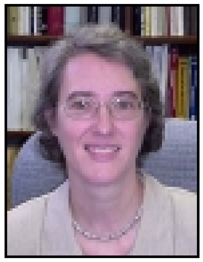
PRISCUM

The Newsletter of the *Paleontological Society* Volume 11, Number 1, Spring 2002



Partnerships in Paleontology by Patricia Kelley, President

Universities in North Carolina are preparing for budget cuts, as are schools in other states. As we worked on our departmental strategic plans last month, we were advised that programs with linkages to other units on campus would be more likely to retain resources. I scrambled to document partnerships between my department and other units that would demonstrate our high level of integration (and thus our vital role in the University's mission).

Strength today appears to be in partnerships. Your Paleontological Society officers have recognized that principle as we make plans for the Society. We now work cooperatively with several different professional societies on a variety of ventures.

Other societies share our goal of advancing the field of paleontology, and it makes sense to work with them (rather than compete with them). For a number of years, we have sponsored the North American Paleontological Convention (slated next for June 2005 in Nova Scotia – mark your calendars!) in cooperation with other members of the Association of North American Paleontological Societies. The Mid America Paleontology Society generously provides support to our Student Grants-in-Aid program and Strimple Award fund each year. We recently began new cooperative ventures with the Palaeontological Association and the Society of Vertebrate Paleontology. We now have an agreement with the PalAss to provide reciprocal discounts on publications to members. Our Education and Outreach Committee has been working closely with SVP on several activities and we will be jointly publishing a new dinosaur resource book (in cooperation with AGI).

We are a member society of AGI and have worked with that umbrella organization on several occasions. The American Geological Institute and PS co-published a new booklet, *Evolution and the Fossil Record*, and cosponsored (along with the National Association of Geoscience Teachers) "An Evolutionary Evening" at the Boston GSA meeting, celebrating the recent WGBH documentary on evolution. In addition, the Association for Women Geoscientists, in cooperation with the PS, presents the Winifred Goldring Award each year to a promising female student with career aspirations in paleontology. (Winifred Goldring, by the way, was the first woman President of the PS, in 1949; more than half a century later I am only the fourth woman to

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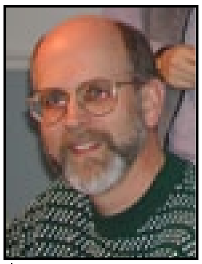
serve as President!)

Probably the greatest degree of collaboration occurs between the PS and the Geological Society of America, because GSA provides the venue for our annual and sectional meetings. Last spring, GSA formalized an Associated Societies Forum, which allows more input into GSA decisions and fosters networking among the leaders of the geoscience societies and GSA divisions. Watch for more collaborations to develop with this new outlet for communication among the societies.

If you have ideas for additional partnership opportunities, please pass them along (kelleyp@uncw.edu). Such collaborations help us serve our membership and advance the science of paleontology!



Treasurer's Report for Fiscal 2002

by Thomas Kammer, Treasurer

Your Society remains in strong financial shape. Assets at the end of 2001 totaled $1,649,816, which was a decrease of $104,825 from the end of 2000. Cash in bank accounts was $121,885, which was down by $32,198. Investments were $1,527,931, which was down by $72,627. The decline in investments resulted from $55,000 budgeted for Society operations, and a net loss of $17,627 (1.2%) in our investment portfolio. Investment allocations were 40% stock mutual funds, 40% bond mutual funds, and 20% cash.

Total income was $432,178. This included $290,827 from dues and subscriptions to our journals, $7,964 from donations, $31,587 from page charges, $12,644 from Special Studies publications, $7,152 from royalties, $880 from bank interest, $1,124 from rental lists, and $55,000 from investment income. The PS also received an NSF grant of $25,000 for support of the 2001 NAPC Meeting in Berkeley.

Total expenses were $473,820. A detailed listing of expenses will be provided at the Annual Business Meeting and Luncheon at the Annual GSA Meeting in Denver. Some of the more notable expenses included: $25,000 from NSF was transferred to NAPC; $249,447 to print our two journals plus the associated Memoirs; $38,701 to print *Deep Time*, which was paid from the Paleobiology Patrons Fund; $39,500 for editorial costs of the two journals; $44,015 for Business Management of our journals and Society memberships by Allen Press; $13,011 for Special Studies publications; $14,000 for student research grants; $12,220 for PalSIRP grants; and $20,950 for overhead to operate the Society (meeting expenses, travel by Council members, insurance). This overhead cost was only 4% of total expenses.

Once again, I want to remind all Society members to please renew your journal subscriptions early, certainly by December 31 each year. Early renewals could save the Society thousands of dollars in business management fees by Allen Press if we don't have to send out so many renewal notices plus stop and then re-start journal subscriptions to late-paying members.

Paleontological Society Coordinator's Report, May 2002

by Mark A. Wilson, PS Program Coordinator

A certain sign of the health and energy of modern paleontology is the diversity of programs our colleagues are presenting. This year, we have many opportunities for sharing and learning in our discipline. If you have ideas for additional programs, or other comments and suggestions, please contact me at the Department of Geology, The College of Wooster (mwilson@wooster.edu).

