE MUSSEL (MYTILUS EDULIS) MORTALITY IN BRITISH COLUMBIA: COMPARISON OF PACIFIC AND TRANSPLANTED ATLANTIC MUSSELS.

JAMIESON, Glen S., Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C. V9R 5K6

Normal longevity of British Columbian blue mussels (Mytilus edulis) is about one year, with mortality suggested to be a natural senescence. In 1989, Nova Scotian mussels were brought to British Columbia so that comparative survival between Atlantic and Pacific mussels strains could be investigated. Nova Scotian mussel mortality was low in 1989, and F1 progeny remain alive in 1991. Biochemical analysis of constituent seasonal energy reserve suggested that substantial physiological differences may exist between the Nova Scotian and British Columbian strains. However, there were also differences between British Columbian strains in different years, indicating that more rigorous comparative monitoring is required to document possible strain differences. After spawning, Nova Scotian mussels began to show an increase in soma weight whereas British Columbian mussels continued to show a decrease in soma weight, with death the apparent ultimate result.

THE INTERTIDAL: PHYSICAL AND BIOLOGICAL INFLUENCES ON SPECIES COMPOSITION, ABUNDANCE AND RECRUITMENT PATTERNS IN THE NORTHEAST PACIFIC OCEAN.

JAMIESON, Glen S. and NOAKES, Donald J., Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, B.C. V9R 5K6

The intertidal environment is unique in that it is exposed to both meteorological and oceanographic climate events, with typically wide temperature and salinity fluctuations over relatively short time durations. Intertidal species high in the subtidal have to primarily cope with terrestrial competitors or predators while those low in the subtidal have to primarily cope with marine examples. This interaction of the physical and biological environment has tended to result in marine species which either move in and out of this zone with the tides or if sedentary, have a hard, impermeable exoskeleton or show burying behaviour to allow them to avoid both predation and adverse physical conditions. Nevertheless, a pronounced zonation of species occurs and because of the relatively short geographic distances involved, this marine environment is likely to be the first obviously impacted by any pronounced pattern of climatic change. Physical and biological events and their probable consequences on the distribution and recruitment of commercial species inhabiting the intertidal are discussed, with consideration of the magnitude of change and data time series required to produce statistically significant effects.

PATTERNS AND PROBLEMS IN THE CLASSIFICATION AND PHYLOGENY OF THE NATICIDAE (GASTROPODA)

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The Naticidae are well known as predatory marine prosobranchs with a cosmopolitan distribution in infaunal habitats. Their Recent diversity (over 200 species in 35 genera) is matched by the extensive fossil record (about 30 extinct genera). The problems of the origin and relationships of this family are considered; the status of the Triassic 'naticids' remains elusive.

The patterns of species diversity and generic macroevolution from the Jurassic to the Recent are discussed, along with the broader limitations of such analyses. Previous generic classifications of this family are compared with an ongoing reanalysis of the available data. Future approaches and prospects in the study of naticid phylogeny are outlined.

SYSTEMATICS AND GEOLOGICAL HISTORY OF THE SUBFAMILY CLINOCARDIINAE (BIVALVIA: CARDIIDAE).

KAFANOV, Alexander I., Laboratory of Ecosystem Dynamics, Petropavlovsk-Kamchatsky, USSR

(No abstact received)

BIVALVE EVOLUTION IN THE NORTH PACIFIC

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(No abstract received)

ALLOZYME AND MORPHOLOGICAL DIFFERENTIATION IN THE FRESHWATER SNAIL VIVIPARUS GEORGIANUS.

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I studied allozyme and morphological variation in the brooding freshwater snail [Viviparus georgianus (Lea)], which is variable in shell morphology among populations, in the southeastern United States. Eleven studied populations were clustered into three genetically isolated allopatric species characterized by at least six diagnostic loci among them out of the 42 loci studied. These allopatric species were eastern populations, western populations, and a middle population at Lake Talquin. Nei's standard genetic distances among the species were large (0.23-0.58) but the within-species distances were small (0.00-0.08). Moreover, genetic distances between the species at Lake Talquin and the other two species were larger than genetic distances between eastern and western species. The western species was more differentiated than the eastern species. Wright's F_{st} of the western and eastern species among populations were 0.67 and 0.36, respectively. Most of the genetic differentiation was due to differences among populations within drainage systems, rather than to differences among systems. The western species should be called as Viviparus goodrichi Archer, which was originally described as a subspecies. Shell morphology measurements will be analyzed by principal component analysis and be compared with genetic data to examine whether the three species and genetically distinguishable populations within species are morphologically distinguishable.

MARINE MOLLUSKS OF THE URVINA BAY UPLIFT, GALAPAGOS ISLANDS.

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In 1954, the floor of Urvina Bay, Isabela Island in the Galapagos was thrust more than 6 meters above sea level, exposing several square kilometers of its marine community. Animal remains indicate the uplift occurred rapidly and that most of the water percolated through the porous lava. The rapid uplift and drainage preserved the integrity of the community in an invertebrate Pompei, providing an opportunity to examine subtidal marine mollusks associated with corals, basalt and sand usually found at depths of 10 m.

Molluscan assemblages from living and eroded corals, basalt boulders and cobble, and sand channels were analyzed for species composition and diversity. Species diversity is greater in eroded coral heads bored by sea urchins and Lithophaga than on undamaged coral heads, and greater beneath coral heads, in basalt cobble and in sand channels than on rubble Pocillopora "islands." A unique assemblage consists of a "swarm" of coralliophilids apparently stranded at the tideline when the uplift occurred.

Species composition on the uplift is compared with known Galapagos species lists.

FAUNAL HISTORY, BIOGEOGRAPHIC PATTERNS AND DIVERSITY IN THE MARINE FAUNA OF THE CENTRAL PACIFIC.

KAY, E. Alison, Department of Zoology, University of Hawaii, Honolulu, HI 96822.

The history of the marine biota of the islands of the central Pacific has two phases: that of the Cretaceous and that of the Tertiary. The Cretaceous Pacific fauna included cosmopolitan Tethyan elements of now extinct corals, rudists, ammonites and belemnites. It was replaced by the Indo-Pacific biota which can be traced to the ancient seaway connecting the Mediterranean and Indo-Pacific from Triassic to Miocene time across what is now the Middle East and Pakistan. Its present center of diversity is in the Indo-Malayan archipelago. Indo-Pacific reef corals in the Hawaiian-Emperor chain appeared in the Oligocene; marine mollusks such as cowries occur contemporaneously in the Miocene of Indonesia, on Guam, Okinawa and Enewetak. Patterns of distribution among the islands are determined by habitat, degree of isolation, and oceanographic events. The last named have ecological implications resulting in, for example episodes of extinction and recolonization. These factors in turn affect diversity and perhaps account in part for low rates of endemism compared with the terrestrial biota of Pacific islands.

THE NATICID GASTROPOD PREDATOR-PREY SYSTEM: DYNAMICS AND EVOLUTION AS PRESERVED IN THE FOSSIL RECORD

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Extant naticid gastropods choose prey nonrandomly in accordance with an energy-maximization model. Previous work indicated that naticid predator-prey dynamics were well established by the Miocene; cost-benefit analysis successfully predicted prey choice of Chesapeake Group naticids, and selectivity of prey size and drillhole site occurred for most prey taxa. Key bivalve prey responded to naticid predation by increasing shell thickness, a strategy that successfully deterred naticid predation; however, a coevolutionary response by the predators could not be demonstrated.

Ongoing work examines the history of the naticid predator-prey system to determine if escalation occurred during the Cretaceous and Paleogene as previously predicted. Work to date reveals no clear trend of escalation. Cretaceous predation levels (8-19% for bivalves) are greater than those for earliest Paleocene samples (3%). Later Paleocene and middle Eocene samples have high predation levels (30%), while predation in the upper Eocene Moodys Branch averages only 10%. Certain taxa are consistently heavily drilled through the Cretaceous and Paleogene; these include lucinids, corbulids, arcoids, and turritellids. No clear trends of escalation in behavioral stereotypy are apparent.

DYNAMICS OF NATICID GASTROPOD PREDATION IN A LATE PLEISTOCENE FOSSIL ASSEMBLAGE FROM THE PALOS VERDES SAND FORMATION.

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Drilling predatory gastropods leave an abundant fossil record of their activities that is useful not only in investigating patterns of interaction in paleocommunities, but also in formulating and testing evolutionary hypotheses about the relationship between predator and prey species. A late Pleistocene fossil assemblage from the Palos Verdes Sand Formation of Costa Mesa, Orange County, California containing large samples of naticid drilled molluscs, especially gastropods, provides an opportunity to quantify aspects of predator prey interaction. In a three pound sample of collected material, there are nine genera of gastropods and five genera of bivalves that contain specimens with naticid boreholes in their shells. Of the gastropods, the most frequently drilled genera are Antiplanes, Nassarius and Olivella. The ratio of drilled to undrilled specimens for each group is as follows; Antiplanes 7/5 (58.3%), Nassarius 146/105 (58%) and Olivella 53/77 (47.6%). Of the bivalves present, the most frequently drilled genera are Corbula, Glycymeris and Donax. The ratios of drilled to undrilled for these groups are Corbula 1/11 (8.3%), Glycymeris 9/232 (3.7%) and Donax 35/1125 (3%). Plots of measurements of shell length against drill hole diameter and shell thickness against drill hole diameter in the valves of Donax test the prediction of a positive correlation between prey size and predator size. Results, R=0.4 for length vs. drill hole diameter, and R=0.5 for thickness vs. drill hole diameter, show a definite correlation. Data on predation frequency on specimens of Nassarius and Olivella relative to shell size, test the prediction that predation is selective. Results for Olivella, show that predation follows the size distribution of the population, indicating that there is no preferential selection by naticids for large sized prey items. In contrast, for Nassarius, results show a significant increase in predation frequency with size, suggesting that there is a size refuge for small specimens. Currently, another three pound sample of the same fossil material is being examined to see if similar results are obtained.

MYSTERY FLUKE IN MELANOIDES TUBERCULATA (GASTROPODA:THIARIDAE) IN THE SAN ANTONIO ZOO, SAN ANTONIO, TEXAS.

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The introduced thiarids, Thiara granifera and Melanoides tuberculata, are now both involved in trematode cycles in North America. Philophthalmus gralli, an Oriental eye fluke, was first reported in T. granifera in San Antonio, Texas in 1969 and in New Braunfels, Texas in 1975. In October, 1990, rediae and cercariae of a monostome fluke were discovered in M. tuberculata in the San Antonio Zoo. North American keys to trematodes place the cercariae in one of three families: Notocotylidae, Nudacotylidae, or Pronocephalidae; however, the mystery cercariae disagree with these family descriptions by having stylets (teeth) in the acetabulum, by not showing prominent adhesive glands, and by not forming metacercariae. These differences suggest that the fluke was introduced from another geographical area. To date, we are unable to find the host with the adult fluke. At some sites in the zoo, rates of infection are as high as 80% of the snails with populations of 300-400 snails/m^2. Additionally, M. tuberculata is here reported as an intermediate host for P. gralli in the zoo.

THE PALEOECOLOGY OF THE CHEMICALLY BORING BIVALVE GENUS LITHOPHAGA.

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The chemical-boring bivalve Lithophaga is a significant bio-eroder of coral reefs, but its fossil record is poorly understood. The mytilid genus originated in the Carboniferous. By the Triassic, the genus had evolved from a nestler to a chemical borer, coinciding with the rise of scleractinian corals. Lithophagids are now common around the world at low latitudes. Triassic morphologies are remarkably similar to recent ones. The major differences between lithophagids arise with changes in mode of life, particularly, adaptation to living versus non-living substrates. A study of Eocene lithophagids from Florida has revealed that this fossil species developed the ability to inhabit living coral, not just non-living substrates. This ability has been lost in modern Atlantic species, but occurs in certain Pacific species. Live-coral boring either evolved separately in Florida Eocene and in modern Pacific lithophagids, or was spread throughout the Tethyan seaway by larval transport.

RELATIONSHIPS BETWEEN DRILLING PREDATORS AND PREY IN AN EARLY PLEISTOCENE MOLLUSCAN ASSEMBLAGE FROM FIJI

KOHN, Alan J., and ARUA, Ingela

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Gastropods are often ecologically important predators, and those that drill the shells of their prey leave a quantifiable record of prey-predator interactions. Analysis of this record facilitates reconstruction of the trophic structure of fossil communities, a major goal of paleoecology. Assessment of the occurrence and types of boreholes in 2,596 shells of 360 molluscan species from early Pleistocene assemblages from Fiji indicated differential susceptibility to attack among species. Among gastropods, 61% of families, 54% of genera, 50% of species, and 26% of individuals were drilled. The drilling predators were naticids (20 species) and muricids (5 species). Almost all boreholes were complete, suggesting generally successful predation. The most abundant families in the assemblage are the Nassariidae, Turridae, Olividae and Naticidae; the Turridae, Costellariidae, Cerithiidae and Mitridae were most susceptible to drilling (>40% of individuals drilled). In contrast, only 10% of all bivalves in the sample were drilled. We also consider the importance of drilling and peeling predation as mortality factors, their relationship to prey shell size, form and sculpture, and comparisons with a nearby similar Recent community.

PARALYTIC SHELLFISH POISONING TOXINS AS A CHEMICAL DEFENSE IN THE BUTTER CLAM (SAXIDOMUS GIGANTEUS)

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Studies investigating the relative resistance of bivalve species to saxitoxin (STX), and the influence of STX contaminated clams on the feeding behaviors of three important vertebrate predators (sea gulls, fish and sea otters), strongly suggest that butter clams are able to utilize dinoflagellate toxins as a highly effective deterrent to predation. Action potential recordings indicate that the butter clam and the Washington clam (S. nuttalli) are 10-100 times more resistant to STX than four co-occurring bivalves (Mya arenaria, M. truncata, Tresus capax, Protothaca staminea). In feeding experiments with naive, free-ranging, wild Glaucous-winged gulls (Larus glaucescens), toxic butter clams were regurgitated in < 15 min, and non-toxic butter clams were never regurgitated. Gulls previously conditioned with toxic S. giganteus refused to eat either toxic or non-toxic butter clams, but would accept other bivalve prey. Gulls foraging at a chronically toxic site, took significantly fewer butter clams than at a non-toxic site. Stagehorn sculpins (Leptocottus armatus) also developed an aversion to toxic butter clams, but unlike sea gulls, were able to distinguish between toxic and non-toxic individuals. It is concluded that 1) neuronal resistance to STX has pre-adapted the butter clam to sequester paralytic shellfish toxin (PST), 2) siphon cropping by fish is the most likely mechanism to have driven the evolution of PST as a chemical defense in butter clams, and 3) once acquired, the ability to retain these highly lethal neurotoxins can be an effective defense against a wide range of vertebrate predators.

A PHYLOGENETIC ANALYSIS OF THE PULMONATE GASTROPODS AND ITS IMPLICATIONS FOR PULMONATE INVASION OF FRESH WATERS

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That freshwater basommatophorans had a terrestrial ancestor is a commonly proposed and long-held hypothesis of pulmonate evolution. The alternative hypothesis is that pulmonates invaded fresh waters directly from marine environments. To test these hypotheses, I conducted a phylogenetic analysis of 18 taxa (14 families of basommatophorans, 3 of systellommatophorans, and Stylommatophora) using 84 anatomical, conchological, and life history characters polarized against a hypothetical ancestor. The single most parsimonious tree formed by HENNIG 86 had a length of 198 and a ci of 0.56. The most parsimonious interpretation of changes in habitat is that pulmonates invaded freshwater once directly from the ocean and invaded land at least 3 times. All terrestrial invasions happened within a clade composed of Ellobioida, Trimusculidae, Systellommatophora, and Stylommatophora, which is the sister taxon to the freshwater basommatophorans.

PHYLOGENETIC RELATIONSHIPS IN THE SUBFAMILY ODONTOCYMBIOLINAE (GASTROPODA: VOLUTIDAE): PRELIMINARY RESULTS.

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Phylogenetic relationships are poorly known within the Volutidae, in spite of the relatively small number of species in the family. Phylogenetic analysis based on anatomical, radular and shell characters provides a hypothesis about the relationships at the generic level in the volutid subfamily Odontocymbiolinae. Outgroups considered are the genera Alcithoe and Nanomelon, subfamily Zidoninae. Accessory salivary glands loosely wound around the primary salivary glands represent a synapomorphy for Odontocymbiolinae + Zidoninae. The two subfamilies apparently constitute a monophyletic group within the Volutidae. The four odontocymbioline genera differ from the outgroup by the presence of a tubular extension in the anterior part of the stomach, closed sperm duct and prostate, and rachidian tooth with cusps well separated from the basal plate. Further transformation of these characters define the hierarchy within the subfamily, beginning with the more primitive genus: Miomelon, Tractolira, Odontocymbiola and Minicymbiola. Characters traditionally used in volutid systematics such as shell sculpture and the shape of basal lobes are homoplasies in the Odontocymbiolinae. The generic status of Minicymbiola is doubtful: no autapomorphies distinguish this "genus" from Odontocymbiola.

PLEISTOCENE EVOLUTION OF THE NORTH PACIFIC MOLLUSCAN FAUNA.

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During the Pleistocene epoch the molluscan fauna of the North Pacific Ocean were subject to numerous physical perturbations associated with the expansion and contraction of the polar ice sheets. Changing temperature regimes and sea level during this time provided almost ideal theoretical conditions for speciation and extinction. However, little of either appears to have occurred. Instead, range shifts, vicariance events, and immigration appear to have been the prominent features of evolution of the North Pacific molluscan fauna. Range shifts along the California coast have been extremely well-documented, and many Pleistocene fossil assemblages are characteristically referred to as either "cold" or "warm" water deposits. Conspicuous vicariance events center around the division of once continuous distributions into cognate taxa in the northeastern and northwestern Pacific Oceans. Immigration occurred from both South America as well as from the North Atlantic Ocean. In both cases however, emigration from the North Pacific is substantially stronger than immigration into it.