Paleontological Society Short Courses:

2002 (Denver GSA): **The Fossil Record of Predation.** Conveners: Michal Kowalewski and Patricia Kelley

2003 (Seattle GSA): **Bridging the Gap: Trends in Ostracode Biological and Geological Sciences.** Conveners: Lisa Park and Alison Smith

2004 (Denver GSA): **Biological Revolutions in the Neoproterozoic and Cambrian.** Conveners: Ben Waggoner and Jere Lipps

Paleontological Society-Sponsored Topical Sessions at Denver GSA (2002):

Paleobiogeography: Integrating Plate Tectonics and Evolution. Convener: Bruce S. Lieberman

Evolutionary Paleobiology and Paleoecology of the Bivalvia. Conveners: Peter Roopnarine and Carol Tang

Three Billion Years of Reef-System Evolution. Convener: George D. Stanley, Jr.

Developing Perspectives on the Ecological Context of Biological Evolution across the Neoproterozoic-Cambrian Transition. Convener: Loren E. Babcock

Phenotypic Variation: Discriminating Evolution from Environment. Conveners: Steven J. Hageman and Peter A. Kaplan

Advances in the Fossil Record of Insects and Terrestrial Arthropods. Convener: Robert E. Nelson

Wetlands Paleoecology through Time. Conveners: Stephen F. Greb and William A. DiMichele; co-sponsored with the GSA Coal Geology Division

Seafood through Time: The Ecologic Context of the History of Life (honoring Richard K. Bambach). Conveners: Roderic Brame and Andrew M. Bush

Paleontological Society-Sponsored Topical Sessions at GSA Section Meetings (2002):

Invertebrate Paleontology: Symposium in Honor of Ellen J. Moore. (Cordilleran Section GSA, April 2002) Convener: Elizabeth Nesbitt

Recent Advances in the Terrestrial Paleontology of the Pacific Northwest. (Cordilleran Section GSA, April 2002) Conveners: Jeff Myers, Paul Kester, and Greg Retallack

Field Trip: Miocene Molluscan Fossils and Stratigraphy, Newport, Oregon. (Cordilleran Section GSA, April 2002) Organizer: Ellen Moore

Field Trip: Classic Paleobotanical Record of Eocene-Oligocene Climate and Vegetational Change. (Cordilleran Section GSA, April 2002) Organizers: Jeff Myers, Paul Kester, Greg Retallack

Permian of the Southwest. (South-Central Section GSA, April 2002) Conveners: David Rohr and Bruce Wardlaw

Field trip: Guadalupian (Middle Permian) Stratotype, Guadalupe Mountains National Park. (South-Central Section GSA, April 2002) Organizers: David Rohr and Bruce Wardlaw

Evolutionary Morphology. (North-Central/Southeast Section GSA, April 2002) Conveners: Steve Loduca and Tom Baumiller

Taphonomy: Insight towards Stratigraphy, Sedimentology and Evolution. (Northeastern Section GSA, March 2002) Convener: David Lehmann

Other Paleontological Society-Sponsored Events (2002):

New Perspectives on the Origin of Metazoan Complexity. (The Society for Integrative and Comparative Biology, January 2002) Convener: Ruth Dewel

Learning from the Fossil Record (Teacher Workshop, Denver GSA, November 2002) Organizers: Dale Springer and Brent Breithaupt

Future Paleontological Society-Sponsored Events (2003):

Workshop: Quantitative Methods for Empirical Paleontology. (Pending successful NSF funding, August 2003) Organizers: Carol Tang and Peter Roopnarine

Patterns and Processes in the Evolution of Fishes. (The Society for Integrative and Comparative Biology, January 2003) Convener: Francesco Santini

GSA Annual Meeting Changes Its Calendar

Starting with the upcoming annual meeting in Denver, GSA is breaking with its tradition of running the technical session from Monday to Thursday, and instead will start their program on Sunday and end the meeting on Wednesday. This scheduling change will impact the PS and instead of running the short course on Sunday, it will occur on Saturday. In addition, the PS luncheon, which traditionally has been on Tuesday, will move to Monday. So, mark your calendar to accommodate these changes.

Reviews of PS-Sponsored Sessions at the GSA Annual Meeting in Boston

Brachiopod research? No better time than now . . .

by Sandy Carlson

The 2001 Paleontological Society Short Course on "Brachiopods Ancient and Modern" was held in Boston at the Annual Meeting of the Geological Society of America. Thirteen invited contributors presented half-hour talks on brachiopod phylogeny, genetics, development, physiology, biomineralization and diagenetic alteration, functional morphology, ecology and paleoecology, paleobiogeography, as well as diversity. (Regrettably, a fourteenth invited contributor was unable, at the last minute, to present either a talk or a paper on brachiopod biostratigraphy, explaining the lack of representation of this important aspect of brachiopod research.) Our attendance hovered around 100 for much of the day. Glancing out at the audience from time to time, it seemed to me that listeners were fully engaged and their interest piqued by each of the presentations. My co-convenor, Mike Sandy and I, deemed the Short Course an unequivocal success for both brachiopod paleontologists and non-brachiopod paleontologists alike.