LATE CENOZOIC PALEOCEANOGRAPHY OF THE NORTH PACIFIC OCEAN

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Ever since the start of the Cretaceous, at least, the North Pacific Ocean has been dominated by a central gyre with equatorial and northern currents and eastern and western boundary currents. Major changes in tectonic and oceanographic patterns have not effected it. Thus, the North Pacific Ocean has not had biological interchange with other oceans, except through the Bering Straits. All interchange has been through migration with or against prevailing currents.

The intensity of oceanographic processes in the North Pacific has changed markedly at various times in the Cenozoic. The oceanographic history of the North Pacific Ocean, like the rest of the world's oceans, is intimately linked to the tectonic and oceanographic isolation of Antarctica near the end of the Oligocene. The circum-Antarctic current developed, restricting the efficiency of meridonal heat transport, and cold, Antarctic bottom water formed and invaded all ocean basins. Oceanic circulation and upwelling intensity increased through the Neogene, as glacial conditions expanded on Antarctica and ice shelves formed. Throughout the Neogene, the North Pacific experienced eutrophication around its margins and increased isolation in the central gyre. In the east and north, the faunas developed chiefly through in situ evolution because the southerly, cool, eutrophic eastern boundary current served as a barrier to migration from the south, and the cool waters of the northwestern Pacific prevented migration from the west.

THE PRELIMINARY REPORT ON THE PHYSA SPECIES BY USING ISOZYME TECHNIQUE (GASTROPODA: PHYSIDAE)

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In pulmonate snails, the Family Physidae is one of the four major families of the Superfamily Hygrophila. There are, at least 130 names in this family from the North American Continent alone, but only a few species are defined satisfactorily. The taxonomy of the family Physidae is in chaos; there is an urgent need to revise the family Physidae and find clear-cut characters to distinguish species. The objective of this study was to find the feasibility of using isozyme markers to identify species of Physa.

Horizontal starch gel electrophoresis was employed to compare populations of Physa collected from Colorado and Utah. Seven enzyme systems were examined and gene products of 24 presumptive loci were resolved. The multilocus genotype data were analyzed using the Biosys-1 computer program. The results indicate that the genetic variation revealed by electrophoresis will be useful in systematic studies of Physa at the species level.

A RE-EVALUATION OF THE ROLE OF MYTILUS CALIFORNIANUS IN A ROCKY INTERTIDAL COMMUNITY.

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In the rocky intertidal community of western North America mechanisms which prevent the mussel Mytilus californianus from occupying all available space, such as preferential predation, wave shear, and battering by logs, have long been considered responsible for maintaining the diversity of this community. However, an examination of mussel beds in California and Oregon revealed that virtually all species competitively inferior to M. californianus live on the shells of this mussel. Consequently, these species can co-exist with M. californianus even where it occupies all rock surfaces. This suggests that diversity is maintained not by mechanisms which remove mussels from the substrate, but because mussels supply their competitive inferiors with a refuge from competition.

In addition, an examination of the population dynamics of species common on both substrates showed that while growth and reproductive status were not affected by the type of substrate, both recruitment rates and survivorship were higher on mussels than on rock. Therefore, all else being equal, it is more beneficial to live on mussels than on rock.

NASSARIID GASTROPODS AS DESTRUCTIVE AGENTS IN MARINE FISH TAPHONOMY

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The voracious scavenging behavior of nassariid gastropods is well documented, but the direct physical and taphonomic effects of their feeding on carcasses is not well known. Feeding studies of Nassarius moestus (Hinds, 1844) on the intertidal mud flats near San Felipe, BCN, Mexico, show that they are primary destructive agents to fish carcasses, and provide clues in understanding the taphonomy of marine fishes in nearshore and intertidal environments. Nassariid gastropods affect fish taphonomy through skeletal disarticulation, exposure of skeletal elements to pre-depositional erosion, prevention of whole-body transport and deposition, and through differential dispersal of skeletal elements. The influence of nassariid gastropods on fish taphonomy is probably temporally and geographically extensive, since both bony fishes and nassariid gastropods co-occur circumglobally throughout the Cenozoic and in Recent environments. This study also reveals information about the feeding behavior and ecology of N. moestus .

MARINE MOLLUSKS OF ROCAS ALIJOS

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The Alijos Expedition of October 1990 was the first to collect mollusks from Rocas Alijos, an isolated remnant of a once larger volcanic island. Rocas Alijos is 185 nautical miles west of of Bahia Magdalena, Baja California Sur, from which it is separated by deep water. 165 species of mollusks were collected from intertidal to sublittoral depths by divers and by grab samples. At least six species are endemic new species and five others are shared only with Isla Guadalupe, a similarly isolated island to the north. The fauna is a mixture of Californian and Panamic elements. The affinity of the gastropod fanua is predominantly Californian and that of the bivalve fauna is primarily Panamic. Many Californian species have their southernmost records at Rocas Alijos. No Indo-Pacific faunal elements are known.

AGGRESSIVE AND REPRODUCTIVE BEHAVIOR OF CAPTIVE OCTOPUS BURRYI (MOLLUSCA: CEPHALOPODA).

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A number of immature Octopus burryi Voss 1950 were captured in Narragansett Bay, Rhode Island from August through November,1990. Apparently these individuals were transported north of Cape Hatteras as planktonic paralarvae, which settled out locally and assumed the benthic adult life style. A pair was captured by the author and maintained in the laboratory for nearly 3 months. Although the male outweighed the female by 50% initially (33g vs. 19g wet wt.), the female rapidly assumed and retained dominance thenceforth. After some 60 days the female outweighed the male by 50% . Copulation was first observed for this species, beginning about 3 weeks prior to the onset of spawning. Total egg biomass (71 g) was some 41% of the female's maximum pre-spawning biomass. The eggs proved fertile, but no hatchlings survived more than a week. Photographic documentation of a variety of O. burryi behavior and color patterns will be presented and compared with those of related species.

LATE CENOZOIC EVOLUTION AND DEVELOPMENT OF THE NORTH PACIFIC MOLLUSCAN FAUNA

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The molluscan fauna of the high-latitude North Pacific changed dramatically during the late Cenozoic. Faunal changes occurred in response to both worldwide and regional warming and cooling trends, as well as to paleogeographic and tectonic events.

The main worldwide climatic events were warm peaks in the early middle Miocene, late Miocene, and Pliocene. These introduced relatively warm-water taxa to northern latitudes. The main cooling event was the onset of northern hemisphere glaciation at the end of the Pliocene and continuing to the modern day.

Tectonic plate movements in southern Alaska caused uplift of coastal mountains, which led to glaciation in the Gulf of Alaska starting in the earliest middle Miocene (ca. 15 Ma). This regional glaciation began at the peak of worldwide Neogene climatic warming. Northward incursions of warm-water mollusks into this cold-water region were El Niño-like events that aid in dating the relatively endemic northern cold-water faunas.

The opening of Bering Strait during the Pliocene (ca. 3-4 Ma) produced the only direct connection between the Arctic and Pacific Oceans since the Middle Cretaceous (Albian), about 105 million years ago. This opening left a distinct faunal signal, because it introduced a large number of Pacific species into the Arctic and a few Arctic species into the Pacific. The North Pacific molluscan fauna has remained essentially the same following the opening of Bering Strait and the subsequent onset of northern hemisphere glaciation.

MEIOCARDIA OF THE INDO-WESTERN PACIFIC AND THE WESTERN ATLANTIC.

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Meiocardia is a very small group of the Glossidae. Fossil species of Meiocardia are reported from the Tertiary sediments of Europe and U.S.A., but living species are only known from the Western Pacific and the Western Atlantic. Present classification of the Western Pacific species is confused and it will need to review them.

Meiocardia moltkiana of Japanese authors is not the species of Gmelin (1791), but is identical with M. sanguineomaculata (Dunker, 1882). M. moltkiana (Gmelin), the type species of Meiocardia, has a higher shell with strong concentric ribs and is a species distributed from Taiwan to the Red Sea. M. lamarckii of Japanese authors is not the species of Reeve (1845), but is possibly assignable to M. cumingii (A.Adams, 1864). There is no confusion of identification of M. vulgaris (Reeve, 1845) and M. tetragona (A.Adams & Reeve, 1850). Syntypes of the former are stored in the Natural History Museum in London. Descriptions of two new additions to Meiocardia species from the Philippine-New Caledonia and Seychelles are prepared. The Philippine-New Caledonia species with two secondary dorsal ridges has a very close resemblance to M. agassizii Dall, 1889 of the Western Atlantic, which also has the secondary dorsal ridges. The Seychelles species has very strong concentric ribs and is referable to M. moltkiana of Buelow (1906), not of Gmelin (1791).

CLADES VS. GRADES IN BIVALVE CLASSIFICATION - SOME EXAMPLES FROM THE TELLINACEA

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Supraspecific classification in the Tellinacea is hindered by inadequate descriptions of many type species, by unsatisfactory diagnoses, and by uncertainties about polarities of many character-states. Even the traditional subdivision of Tellinidae into 2 subfamilies is questionable as it seems that lateral teeth have become lost independently in several different clades. Worse, the main criterion by which Scrobiculariidae and Semelidae are separated from Tellinidae, i.e. the presence in the 2 former taxa of an internal resilium seems equally flawed. Five pairs of genera, the first with an external, the other with an external resilium, are examined - Peronaea/Scrobicularia, Arcopagia/Semele, Moerella/Semelangulus, Pinguitellina/Abranda, and Cadella/Semelina. Except for ligamental differences, the members of each pair are very similar to each other. In particular, the last-named pair share an unusual shell character - the cardinal teeth diverge not from the beak, but from a point in front. It seems more likely that an internal resilium has evolved independently in at least 5 different clades; the alternative, that the resemblances result from convergence, is less probable. This implies that Scrobiculariidae and Semelidae cannot be satisfactorily segregated from Tellinidae.

PATTERN FORMATION IN CYPRAEID GASTROPODS: SUPPORT FOR DIFFUSION-REACTION MODELS

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The determinate growth mode and adult pigmentation patterns exhibited within the cypraeid group provide a system for testing hypotheses concerning pattern formation during shell secretion in mollusks. Color patterns developed on the prograding margin during juvenile shell growth can be modeled by both a diffusion-reaction and a neural sensory hypothesis. However, infrequent aberrations seen in adult color patterns favor the diffusion-reaction model to the exclusion of any pre-sensory aspect during shell biomineralization. Because adult pattern formation occurs relatively instantaneously during shell formation, disruptions in this system allow a test for the realignment of mantle secreting cells. Non-alignment seen in specimens with disrupted adult patterns indicates that the "tasting" of the previous material does not occur. Both *Cypraea cribraria* and *C. arabica* display a direct one-to-one correspondence between mantle papillae and underlying color markings. A heterogeneous condition within the hemolymph may be established by the irregularity of the outer epithelial papillary surface that creates a condition for non-random pigment expression. Diffusion-reaction models require such heterogeneous conditions along initiating surfaces. Thus, a two-dimensional diffusion-reaction model is adequate to explain the adult markings in cypraeids. This model establishes a heterogeneous condition distal to the surface of secretion within the hemolymph derived from the irregular papillary surface. Simultaneously, a field of activation is generated that reads these incongruities and deposits pigments accordingly. Historically, when compared to other related groups (Ovulidae and Velutinacea), the cypraeids have developed these color patterns recently as a result of both gaining papillae and depositing a final adult shell layer. This study emphasizes the importance and benefit of seeking explanations for aberrations in order to better understand more general processes.

ELECTROPHORETIC AND ANATOMICAL DIFFERENCES IN LAVIGERIA: DIVERGENCE IN AN AFRICAN RIFT LAKE ENDEMIC GASTROPOD

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Although the gastropods of Lake Tanganyika provide one of the best examples of the spectacular endemic radiations that characterize some rift lakes, their evolutionary relationships are poorly known. To understand the mechanisms of lacustrine speciation, I am investigating the relationships between morphs in the genus Lavigeria (Thiaridae). This genus is extremely diverse both morphologically and genetically. Electrophoretic data supports the distinction of many of the morphs into separate species. Morphologically similar animals from widely separated areas share unique alleles. Sympatric snails of different morphologies are not related in most cases. However, I found examples of both morphological convergence (genetic differences between populations exceed morphological differences) and morphological divergence without genetic separation. Consequently, the genus Lavigeria may contain about twelve species, not the currently described two.

Because anatomy is the traditional taxonomic tool for fresh water gastropods, I analyzed 28 characters, both qualitatively and statistically, to look for species differences. I found a unique gland in the foot at the base of the female's ciliated groove in the deep water species. No other size-independent variable assorted with shell morphological differences. In the case of Lavigeria, divergence of genetic and shell morphometric characters is not coupled with anatomical changes.

THE "YOYO CLAMS" OF FLORIDA, AND A DISCUSSION OF SYSTEMATIC CHARACTERS IN GALEOMMATIDAE.

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Five new species of the galeommatid genus Divariscintilla have been discovered in eastern Florida. All five are commensal with a single species of mantis shrimp on shallow-water sand flats, and are known to co-occur within the extensive burrows of the shrimp. The only other known member of the genus is the type species, D. maoria Powell, also an inhabitant of mantis shrimp burrows, in New Zealand.

Anatomical description of the five Floridian species has included an interesting suite of complex characters, presumably reflective of the clams' specialized habitat. Several of these ("hanging" foot morphology, "flower-like organs") are also known from species assigned to other genera, currently placed in other families. With present taxonomy of the superfamily still largely dependent on hinge and ctenidial characters, the status of these interesting specializations has come into question.

A cladistic analysis (using Hennig86) has been conducted on anatomically well-known species in the family Galeommatidae (including Galeomma, Scintilla, Ephippodonta, Divariscintilla, Phlyctaenachlamys, Vasconiella, and others), plus selected members of other galeommatoidean genera. Characters analyzed involved the shell, mantle, foot, ctenidia, digestive system, reproduction, and ecology. Results to be discussed will examine the relative systematic value of various characters, comment on generic and familial definitions, and indicate critical species in need of closer scrutiny.

FINE SCALE DIVERSITY PATTERNS IN FRESH-WATER MOLLUSCAN FAUNAS - A TOOL FOR ASSESSING MASS EXTINCTIONS.

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The end Cretaceous extinctions have attracted considerable attention in the last decade. Evidence exists for a catastrophic physical event closely associated with the Cretaceous-Tertiary (K-T) boundary. However, determination of a causal linkage between physical events, such as bolide impacts, and extinctions is not a trivial exercise. The disturbance of modern communities is typically associated with declines in ecological diversity. Such declines are reflected in both the total number of species (Richness measures) and the proportional abundance of species (Evenness measures). Fossil fresh-water molluscan communities have lower diversities and occur across fewer rock types than fossil marine communities. These characteristics allow diversity to be calculated from fresh-water molluscan assemblages with smaller sample sizes and with a reduced taphonomic noise as compared to marine assemblages. I present here evidence that declines in measures of the proportional abundance of fresh-water molluscan species sampled from individual stratigraphic horizons can be observed as one works up-section towards an extinction event. This pattern of a gradual decline in diversity appears in the Pliocene extinction of an endemic fauna from an African rift lake in the Edward-Albert basin. In contrast, no such diversity decline appears in the fresh-water molluscan fauna of the latest Cretaceous Hell Creek formation in Montana. Most studies of diversity at extinction events have used species ranges and richness to measure diversity. Such range-based data are subject to considerable sampling problems. The examination of proportional abundance of species in samples from individual horizons is immune to many of the sampling problems inherent in range-based data.

SEASONAL VARIATIONS IN BROOD SIZE AND LARVAL SIZE OF LASAEA cf. UNDULATA (BIVALVIA) IN HONG KONG

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Monthly samples of Septifer virgatus were examined for Lasaea cf. undulata. Each individual obtained was measured to the nearest 0.1 mm and dissected. Individuals brooding shelled larvae were isolated, broods counted and larval shell lengths measured to the nearest micron.

In Hong Kong, Lasaea cf. undulata produces two broods each year, in spring (May) and autumn (October to December). Spring parents brood large numbers ($\sim$120.parent^{-1}) of longer ($\sim$320-330 µm) larvae; autumn parents brood fewer (< 50.parent^{-1}) numbers of smaller ($\sim$300-320 µm) larvae.

O'Foighil (1986) has suggested for the similarly brooding Lasaea subviridis that prodissoconch morphology is environmentally regulated such that brooded larvae of intertidal parents have a Prodissoconch II morphology whereas individuals brooded by submerged parents only develop a Prodissoconch I morphology.

This study of Lasaea cf. undulata suggests that variations in brood size and larval size, and thus morphology, results from seasonal differences in environmental factors, possibly acting upon the larvae but, more likely, upon the parents and thereby indirectly upon the brood. Brood size and larval size are thus likely to vary not just seasonally, but across the spectrum of populations encompassed by the species range.

TEMPORAL CHANGES IN THE ABUNDANCE OF THE CLAM MACOMA BALTHICA ON AN INTERTIDAL MUDFLAT IN PORT VALDEZ, ALASKA.

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The bivalve Macoma balthica is the dominant large infaunal species at Dayville Flats at the head of Port Valdez, Prince William Sound. The distribution of this clam correlates with lateral variation in lithofacies, from low abundance values in the gravelly-sandy beds in the western end of the flats to highest values in the muddier eastern end. The bivalve occurs in its greatest numbers in muddy substrates in the upper and middle intertidal zones in the eastern section of the flat. Time-series samples, initiated in September, 1989 demonstrate reduced abundance of M. balthica as compared with abundance values recorded in an earlier study in 1974-1977. The reason for the decline is being examined in the context of changes in substrate and relative changes in freshwater imput on the flat subsequent to construction (in 1974) of a road, along the upper shore of Dayville Flats.