Reflecting back on the full day of stimulating contributed talks (and papers, as well), I have the following observations to make about the outcomes of the Short Course:

1. In organizing the Brachiopod Short Course, Mike and I had asked (strongly encouraged is perhaps more accurate!) the speakers to address two specific questions in each of their topical presentations. First, we asked them to review and summarize what seemed, in their opinion, to be the most significant developments over the previous twenty years of research on their topic. This first request was most in keeping with the original goals of the PS Short Course, its purpose to bring the audience up-to-date since the earlier PS Short Course on Lophophorates in 1981. Second, we asked the speakers to articulate at least one (or more) major research ideas or projects that that they felt were today the most interesting or pressing, thus highlighting the most significant aspects of future research on brachiopods, in their considered opinion. In other words, if they were magically granted a large sum of unrestricted research money, what questions would they choose to tackle first?

I was very impressed with the enthusiasm and vigor with which all the participants embraced our two requests. Mike and I were, of course, hoping that this would happen, but I think it succeeded far beyond our expectations. The talks (and papers; see Carlson and Sandy, 2001) were information- and idea-rich; thoughtful, deep, creative, and of a very high caliber, in terms of both content and presentation. I left the Short Course feeling not only much better informed about many aspects of brachiopod research that I knew about previously only in a general sense, but also energized about possible research projects in my future. And yet, the talks were accessible, and not simply geared to a "specialist audience" of brachiopod researchers only; it was my impression that many of the ideas expressed and questions posed could be applied successfully to other metazoan groups with fossil records as well.

2. Rather than simply talking past one another in one talk after the next, I felt that the biological and paleontological speakers were well aware of and informed about one another's work. Their mutual respect and sense of working together toward the common goal of reaching a better understanding of brachiopods was palpable. As a result, at the end of the day after hearing all the talks in succession, I found it much easier to make connections among issues that were raised by more than one speaker. I wished that I had tape-recorded the whole meeting, in order to be able to rekindle the sense of synergy that built throughout the day. Starting with a phylogenetic perspective, moving through a series of talks on living brachiopods,

and then finishing up with a series of talks on fossil brachiopods was a progression that allowed me to better appreciate each aspect of brachiopod evolution.

It has been said in the past, almost perfunctorily, about these sorts of meetings that a watershed or critical point has been reached, and that the meeting serves to highlight this point. I would read statements like this in the past and wonder how much was truth and how much empty hyperbole. I am now honestly convinced that brachiopod research is excitingly integrated and interdependent, more so than for most other invertebrate phyla. Truly great strides have been made in brachiopod biomineralization, genetics, development, and physiology, in particular, over the past two decades. And we really are at a point where some very exciting interdisciplinary work can now begin between brachiopod biologists and paleontologists.

3. There are an enormous number of compelling research projects on brachiopods that are waiting to be pursued! It simply can't be ignored that in order to more profitably explore the paleobiology of extinct brachiopods, it is necessary to better understand the biology of living brachiopods. Although this point has been noted repeatedly in the past, the Short Course brought it very clearly into focus, at least for me. Morphologically, extinct brachiopods are far more diverse than are extant brachiopods. What might this suggest about differences in their genetics, developmental biology, or physiology, with implications for their paleobiogeography, functional morphology, and patterns of diversity, to select just a few research areas that are ripe for further investigation?

Genetics and the stratigraphic record - we can use our new-found (and still rather skeletal) understanding of phylogenetic relationships among living brachiopods using molecular sequence data (thanks largely to Bernie Cohen and others) to test established claims about morphological character evolution. We can use the relative order of appearance of clades in the stratigraphic record to test hypotheses about (and perhaps even calibrate) clock-like molecular evolution and establish divergence times of major clades.

Development and evolutionary history - an impressive body of comparative developmental data have now been gathered (primarily by Gary Freeman) on living brachiopods to allow us to make testable predictions about the role that development has played, in some detail, in shaping brachiopod evolutionary history. Different degrees of developmental flexibility may have shaped patterns of morphological diversification during the Cambrian radiation of brachiopods (and other metazoans).

Physiology, ecology, and paleoecology - detailed knowledge about low-energy brachiopod physiology (because of the work of Lloyd Peck and others) has provided new explanations for their extremely long fossil record, and their ability to survive times of high ecological stress due to low resource supply. What might this suggest about those many brachiopods that did not survive major extinction events?

The future holds the exciting promise of the pursuit of these projects, and many, many more. Let's get to work!

If you were unable to attend the Short Course, but have an interest in learning about the many different kinds of questions that brachiopodologists are asking these days, I strongly encourage you to locate a copy of the Paleontological Society Papers, Vol. 7 (see order form on p. 28), and peruse the contributions yourself. I'm sure that you will appreciate the breadth and depth of coverage of a wide variety of topics related to brachiopod biology and paleontology (see also Brunton et al., 2001; Carlson, 2001; Kaesler, 1997 and 2000).

Last, but certainly not least, Mike and I extend our many, sincere thanks to the Paleontological Society for providing partial travel funds for four of our speakers who normally do not attend the GSA meetings. Their participation increased the value of the Short Course immensely.