LEAF-LITTER MALACOFAUNA OF A TROPICAL RAIN FOREST. PRELIMINARY RESULTS.

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Snails are known to be part of the leaf litter fauna. Then, which snails are there? To answer this question, 30 x 30 cm of leaf litter samples have been taken monthly (April 1990 to April 1991), under the cover of four trees (2 of Ficus yoponensis and 2 of Nectandra ambigens) in a Tropical Rain Forest of SE Mexico.

Preliminary results show 13 families and 12 genera present in the leaf litter of both trees, most of them are micromollusks, some young specimens of large snails (Euglandina, Streptostyla). Nonetheless, live specimens are scarce. Fauna has cosmopolitan (Hawaiia minuscula), tropical (Guppya, Karolus, Cecilioides), and a weak holoarctic (Punctum) components. The fauna from each type of leaf litter will be compared, afterwards a second question will be addressed: Are snails involved in the leaf litter decomposition processes?

ENVIRONMENTALLY-CORRELATED INTRASPECIFIC VARIATION IN PRUNUM CONIFORMIS FROM THE NEOGENE OF THE DOMINICAN REPUBLIC.

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Adult size and overall shell morphology are commonly used to recognize species of marginellid gastropods. We analyzed shell form in three fossil marginellid species from the Neogene of the Dominican Republic: Prunum coniformis, P. latissima and P. maoensis. The three species are found in separate geographic regions and characteristically different paleoenvironments. All three share discrete shell characters, but vary in shell size and shape. Samples of very small P. coniformis occur in shallow (<10-20m), probably brackish deposits with sandy substrates. Stout, thick-shelled samples of P. maoensis and P. latissima occur exclusively in high-energy, nearshore, sandy deposits, with frequent pebbles. Deeper marine deposits (>20 m) contain abundant large P. coniformis. Morphological variation among species is continuous. We can detect no temporal pattern in the variation.

The variation among these fossil species is strikingly similar to that found within single modern species in this genus. The continuous nature of variation among these three fossil species, the association of different morphologies with different paleoenvironments, and the similarity to variation that occurs within individual modern species, indicates that "P. latissima" and "P. maoensis" were probably high-energy forms of P. coniformis. The extent to which this environmentally-correlated variation was genetically versus ecophenotypically controlled is unknown. This example highlights the importance of paleoenvironmental information to species-level interpretations in the fossil record.

EVOLUTION OF THE BIVALVE GENUS LASAEA

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Present results indicate that sexual members of the marine bivalve genus Lasaea with planktotrophic larval development are much less successful than their direct-developing, asexual congeners. I have constructed a set of alternate hypotheses to explain how this biogeographic paradox may have evolved. To test these hypotheses I am reconstructing intrageneric evolutionary and biogeographic relationships using mitochondrial DNA genotypes. I am presently sequencing a mitochondrial gene, Cytochrome Oxidase III, from a variety of Lasaea populations. The aims are to characterize phylogenetic relationships in this genus on a global scale and to look for evidence of transoceanic rafting by direct developers.

RADULAR VARIABILITY IN THE HERBIVOROUS MESOGASTROPOD LACUNA: INTRA- AND INTERSPECIFIC PATTERNS.

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Variability in the shapes of radular teeth is uncommon within species of herbivorous gastropods. However, such variability has been reported for several species in the genus Lacuna, all of whom live on and consume marine macrophytes. The degree of tooth shape variability reported is as extreme as that seen among species in other groups and probably influences the functional ability of these radulae to rasp different algal food items. This reported variability could be the result of sibling species, hybridization among closely related species, ontogenetic changes in radular morphology within species, genetic polymorphisms within species, or phenotypic plasticity within individuals. Protein electrophoresis and morphological analyses (of shell and radular characteristics) are being used to test among these alternatives for a variety of North American and European species of Lacuna. Initial results indicate that for some species this variability is not due to hybridization or an ontogenetic change in morphology and can be phenotypically plastic within individuals.

BIOGEOGRAPHY AND SYSTEMATICS OF POLYGYRA, LAND SNAILS FROM WESTERN MEXICO AND SOUTHERN U.S.A.

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While working on descriptions of new species of land snails from Mexico, we noted that the systematics of Polygyra, having over 70 species, needs to be revised. Shell and genital characters in a cladistic analysis produced a phylogenetic hypothesis differing from traditional classifications in several important details. The undescribed Mexican Polygyra are members of a western Mexico group of species. Biogeographical analysis supports the idea that western Mexican Polygyra are derived from Polygyra in southern U.S.A. Future phylogenetic analyses of this group will incorporate molecular data being gathered by other malacologists.

THE AUSTRALASIAN PROTOCARDIINAE REVISITED.

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The Protocardiinae are the oldest representatives of the family Cardiidae, with a fossil record extending back to the Triassic. This relict group now occurs mostly on the outer shelf and upper continental slope, and the Western Pacific is the area of maximum diversity.

Based on an extensive suite of material from the Cenozoic and Recent of the Indo-Pacific, the Australasian species of Protocardiinae are reevaluated in terms of taxonomy and biogeography. Five Recent Australian and one New Zealand species have been recognized and are traditionally allocated to *Nemocardium* (*s.l.*).

Considering its characteristic sculptural pattern and restricted Australian-New Zealand distribution since Cretaceous, I recognize *Pratulum* as a distinctive genus. Reports of its occurrence in tropical locales are the result of misidentification and/or confusion with related genera. Fossil Australian species have also been erroneously referred to *Pratulum*, and the claim that it represents a Tethyan Indo-Pacific element appears unfounded. I recognize two Recent Australian (one undescribed) and one New Zealand species of *Pratulum*.

The genera *Microcardium* and *Trifaricardium* are here reported for the first time in Australasia, with one new species each in Australia and New Caledonia. The other Australian species are classified in *Lyrocardium* and *Frigidocardium*, with a single species remaining in *Nemocardium* proper.

PRELIMINARY REVIEW OF HOLOCENE AND PLEISTOCENE NORTHEASTERN PACIFIC GLYCYMERIS

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Of the eight species names used for Holocene and Pleistocene northeastern Pacific Glycymeris, only two are valid: G. septentrionalis (Middendorff, 1849) [Syn. G. barbarensis of authors, not of Conrad, (1857), G. corteziana Dall, 1916; G. guadalupensis Strong, 1938; G. migueliana Dall, 1916; G. profunda (Dall, 1878); G. subobsoleta (Carpenter, 1864)] and G. keenae Willett, 1943.

The name Glycymeris barbarensis has been applied to Pleistocene and modern specimens from southern California over the past 90 years. Recently rediscovered specimens believed to be the primary types at the Academy of Natural Sciences of Philadelphia have been tentatively identified as G. major (Stanton, 1896), a Paleocene to Eocene fossil from California.

Glycymeris keenae is extant only at Forrester Island, Alaska. This species is small, with a rounded-trigonal outline and only concentric sculpture. Several lots from Monterey Bay, central California, are considered fossil because of their state of preservation. Fossil mollusks from a late Pleistocene sea-level lowstand are commonly dredged from this area of the California coast, and so these specimens are referred to this lowstand. This species ranges in age from latest Pleistocene to Holocene.

Glycymeris septentrionalis is a very variable species, as indicated by its list of synonyms. Specimens from a single locality show a narrow range of variability in the shell outline, the size and shape of the hinge, and the thickness of the shell, but over the geographic range of the species all shell features vary considerably. This species ranges geographically from the type locality at Chirikof Island (=56°N.) in the western Gulf of Alaska southward to Rocas Alijos (25°N.), Baja California Sur, Mexico, and has been reported from faunas as old as Miocene.

REPRODUCTIVE ECOLOGY OF THE ANTARCTIC PHILOBYRID BIVALVES.

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With growing threats to the relatively pristine ecosystem of Antarctica, it is imperative that we quickly examine the present malacofauna and the ecological "sanctity" of the moment. The philobryid bivalves offer an excellent group of molluscs for the determination of reproductive ecology of a widely distributed Antarctic component. With several circumantarctic species, these small bivalves compose a family of brooders that release their young at a late juvenile stage. A monomyarian condition and correspondingly large pallial cavity allow for broods of between 16 (Lissarca notorcadensis; deeper water, often found epibysate on echinoid spines) and up to 70 (L. miliaris; shallow water, often found epibyssate on algal fronds and rocks) early dissoconch juveniles. The small prodissoconch I and large prodissoconch II is atypical of brooding bivalves and likely represents a plesiomorphic trait from nonbrooding arcoid ancestors.

Viviparity in Antarctic fauna appears to be a common phenomenom but our understanding of this stems from studies of relatively few organisms. Undoubtedly the philobryids are well adapted to brooding but this is not necessarily an adaptation to polar conditions but instead could be a conservative trait reflective of the group's phylogeny. Future studies will determine the relationship between polar habitats and brooding behavior.

PRELIMINARY IDEAS TOWARD A REVISION OF THE OVULIDAE (GASTROPODA: CYPRAEACEA)

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About 400 specific and 65 generic names have been given to living ovulids. Taxonomy of the Ovulidae is in disarray as almost all taxa have been named on the basis of shells alone. Cate, the last worker to monograph the group, recognized about 240 species.

Comparative studies of large suites of specimens show many Indo-Pacific species to have much broader geographic ranges than previous thought; there is little endemism. Size, shape and color of ovulids are often affected by their hosts. Many species are highly variable and have been named several times as a result. I currently recognize about 160 species in the family.

Generic level revision of ovulids must be based on anatomical and biochemical studies. The anatomy of only a few species has been reported. Published photographs of live animals and radulae are useless unless the corresponding shells are illustrated, or deposited in a museum; almost half of the identifications of ovulids in the literature are incorrect. Of the 65 available generic names, 16 are invalid by synonymy of the type species with that of another genus. Another dozen might be synonymized on the basis of current knowledge of the animals.

SAN NICOLAS ISLAND MACROINVERTEBRATES: PAST AND PRESENT

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Although various studies have focused on intertidal marine life of San Nicolas Island, no comprehensive collection of modern macroinvertebrates has been conducted on this island. I compared modern and Pleistocene Age (120,000 years B.P.) macroinvertebrates of San Nicolas Island, the outermost of the eight Channel Islands located off the coast of southern California. From 24 August 1990 to 28 February 1991, I conducted a comprehensive sampling of beach casts on specific beaches and in tide pools. Modern molluscan, cirriped, and echinoderm species were collected and identified. In total, 146 species of macroinvertebrates were sampled. I identified 90 gastropods, 2 chitons, 45 bivalves, 1 cephalopod, 4 echinoderms, and 4 cirripeds.

With a few exceptions, the modern macroinvertebrate fauna collected on San Nicolas Island resembled the native Pleistocene deposits dated by Norris and Vedder (1963).

DEVELOPMENT OF THE LAND MOLLUSK FAUNA OF THE NORTHEAST PACIFIC RIM.

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Land mollusk faunal "physiognomies" along the northeast Pacific rim have changed since the early Tertiary. Early middle Eocene land snail fossils from the Santiago Formation, San Diego County, California, have shell height (h) and diameter (d) relationships differing from any found in the Recent land mollusk fauna of California or other northern hemisphere faunas. Similar h,d values are found in the Recent Helicostylinae of the Philippine Islands and Papuininae of northern Australasia. Both Helicostylinae and Papuininae represent endemic radiations on island groups in wet tropical forest. The Santiago Formation fossils may represent such a radiation, and suggest climatic and isolational settings similar to the present-day Philippines.

THE EARLIEST BIVALVES AND THEIR ORDOVICIAN DESCENDANTS

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Replicated shell microstructure in a specimen of Fordilla troyensis from the Early Cambrian of Greenland confirms a close relationship between Fordilla from the North Atlantic region and Pojetaia from the Early Cambrian of Australia and China. These genera may be best regarded as stem-group bivalves in that they probably predate the latest common ancestor of living members of the class. Two other bivalved molluscs from the Middle Cambrian (Tuarangia and Pseudomyona) had D-shaped valves, a single adductor muscle, and shells formed of foliated calcite; they have been interpreted either as early pteriomorphs or as bivalved monoplacophorans. They may, in fact, be larval bivalves. The challenge is to relate these Cambrian taxa to the members of the modern subclasses and orders of the Bivalvia which first appear in Ordovician strata.

MODERN DEATH ASSEMBLAGES AS A TAPHONOMIC TOOL: EVIDENCE FROM SAN NICOLAS ISLAND, CALIFORNIA.

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As every student of paleontology learns, fossils are but remaining threads of the once luxuriant tapestry of life. Quantifying the "death decay and disintegration" of living assemblages should aid in reconstructing the ecological patterns of extinct faunas, for the death assemblage is the raw material of the fossil record.

I compared four subtidal death assemblages from two habitats, with four adjacent fossil assemblages on San Nicolas Island, California. All fossil assemblages were sampled from the second emergent marine terrace that is correlated with substage 5e of the marine oxygen isotope record (~120,000 years ago). The death assemblages represent two distinct communities that are found in sandy beach, and rocky shore, environments. Death assemblages were found accumulating throughout the rocky shore habitat, whereas sandy bottom death assemblages were only found in localized sediment traps adjacent to sandstone benches or boulders. There were 64 species recovered from the fossil assemblages, 68 from the death assemblages, and 39 species were common to both. A comparison between the Pleistocene fossil assemblages and modern death assemblages reveals that habitat or substratum type can be inferred from relative abundance measures of the species present.

A PRELIMINARY ANALYSIS OF A HYBRID ZONE BETWEEN MYTILUS TROSSULUS AND MYTILUS GALLOPROVINCIALIS

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A genetic analysis of Mytilus populations from the coast of California was conducted using protein electrophoresis. The focus of the study was intergradation and hybridization between Mytilus trossulus and M. galloprovincialis. Mussels from several habitat types were analyzed in an effort to understand the factors that maintain this hybrid zone. Principal component analysis was used to classify individual mussels as M. trossulus, M. galloprovincialis, or hybrids. Populations north of Cape Mendocino were pure M. trossulus. A mosaic of hybrid populations occurred between Cape Mendocino and Point Conception, and south of Point Conception populations were pure M. galloprovincialis. The potential factors maintaining this hybrid zone will be briefly discussed.

WHAT DO WE KNOW ABOUT CRETACEOUS PACIFIC SLOPE VENERID BIVALVES?

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The family Veneridae evolves out of the Arcticidae during the Cretaceous. Studies to date suggest that various venerid genera evolved from different arcticids and the family is polyphyletic in the sense that it did not arise from a single arcticid progenitor.

A review of all of the known Pacific Slope Cretaceous venerids suggests that very few have been adequately studied. Furthermore, as shallow water faunas of some ages have yet to be studied, the possibility of finding more new species and genera is large. None of the other Pacific Slope genera may prove to be as well represented as is Calva Popenoe, 1937, which can be divided into four subgenera and 16 species. Geographic occurrences of two of the subgenera suggest that one is more thermophilic than the other, and the changes in their distributions may reflect broad climatic fluctuations.

Other genera, such as Tenea Conrad, 1870, which ranges from Albian to Maastrichtian but is represented by only one described species, should when studied increase the number of Cretaceous species. Tenea was placed in the Arcticidae in the Treatise, but Tenea inflata (Gabb, 1864) has a corbiculoid hinge and a fairly deep pallial sinus, suggestive of the Veneridae.

THE APLACOPHORA AS PROGENETIC ACULIFERA

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Progenesis is proposed as the evolutionary process by which the Aplacophora acquired a highly derived worm shape while retaining an apparently primitive internal organization. Evidence for progenesis is (1) developmental ease of acquiring a worm shape through elongation of an embryo; (2) similarity in internal organization between less and more elongate species; (3) lack of internal specializations in contrast to the vermiform chiton Cryptoplax; (4) small size of most Aplacophora, important in the deep sea, and probably early maturation; and (5) presence of character states which are less developed that those of homologous characters in other mollusks.

An archimollusk is proposed with the plesiomorphies of metamerism and a dorsal cuticle stiffened by $CaCO_3$ but without organized external shell or spicules. The Conchifera (shelled mollusks including Monoplacophora) took separate evolutionary pathways to externalize $CaCO_3$ as shown by the ontogeny of shell in the Conchifera and spicules and shell plates in the Aculifera. Both groups were derived independently from nonaculiferan ancestors. The spicules of Aplacophora and Polyplacophora are therefore considered to be a synapomorphy and the shell plates of Polyplacophora an autapomorphy. The resulting cladogram allows Monoplacophora to evolve at the same time or earlier than the Aculifera, which retained some metamerism in the chitons but lost it in aplacophorans through progenesis.

NORTH PACIFIC APLACOPHORA

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Aplacophoran mollusks have been collected in the North Pacific from 20 m to hadal depths over 7,000 m, and from the sublittoral of the nutrient-rich east Pacific coast to the abyss beneath the oligotrophic North Pacific gyre. Aplacophora occur at all hydrothermal vents and also upon guyots. Some species are apparently stenotopic, but others live in physically stressed environments. A few species are very widely distributed, but most insofar as known have restricted geographic ranges. Although the total number of species in the North Pacific is small, less than 70 published species, the group persists in all continental shelf and deep-sea environments.

CLADISTIC PHYLOGENY OF THE CARDIID BIVALVES

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Previous classifications of cardiids have been based on a small number of key characters, or have been superficaially based on shell shape. The phylogeny of Kafanov and Popov was based on 1) morphology of the stomach, and 2) shell microstructure; similar shell shapes evolve independently in different lineages.