Brunton, C. H. C., L. R. M. Cocks, and S. L. Long (eds.). 2001. Brachiopods past and present. Proceedings of the Millenium Brachiopod Congress, 2000, The Systematics Association Special Volume Series. Taylor and Francis, London.

Carlson. S. J. 2001. Ghosts of the past, present, and future in brachiopod systematics. Journal of Paleontology, 75(6): 1109-1118.

Carlson, S. J. and M. R. Sandy (eds.). 2001. Brachiopods Ancient and Modern. Paleontological Society Paper, 7. 261 pp. Yale University, New Haven, Conn.

Kaesler, R. (ed.). 1997. Treatise on Invertebrate Paleontology, Part H, revised, Brachiopoda. Volume 1. Geological Society of America and University of Kansas, Denver and Lawrence.

Kaesler, R. (ed.). 2000. Treatise on Invertebrate Paleontology, Part H, revised, Brachiopoda. Volumes 2 and 3. Geological Society of America and University of Kansas, Denver and Lawrence.

Partnerships in Paleontology: Involving the Public in Collaborative Research

by P.G. Harnik and R.M. Ross (conveners)

Engaging K-16 classrooms and the general public in authentic research can be an effective way to teach scientific processes and content while providing researchers with data that may otherwise be unavailable. Research partnerships are not new to paleontology, a field that has long benefited from the involvement of highly skilled amateurs. Only recently, however, have collaborations extended to undergraduate and precollege classrooms and to the general public. This symposium created a forum for paleontologists and educators to discuss the benefits and challenges of research partnerships. The issues raised are particularly relevant at present as awareness grows of the roles scientists play in education policy and reform (e.g., the Kansas evolution debate). In addition, research partnerships may be a model for how to leverage additional labor and financial resources for a variety of research initiatives.

While some critics may be skeptical of the scientific validity of projects involving non-specialists in data collection, several talks presented rigorous results of such collaborations. Claudia Barreto and coauthors discussed their research examining extinction patterns at the K/T boundary in which volunteers from the Milwaukee Public Museum surveyed the Hell Creek Formation for dinosaur remains. Such extensive fieldwork, accomplished during a relatively brief amount of time, would not have been possible without the participation of a large number of volunteers. Kirk Johnson echoed these sentiments in his talk on the Certification in Paleontology Program at the Denver Museum of Nature and Science, a program that has graduated approximately 150 students, many of whom assist with ongoing research. Thor Hansen and coauthors' project involving middle school students in documenting moon snail predation along North America's coastline similarly involves extensive data collection over a broad geographic region, data that would otherwise pose a challenge for small groups of researchers to collect.

Assessing and balancing the needs of all partners makes for more effective collaborations that satisfy their respective scientific and educational goals. Warren Allmon and coauthors presented their work involving a wide audience in documenting Ice Age environments in New York State and their attempts to balance open-ended student exploration with data consistency. Tamara Ledley and coauthors discussed a template for student-scientist partnerships in which scientists define their expectations and methods during project development. Maria Lawrence and coauthors presented qualitative evaluation methods for assessing the educational outcomes of student participation in Devonian paleoecology research. Brian Bisbee's talk explored amateur response to an online collections database of Mazon Creek specimens and the use of focus groups in shaping the web interface. John Calder's contribution examined balancing the interests of natural resources agencies with those of avocational paleontologists in the monitoring of fossiliferous sites in Nova Scotia. In discussing audiences, several talks (e.g., Hansen et al., Lutz-Ryan et al., and Tremain et al.) emphasized the role that research experiences can play in enhancing diversity in the geosciences through partnerships with diverse classrooms.

The importance of recognizing and rewarding participant contributions was emphasized by Elizabeth Southwell and coauthors, in a presentation by Brent Breithaupt, for their work with volunteers at the Red Gulch Dinosaur Tracksite in Wyoming. Ledley encouraged partnership developers to consider recognition methods when outlining projects, and Elaine Hoagland (Council for Undergraduate Research) emphasized the value of acknowledging student contributions in publications.

How we evaluate whether collaborative partnerships are successful at meeting their scientific and educational goals was a primary theme of the session. Lawrence emphasized the importance of qualitative evaluation methods in assessing educational outcomes, an approach employed by Joanna Wright and coauthors to evaluate their field-based professional development program for secondary school science teachers. Returning participants were suggested by Blue Magruder and Larry Agenbroad as a proxy for participant satisfaction with EarthWatch programs. Paul Harnik and Rob Ross outlined how assessment of student data accuracy is critical to ensure that data can be usable in authentic research. Both Johnson and Barreto discussed peer-reviewed publications using non-specialist data as a measure of the scientific quality of partnerships.

Several talks described systems in place for supporting collaborative research. Jewel Prendeville reviewed NSF geoscience programs that potentially fund collaborations, including Enhancing Diversity in the Geosciences, Geoscience Education, and more broadly, the National Science Digital Library and education supplements to geoscience research grants. The Council for Undergraduate Research facilitates partnerships through dissemination of 'best practices' during workshops, conferences, and their newsletter. EarthWatch is another support system that matches members of the public with research projects and provides financial support for these collaborations.

This session demonstrated the great diversity of approaches being taken to integrate paleontology research and education through the involvement of non-specialists in scientific collaborations. Talks covered a wide variety of research areas (e.g., vertebrates, invertebrates, plant fossils, and trackways) and included a broad group of speakers (e.g., museum educators, scientists, evaluators, administrators, and IT staff). Project audiences are quite diverse, including K-16 students, teachers and public volunteers. While some projects were more skewed towards specific research questions, and others focused more broadly on partnerships as educational strategies, all of the talks attempted to balance these dual goals.

Paleontology holds an intrinsic interest for students and the public and as such can be an effective tool for teaching a variety of scientific content as well as for leveraging research assistance. In order for these projects to accomplish authentic science, data accuracy and participant error must be determined. In order for these projects to accomplish authentic education, formative and ongoing evaluation must occur. Results of both of these assessments must then feedback into project development.

We would like to thank all participants for an engaging symposium and the Paleontological Society for its sponsorship. Abstracts and Powerpoint presentations are available online at <http://www.erp.priweb.org/ProceedingsPage.jsp>. Some manuscripts from the session will be included in a *Journal of Geoscience Education* theme issue on geoscience research partnerships to be published January 2003.

High-Resolution Geochemical Bioarchives: Recognition of Signals and Implications for Evolution, Paleoecology, and Paleoclimatology

by D. Goodwin and S. Schellenberger (conveners)

Researchers investigating geochemical variation in modern and fossil organisms presented papers at a Paleontological Society sponsored topical session, held at the last GSA annual meeting in Boston. The session was a great success. Topics of sixteen papers ranged from trace element chemistry of coral skeletons to stable oxygen and carbon isotopic variations in freshwater otoliths.

The opening paper, presented by Doug Jones, outlined the history as well as recent developments of integrated geochemical and sclerochronologic analysis. Doug highlighted the potential for increased high-resolution analyses as well as outlining the application of bioarchival data to the study of heterochrony. David Dettman then expanded on the high-resolution component of the previous talk by presenting isotopic variation ranging from annual to sub-daily scales in bivalve mollusks. His presentation hinted at the possibility of reconstructing ultra-high resolution (hourly!) records from the fossil record. David Goodwin continued with the high-resolution theme by discussing how changes in bivalve growth through ontogeny affect sample resolution and completeness. Comparisons between his modeling results and observed profiles indicate that sampling strategies need to account for changes in growth rate. Next, Linda Ivany presented oxygen-isotope data from early Eocene bivalves from Alabama. Linda's findings suggest that these ancient near-shore environments were strongly influenced by the influx of freshwater.

Glenn Jaecks' presentation came after the string of clam papers, but his talk was still concerned with bivalved organisms, specifically thecideide brachiopods. His results show that fossil members of this group have much greater oxygen-isotope variability than their modern counterparts, possibly related to greater seasonality, salinity variation, or both. David Rodland's talk focused on high-resolution oxygen-isotope records from modern and fossil lingulid brachiopod shells. His data indicate that while isotopic profiles from biogenic phosphate do not represent equilibrium values, the carbonate fraction does. David Weinreb presented oxygen-, carbon- and strontium-isotope data from Cretaceous Western Interior Seaway ammonoids. These data suggest that the oxygen and carbon variation are principally the result of changes in salinity, leading the authors to speculate that the ammonoids migrated between coastal and off-shore environments. Brian Huber's presentation compared the isotopic variation between high-latitude foraminifers and belemnites. He concluded that belemnite oxygen-isotope values are a reliable proxy for high-latitude deep-water benthic habitats.

The next three presentations were principally concerned with trace element variation. Anne Cohen presented research on diurnal variation of Sr/Ca ratios in zooxanthellate corals. She showed that Sr/Ca ratios from the skeletal material deposited at night provide more reliable sea surface temperature estimates than from skeletal material calcified during the day. Next, Owen Sherwood presented several trace element records from deep-sea gorgonian corals. His data suggest that Mg/Ca ratios are a promising new source of deep-sea paleotemperature records. Brad Rosenheim presented a new technique for age determination in sclerosponges based on Sr/Ca ratios. This technique may aid in the application of geochemical records from sclerosponges to decadal climate variations.

In the final set of talks, we left the marine realm to discuss geochemical records from terrestrial and fresh water systems. Kathryn Hoppe led off with a discussion of the biological and environmental controls on oxygen-isotope variation in modern domestic horses. The analyses showed that metabolic and environmental changes can dramatically alter the isotopic values of an individual's body water, thus affecting records reconstructed from fossil teeth. Andrea Dutton presented a model of the mean and variability of oxygen-isotope values in rivers and meteoric precipitation from the United States. Comparison of modeled mean riverine and meteoric water agreed well. However, variability did not, likely reflecting hydrologic processes such as infiltration and evapotransporation. Henry Fricke's paper documented large carbon isotope variation in Eocene terrestrial vertebrates from North America. His work showed that carbon-isotope values can vary significantly in a C3-world, perhaps reflecting productivity, precipitation or water availability. Kathryn Thomas presented oxygen isotope data collected from a Late Cretaceous hadrosaurian dinosaur. Her results suggest that these isotopic variations are reliable recorders of growth rate changes through ontogeny. Finally, Christopher Wurster's paper outlined carbon and oxygen isotope variation in freshwater otoliths. His findings indicate that metabolic activity, recorded by carbon-isotope variations, are inversely correlated with oxygen isotope values. However, an independent proxy for metabolic activity is needed to resolve nature of the carbon/oxygen correlation.