A cladistic analysis is undertaken using most recognized fossil and Recent cardiid and tridacnid genera and subgenera. The carditids Cardita and Cyclocardia are outgroups. Morphology of the entire shell and soft part anatomy are studied, including: labial palps, ctenidia, foot, byssus, siphons, tentacles, stomach, and gut. Cardiid anatomy is very conservative. Most phylogenetic information comes from the complex shell, notably the hinge, ribs, and ornamentation. Cardiid shell microstructure is found to be remarkably uniform.

The Protocardiinae is the sister taxon to the rest of the family. The Cardiinae sensu Keen is paraphyletic: Plagiocardium is the least derived member of the Clinocardiinae, and Parvicardium is the least derived member of the Fraginae, which also includes tridacnids. Keen's Laevicardiinae is polyphyletic and should be abandoned: Laevicardium is a protocardiine, Cerastoderma belongs with the Lymnocardiinae (the sister taxon of the Fraginae), Dinocardium is allied with the cardiine Vepricardium; remaining members belong in the Clinocardiinae. The Trachycardiinae is a monophyletic taxon.

SYSTEMATICS EVOLUTION AND GEOGRAPHICAL DISTRIBUTION OF THE GENUS MYTILUS

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Despite their scientific and commercial interest and their widespread distribution throughout the cooler waters of both northern and southern hemispheres, the taxonomy of mussels belonging to the genus Mytilus remains controversial. This paper reviews the systematics of this group albeit with particular emphasis on the smooth-shelled mussels of the M.edulis complex and stresses throughout the need for a multidisciplinary approach. Multivariate analysis of allozyme and morphometric data obtained for mussels worldwide now provides compelling evidence for the existence of three distinct evolutionary lineages - M.edulus, M.galloprovincialis and M.trossulus. No single taxonomic character discriminates unequivocally between these taxa though certain characters, either individually or in combination, are virtually diagnostic. All three lineages occur in northern waters but only M.edulis and M.galloprovincialis have so far been recorded from the southern hemisphere. Whether these taxa are accorded full specific status will require an agreed operational definition of biological species. Future research should focus on the biological mechanisms that maintain the distinctive characteristics of these mussels across vast distances despite the occurrence of hybridisation and the massive potential for larval dispersal. The origin, evolution and global distribution of mussels within the genus are briefly discussed.

KEEPING UP TO DATE ON PANAMIC PROVINCE BIVALVE LITERATURE.

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Over 170 papers have been written since 1971 that affect Panamic Province bivalve taxonomy and/or distribution. The genus has been changed for 113 species of bivalves. Twenty-three new species have been described. Forty-one species previously known from other parts of the world are now known to occur within the Panamic Province. Twenty-nine other species have been added to the total known fauna. During the same time period, 37 species, which were listed earlier, were deleted.

PATTERNS OF DISTRIBUTION OF OSTREOID BIVALVES ALONG THE WESTERN COASTS OF AUSTRALIA

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The ostreoid fauna of western Australia is dominated by species of Indo-West Pacific regional affinity.

The distributional patterns of these species, and of those of members of the overlapping southern Australian fauna, appear to reflect the geological history of the continent and its waters, and the present climatic regimes, current systems and available habitat types.

It is inferred that the temporal variability of species' range limits is related to that of the south-flowing Leeuwin Current and of its inshore counter-current. The sparse data on biotic factors involved in such relationships are reviewed.

BIVALVIAN MACROSYSTEM BASED BOTH ON CONCHOLOGY AND ON ANATOMY.

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The primary branches of the class are characterized by general structural types of dentition, gills and stomach. They are superorder Nuculiformii (=Protobranchia), Mytiliformii (=Autobranchia), Conocardiiformii (=Septibranchia). The first superorder is divided into orders Nuculiformes and Solemyiformes (each with 2 suborders) on the basis of dentition, and structure of the gills and stomach. The superorder Mytiliformii is divided into eight orders on the basis of dentition (and sometimes presence or absence of anterior dorsal margin), partly the structure of the gills and heart, and the structure of the stomach. These orders are (number of suborders in brackets): Unioniformes (3), Mytiliformes (2), Pectiniformes (2), Pholadomyiformes (3), Hippuritiformes (2), Luciniformes (4), Carditiformes, Cardiiformes (5). The superorder Conocardiiformii is divided into four orders on the basis of shell shape, structure and function of the septum and stucture of the stomach. The extinct order Conocardiiformes is included here on the basis of presence of septal muscle impressions. These four orders are: Verticordiiformes (2), Conocardiiformes (3), Poromyiformes, Cuspidariiformes (2 suborders, Dallicordioidei is perhaps an independent order).

A NEW SPECIES OF *LOTTIA* Gray, 1833 FROM THE NORTH-EASTERN PACIFIC.

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An undescribed species of *Lottia* Gray, 1833 has been identified from rocky shore communities in central and northern California. This new *Lottia* sp. has previously gone unrecognized as its shell color patterns and sculpture resemble those observed in the polytypic species, *Lottia ochracea* (Dall, 1871). The lottiid radula is diagnostic at the species level and while *L. ochracea* and the new species are difficult to distinguish using conchological features, radular characters unequivocally demonstrate that *L. ochracea* and the new lottiid are distinct taxa.

There are at least two ecological forms of the new *Lottia* sp.--a tessellate form and a solid form. These two forms may be common on smooth bare rocks in the middle to low intertidal. They also occur subtidally. There is limited evidence for epizoic and coralline forms, as well. A single specimen has been found at a depth of 15 feet on *Tegula brunnea* Philippi, 1848. In lottiids, changes in shell color pattern may indicate movement of individuals between different substrata. The fine reticulate pattern at the apices of many solid forms suggests that these individuals may be moving from coralline substrates to the smooth bare rock substratum on which they are commonly found. These four ecological forms have also been recognized in *L. ochracea* (Lindberg, 1979).

Although little is known thus far about the natural history of this new species of *Lottia*, phylogenetically, it appears to be closely related to *L. ochracea*, a taxon with which it shares many conchological and radular synapomorphies.

RECONSTRUCTING THE HISTORICAL BIOGEOGRAPHY OF *FISSURELLA (FISSURELLA)* BRUGUIÈRE, 1789: A PHYLOGENETIC APPROACH.

STUBER, Robyn A., Department of Integrative Biology and Museum of Paleontology, University of California, Berkeley, CA 94720

Evolutionary relationships between 26 extinct and extant members of *Fissurella (Fissurella)* Bruguière, 1789 are examined using parsimony methods. Based on a phylogenetic analysis of 37 anatomical, radular and conchological characters, *Fissurella (sensu stricto)* is a monophyletic taxon consisting of Clade A and Grade B. The most derived members of *Fissurella (s.s.)* belong to Clade A. These taxa extend from the Pliocene of Chile and South Africa to the Recent of Peru, Chile and Argentina.

Members of Grade B, containing the most primitive representatives of *Fissurella (s.s.)*, are known from the Pliocene of Venezuela, Chile and South Africa. Because relationships between these primitive taxa are unresolved, a temperate or tropical origin for *Fissurella (s.s.)* is equivocal; however, paleontological evidence indicates that derived members of this clade arose before the closure of the Panamic Portal (3.1 Ma) and dispersed into the northeastern Pacific during the Pliocene or Pleistocene. Extant *Fissurella (s.s.)* species exhibit an anti-tropical distribution (McLean, 1984:18; Lindberg, in press). Combined phylogenetic and paleontological evidence demonstrates that this geographic pattern is resulted from dispersal and vicariant processes.

STALKS, SLOPES, AND TRAILS: THE EFFECT OF CONFLICTING DIRECTIONAL CUES ON THE ORIENTATION OF THE MARSH PERIWINKLE *LITTORINA IRRORATA*

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The marsh periwinkle *Littorina irrorata* has been shown to utilize a variety of orientation cues, including beach slope, grass stalks, and conspecific mucous trails, to maintain its position in the intertidal zone. Although *L. irrorata's* response to visual stimuli has been well documented, the interactions and relationships that exist between these redundant orientation cues is poorly understood. In this study, I compared the responses of groups of snails to individual cues (conspecific trails, visual stimuli , and a 5° slope) as well as pairs of cues presented simultaneously but in conflict with one another. Snails oriented significantly to all three stimuli but snails crawling in response to conspecific mucous trails had the shortest trail lengths and the least circuitous paths. Snails presented with a choice between a mucous trail and a slope preferred the trail. Orientation became bimodal and equal numbers of snails responded to the trail and artificial stalk when the two cues were offered simultaneously. Moreover, snails appeared to weigh conflicting directional information provided by both the slope and artificial stalk equally, resulting in a mean vector angle located between the two stimuli.