This Paleontological Society sponsored topical session was enlightening and informative. These high-resolution geochemical studies are providing important insight into environmental, ecological, and physiological conditions from the Paleozoic to modern day. The session chairs, Stephen Schellenberg (San Diego State University) and I, thank all of the presenters for sharing their exciting new research. We believe this session not only highlighted innovative new approaches in paleontology but also promoted discussion and collaboration within the paleontological community and between paleontologists and geochemists. Finally, we thank the Paleontological Society for its sponsorship and support.

Stratigraphic Paleobiology

by Steven M. Holland and Mark E. Patzkowsky (conveners)

In the past decade, stratigraphy has been propelled from a largely descriptive science to a mature hypothesis-testing science. An improved understanding of the architecture and genesis of the stratigraphic record has not only offered paleobiologists a new set of tools with which to investigate the fossil record, but has allowed paleobiologists to construct innovative hypotheses about the fossil record and the history of life. The Stratigraphic Paleobiology topical session at the annual GSA Meeting in Boston, 5 November, 2001, highlighted the research of many of those who have integrated recent stratigraphic advances into their paleobiological research.

The sixteen presentations of the morning session began with a series of talks documenting the close relationship between sequence stratigraphic architecture and fossil distributions. Heidi McDonald & Martin Gibling discussed the sequence stratigraphic distribution of floras, preservation styles, and preserved vertebrate trackways in Carboniferous strata of Nova Scotia. Carl Leonard demonstrated variations in conodont abundance and biofacies relative to flooding surfaces and sequence boundaries in cratonic Pennsylvanian strata of Kansas. Chuck Savrda detailed several examples of how sequence stratigraphy can guide ichnologic interpretations, as well as how ichnology can inform sequence stratigraphic interpretations. Ray Rogers showed how the abundance and taphonomy of vertebrate remains in Campanian strata of Montana are related to changes in overall subsidence and sedimentation rates.

These were followed by five talks on the usefulness of the New Stratigraphy to paleoecological and paleobiological analyses. Diana Thiel and Mary Droser described several monotypic or nearly monotypic shell beds from the Middle Ordovician of the Great Basin and argued that they represent opportunistic blooms of particular species in stressed environments. Tom

Olszewski used ecological gradient analysis of benthic invertebrates to recognize previously undescribed sequence stacking patterns in the Pennsylvianian-Permian of the North American Midcontinent. Andrew Webber applied ecological gradient analysis of benthic invertebrates from the Upper Ordovician of the Cincinnati, Ohio area to argue that the meter-scale cyclicity preserved there does not reflect changes in water depth, but is more likely caused by variations in storm frequency and intensity. Steve Westrop, Jonathon Adrain, and Jad Bean rigorously evaluated the sequence stratigraphic context of a Cambrian biomere extinction and concluded that the apparent abruptness of the extinction is enhanced locally by facies changes, but that the extinction itself is not entirely artifact, as it occurs within monofacial successions. Mark Patzkowsky and Steven Holland used rarefaction and the sequence stratigraphic distribution of samples to correct measured diversity changes in the Ordovician of the Nashville Dome and Cincinnati Arch for differences in facies availability and sampling intensity.

Four subsequent talks explored recent advances in stratigraphic methods to evolutionary studies. Peter Sadler applied constrained optimization algorithms to obtain an optimal ordering of first and last occurrences of graptolites, and from that, construct a high-resolution diversity curve calibrated with dated volcanic ash beds. Steven Holland showed how confidence limits methods on fossil ranges that account for sequence architecture can be used to distinguish last occurrences driven by facies changes from true local extinction events. Through landmark analysis of Cambrian trilobites, Mark Webster documented the parallel relationship between sequence architecture and morphological changes. Chuck Mitchell and David Sheets argued that morphologic time-series can be considered as either stabilized dynamics (e.g., punctuation, equilibrium) or as non-stabilized dynamics (random walks and directional changes), and that it is analysis of stratigraphic and taphonomic patterns that will provide insight into linking these morphologic patterns to evolutionary processes.

The three final talks provided a broad overview of the state of stratigraphic paleobiology. Carl Brett discussed the paradox of layer-cake stratigraphy, that is, how the modern observed patchy distribution of sedimentary environments can be reconciled with the observed widespread distribution of event beds and sequence stratigraphic surfaces. Michal Kowalewski and Richard Bambach outlined the relationships between stratigraphic and depositional resolution and their implications for the fossil record. Susan Kidwell ended the session with a rallying cry for the much-needed paleontological study of discontinuity surfaces. Several themes became apparent during the session. First, the influence of event deposition and sequence stratigraphic architecture in the structuring of the fossil record is pervasive. It occurs in a wide spectrum of environments and for a broad suite of taxa. Many patterns in the fossil record are at least distorted by event deposition and sequence architecture; some patterns are largely the result of these processes.

Second, paleontology has as much to offer sequence stratigraphy as sequence stratigraphy has to offer paleontology. Although much recent work, with some notable exceptions, has emphasized the use of sequence stratigraphic frameworks for designing paleontologic sampling strategies and the interpretation of paleontologic patterns, it is clear that paleontology itself could play an important role in stratigraphic interpretation, including the detection of important stratal surfaces and systems tracts.

Third, there is a pressing need for stratigraphic predictions about the fossil record. Given what is now known about the architecture of the stratigraphic record, the field is well poised to predict its effects on patterns of morphologic change, paleoecologic structure, and biodiversity patterns, both temporal and geographic. From this, paleontologists will be better able to evaluate known patterns in the fossil record and to recognize previously undocumented changes as being biologically significant.

Evaporite Systems I and II: The Geology, Paleontology, and Biology of Evaporite and Near-Evaporite Systems in both Terrestrial and Extraterrestrial Environments

by Susan Wentworth and Penny Morris (conveners)

The two evaporite sessions were sponsored by the Paleontology Society and also by the NASA Astrobiology Institute - Johnson Space Center Institute for the Study of Biomarkers. The goal of the sessions was to facilitate communication among scientists who share an interest in evaporites and related topics, but who might not normally interact because of wide ranges in specific research areas. The diverse presentations in the sessions provided a broad overview of evaporites throughout geologic history (both on Earth and on other planetary bodies). Regardless of the setting, evaporites are a distinct marker of the former presence of water, one of the components necessary for life as we know it. Evaporites on Earth contain biological/paleontological records that are critical to understanding the existence, adaptation, and evolution of life in extreme environments. It seems likely that evaporites on Mars or other planetary bodies would contain some signature of life if it was ever, or is now, present on those bodies. Results of studies of evaporites on Earth will probably be a valuable tool in the ongoing search for signs of extraterrestrial life.

One of the most significant conclusions that can be drawn from the presentations is that evaporites on Earth seem to be characteristically associated with biological/paleontological features, with the possible exception of Archean samples (see discussion below). Krumbein suggested that the most important lineages of early life (Archea, cyanobacteria, and fungi) may have survived harsh periods by adapting to/living in evaporitic environments. In support of this idea, he noted that cataclysmic times in Earth history (e.g., Late Precambrian, Permian, Tertiary, and recent environments) coincide with sedimentary structures produced by extreme halophiles. Similarly, Hickman suggested that evaporite systems may play a refugial role during mass extinction (and also during recovery from them) for organisms able to thrive in hypersaline conditions.

Another important inference of the sessions is that our understanding of some of the earliest rocks on Earth is incomplete at best. Specifically, sulfur isotopes from the Archean North Pole area of Western

Australia (Runnegar et al.) indicate that hydrothermal activity, and only hydrothermal activity, was responsible for formation of the bedded barites present as well as the associated barite dikes and veins. Evidence indicates that the barite was the original mineral deposited; it was not a replacement product of earlier gypsum evaporites, as previously proposed. Sulfur isotopes for coeval cherts and for pyrites disseminated in the bedded barites are consistent with a hydrothermal origin. Runnegar et al. concluded that there is a lack of evidence for microbial activity in the barites. In other Archean samples, Walsh also reported an absence of definitive biogenic material from low-temperature alteration zones associated with basalts in the Barberton greenstone belt, South Africa. Evidence of biological activity is demonstrably associated with most fossil and modern evaporites on Earth, however.

Modern sites for macroinvertebrate studies in the GSA sessions included Shark's Bay, Australia and the Quatro Cienegas Basin in the Chihuahuan Desert of Mexico, Laguna Madre, Texas, and Sivash on the western margin of the Sea of Azov (Hickman; Tang et al.). Hickman indicated that symbiosis between different organisms in extreme environments seems to form a pattern. For example, metazoans and chemoautotrophic bacteria also form partnerships at seeps and vents (despite the distinctions between seep, vent and typical evaporites). The Quatro Cienegas area is providing Tang et al. with the opportunity to study the influences of environment and isolation on diversification and evolution of individual organisms. This area is relatively isolated and contains a high degree of environmental, hydrological, and geochemical variability. Thermal springs, outflows, and marshes are present in addition to evaporative playas along with an endemic snail (*Mexipyrgus*); preliminary data indicate that there may be at least two distinct developmental morphologies present.