FUNCTIONAL MORPHOLOGY OF THE STOMACH IN THE BIVALVE LYONSIA HYALINA CONRAD, 1831

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Lyonsia hyalina is a small free-living bivalve found in shallow waters of the Northwest Atlantic. Mucus is secreted from specialized mantle glands which act to secure sand grains to the fragile shell. In this study structures used for feeding within the viscera of Lyonsia hyalina were examined using micro-dissection and conventional light microscopy. Dissection revealed a complex type 4 stomach characterized especially by a short, simple major typhlosole and a left pouch which receives no ducts from the digestive diverticula. The stomach is suspected to have three particle sorting areas: SA, SA^3, and SA^8. An intact crystalline style was never observed and may have quickly dissolved in every case, since a locse cohesive mass was commonly seen in the stomach and style sac. Histological study revealed various types of ciliated columnar epithelium throughout the gut. The morphology of the epithelium of the style sac and midgut is typical to that described for many bivalves.

TECTONIC SETTING OF THE NORTH PACIFIC MOLLUSCAN FAUNA

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The tectonic setting in which the North Pacific molluscan fauna developed was a complex array of accretionary, rotational, extensional, and translatonal movements on an active continental margin. Relative motion between oceanic plates and the North American plate throughout Cenozoic time appears to have been oblique to lateral in direction and from 5 to 10 cm/yr in speed. After multiple pre-Tertiary accretions, Ceonzoic tectonism followed separate paths north and south of the Klamath–Siskiyou block. In Paleogene time, rift-erupted tholeiitic basalts preceded oceanward shifting of the trench and marine regression coupled with clock-wise rotation to the north, while to the south, depositional systems developed on a margin produced by pre-Tertiary right-lateral displacement along the "proto-San Andreas" zone, with weakly developed trench seaward. Acidic vulcanism and marine transgression began to the north in Refugian time, while to the south deposition of shallow marine biogenic shales and prograding non-marine strata occurred without active subduction. The consumption of the Farallon plate resulted in its breakup beginning about 30 m.y. ago, as its generating spreading center was overcome by the North American plate, initiating the translational motion of the San Andreas zone. Throughout Neogene time, the northward propagation of this zone has continued to the Klamath-Siskiyou block, while north of the block continued subduction has resulted in the 40 m.y. old Cascade magmatic arc.

A COMPARISON OF OPISTHOBRANCH, PROSOBRANCH, AND CRUSTACEAN FEEDING ON GREEN ALGAE.

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The feeding of small marine herbivores was examined for two Oregon rocky shore habitats. In the low intertidal zone, the ascoglossan opisthobranch Placida dendritica numerically dominated the fauna on the green alga Codium setchellii during spring and summer; the prosobranch snail Lacuna sp. dominated in fall and winter. Placida consumed the alga more rapidly than did co-occurring Lacuna, amphipods, and isopods. Slug herbivory may restrict Codium from certain shores.

In high intertidal, saline pools, the large ascoglossan Aplysiopsis smithi was frequent, though not abundant in summer. slug feeding (per individual and unit biomass) produced significantly more tissue loss to the green algae Cladophora columbiana and Chaetomorpha linum than did feeding by the prosobranch snail Littorina sp., amphipods, or isopods. Aplysiopsis reduced Chaetomorpha abundance, thus altering algal community structure in saline pools. Hence, opisthobranch feeding may not only exceed that of coexisting prosobranchs and crustaceans but also affect the abundance of green algal hosts.

RADULAR STRUCTURE OF SMARAGDIA (GASTROPODA: NERITIDAE) A CYTOPLASM-FEEDING SEAGRASS ASSOCIATE

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Smaragdia bryanae grazes specifically on the leaf cell tissue of Halophila hawaiiana, the only seagrass found in the Hawaiian Islands. The sharp-cusped shape and size of the outer lateral tooth of the radula is close to the size of individual leaf cells, and matches the holes cut in the leaf epidermis during grazing. The snails are thought to feed on cytoplasm as the cells are pierced, can-opener fashion, by the outer lateral cusps. No observeable feces were produced during grazing on seagrass for extended periods in the laboratory, consistent with a cytoplasm-feeding mode, where most of the material taken in is digestible.

The similar radulae of the other species of Smaragdia, all associated with seagrasses, suggests that they feed on their hosts in the same manner. This unusual feeding mode is unique within the Neritidae, all microfloral grazers, and explains the divergent radular structure of this genus. The basic plan of the radula seems neritid, but all of the teeth have significant shape differences from other nerites. However, characters of the central, outer lateral and marginal teeth are shared with members of the terrestrial Neritacean family Helicinidae. The possibility of a terrestrial history is also suggested by the close and widespread association with seagrasses (descendants of land plants), extending back at least to the Miocene, where fossil Smaragdia are consistently found with fossil seagrasses or their associates.

PLEISTOCENE MARINE TERRACE ASSEMBLAGES: ARE THERE MODERN ANALOGS?

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The interglacial Pleistocene molluscan faunas are similar to the living fauna. There are few extinct species and fossil species associations tend to include species that live together today. The chief compositional differences result from range changes, at least 33% of the species having retreated from parts of their previous ranges, but otherwise their depositional environments are chiefly consistent with their present habitats. These similarities between fossil and living assemblages invite taphonomic interpretations on uniformitarian grounds, which can work well when depositional sites are carefully selected. However, many terrace assemblages are in basal deposits that rest upon an erosional terrace platform, for which modern analogs are chiefly found beneath the Recent sediment veneer overlying transgressive erosional surfaces; modern shell accumulations on this veneer have few Pleistocene analogs. Comparative preservation potentials favor the Pleistocene assemblages and this may account in part for the unexpected level of completeness of the Pleistocene terrace record.

ORIGIN AND INTERCHANGE OF COLD-ADAPTED NORTH PACIFIC MOLLUSCAN FAUNAS

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There are at least three sources for the cold-water faunas that evolved in the North Pacific beginning in the late Eocene. These are the Indo-West-Pacific (or Tethyan) tropics, the American tropics, and the cool southern hemisphere. With the present state of knowledge it is difficult to assign rankings to these sources, but evidence is mounting that the southern hemisphere is the locus of origin of many North Pacific lineages. Throughout the Cenozoic, there has been extensive interchange between the biotas of the western and eastern North Pacific. This interchange tended to be symmetrical during much of the Paleogene, but after the middle Miocene easterly movement markedly outweighed westwardly invasions. I argue that patterns of oceanic circulation are not responsible for this pattern of interchange. Instead, the extent and pattern of invasion seem to be dictated by the magnitude of prior extinction. Northeastern Pacific molluscan faunas suffered greater impoverishment than did those of the northwestern Pacific during the later intervals of the Neogene, and have received more immigrant taxa.

NORTH PACIFIC CEPHALOPODS, ESPECIALLY THE GONATIDAE

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Only in the last 20 years have collections of north Pacific cephalopods sufficiently sampled the fauna to allow insight into the area and its biota. The benthic octopuses show amphi-Pacific distributions similar to those reported in other benthic mollusks. Octopod endemicity and diversity appear to be higher in the northwest Pacific than in the eastern Pacific, although a complete, and critical, review of taxonomy will be required to fully test the apparent pattern.

A single family of oceanic squids, the Gonatidae, predominates in the north Pacific, with 16 recognized species endemic. This monophyletic family also includes 2 north Atlantic species and a single recognized species from Antarctic Seas. North Pacific gonatids range in habitat from epipelagic to nekto-benthic and form the base of the food chain of marine mammals and sea birds.

Cladistic analysis of the subfamily, based primarily on characters of the tentacle club and stalk, and the mantle and funnel cartilages is underway. Resolution of the phylogeny may provide insight into the biogeographic history of the area.

PROSOBRANCH FUNCTIONAL MORPHOLOGY: WHAT'S AFOOT IN A SEA OF SLIME?

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A review of over 1000 papers from the recent and not-so-recent literature on the functional morphology of prosobranch gastropods reveals that there are specific gaps in our understanding of certain structures, and especially of their function. The habitual use of vertebrate terminology to describe guts and gonads to the neglect of function has resulted in cartilages that aren't and glands that absorb. The shift from light to electron microscopy reveals fascinating details of cellular and subcellular organization, but too often with complete disregard for the organ or organism. Fortunately, exceptions exist that serve as models for the future of functional morphology. Three priorities arise from this study: (1) that function be considered as an integral part of the structure being described; (2) that levels of organization be viewed as parts of a continuum rather than as isolated entities; and (3) that a structure and its function be placed in the context of the whole organism upon which natural selection is acting. (Funded in part by NIH-MBRS RR08102, NSF-RIMI RII-8903827, and UPR-FIPI.)

Potential Pyramidellid Paradigms

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The morphologies of 8 pyramidellid species, representing 6 genera from the western Atlantic and Indo-Pacific are described and compared. Cladistic analysis for 18 characters indicates that the 8 species can be separated into four distinct clades. Soft-part morphology, particularly copulatory organs and trophic apparatus, are useful in determining propinquity. While, the traditional usage of shell characters to define pyramidellid taxa can result (and not surprisingly) in the assignment of species to the wrong assemblages, concholo-gical differences (at least for 2 Indo-Pacific species) are the sole way to distinguish between them.

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