Several investigations of microbes and their role in forming modern microbial mats, stromatolites and biofilms were included in the sessions. Byrne et al. identified a diverse and abundant microbial population, both fossilized and unfossilized, in samples from Storr's Lake, San Salvador, Bahamas. Turich et al. are focusing on molecular characterization of the Storr's Lake (and nearby Salt Pond) organisms. They are modifiying and developing new protocols and primers. Their objective is to evaluate the microbial diversity, which is a challenge because low genetic diversity is characteristic of such communities. In other modern evaporite settings, Morris et al. found that fossilization is limited among Dead Sea biota; organisms included cyanobacteria, fungi, ovoid microbial forms, and sparse biofilm. Molecular biomarkers for cyanobacteria and Archea in stromatolites in solar ponds from the Sinai Peninsula have been identified (Koizumi et al.). Evaporite minerals are also found in some unusual modern environments and, like most evaporites, they are accompanied by evidence of biological activity. Biogenic evaporite minerals can be formed in caves, both in water and subaerially; some of the latter evaporites have not been identified in surface systems (Boston et al). Another unique occurrence is a travertine-type deposit being precipitated from a spring discharging from the surface of a large ice sheet (Grasby et al.). In this instance, it is thought that the sulfur is derived from thick evaporites beneath the ice sheet. Bacteria and biofilm are also present in this system. Data indicate that the circulation depth is more than 1.5 km. Grasby et al.'s inference is that a biological community is active within the flow system, which is in an area of extensive ice sheets and thick (>500 m) permafrost.

In older materials, Cretaceous cold-water methane seeps, known as tepee buttes in Colorado, are associated with microbially mediated, authigenic carbonates (Shapiro et al.) where bacterial sheaths and cocci were replaced by sulfides or preserved as microcrystalline molds and casts. The Eocene Green River Formation was the subject of two presentations. Experimental dissolution (Janusz and Birnbaum) of trona from the evaporitic Wilkins Peak Member yielded a residue consisting of micrometer-sized spheres and fibrous material (submicrometer to mm size). The spheres were interpreted as microbial material and the fibers identified as zeolite, possibly erionite. The authors suggested that the cage-like structure of the zeolite and the presence of loosely bound water may have enhanced ion exchange and facilitated growth of microorganisms. Machlus et al. noted the presence of stromatolites in the deepest basin portion of the Laney Member, which overlies the Wilkins Peak Member. Based on stratigraphic evidence, they proposed that a climate change occurred during the transition from the evaporitic Wilkins Peak Member to the more fresh-water Laney Member, which probably represents a deep, chemically stratified lake. Structures found in the Laney Member of the Green River Formation indicate the presence of a stratified lake, varying in depth, and evaporite deposits.

Other topics included many important aspects of evaporites and related materials, including geology, mineralogy, and geochemistry. Based on studies of saline waters in the Great Basin of the U.S., Tomascak et al. suggested that lithium isotopes in the sedimentary record may provide a good climate proxy. Benison et al. are comparing modern extremely acidic saline lakes in Australia to Permian equivalents in Kansas and North Dakota with the objective of determining criteria to recognize them in the rock record. Sulfate concentrations in Permian sea water (evaporites in eastern and central Europe) have been found to be slightly lower than those in modern marine environments (Peryt et al.). Rosenberg et al. conducted a series of experiments on evaporative chemical evolution of highly saline water. Conventional thermodynamic modeling of highly concentrated saline solutions is restricted by limitations in both theory and data. Phase equilibria were determined for epsomite and hexahydrite, both of which may be present at the surface of Europa (Chou and Seal). These two sulfates are also commonly found in marine evaporites and saline lakes on Earth.

Extraterrestrial samples contain evaporite minerals but whether any of them are accompanied by biological features is not yet known. Even the oldest, most primitive materials in the solar system (interplanetary dust particles and some types of stony meteorites) contain salts (Keller et al.); aqueous alteration and salt deposition occurred soon after the formation of the solar system. It probably resulted from interaction with cometary (icy) materials or from internal heating within parent bodies of the meteorites. Meteorites from Mars, with crystallization ages ranging from 4.5 billion years (Ga) to <165 Ma, also contain traces of secondary evaporite minerals and other aqueous alteration features (Wentworth et al.). Some of these secondary minerals are unambiguously Martian, and carbonates have been dated at ~3.9 Ga by other researchers. This old age indicates that aqueous alteration and salt deposition may have occurred on Mars for a large portion of geologic history, implying that conditions favorable for life may have been present on Mars for a very long time. Remote-sensing techniques have not yet identified large-scale evaporites on Mars, but a new orbital mission may do so (Moersch et al.; Baldridge et al.). Analog studies in Death Valley indicate that Mars orbital remote sensing techniques (with 3-km resolution) have not been sensitive enough to detect large areas of evaporites until now. The new Mars orbital mission, THEMIS, is just beginning to collect data, and the Death Valley analog studies (100-m resolution) are encouraging; i.e., carbonates and sulfates in Death Valley are clearly detectable at that resolution.

"Traces" of Soil Ecosystems through the Phanerozoic: New Insights into Terrestrial Paleoecology, Paleohydrology, and Paleoclimate

by Stephen Hasiotis and Marilyn Wegweiser (conveners)

The purpose of our topical session was to bring together researchers who are interested in learning more about ancient terrestrial ecosystems by studying paleosols formed in different paleogeographic and paleoclimatic settings. Many of us are concerned with extracting from paleosols as much information as possible on the interactions between microbes, plants, and animals and their roles in regulating biodiversity, nutrient dynamics, water balance, carbon and nitrogen cycling, and other biogeochemical cycles and processes in the soil. The goal is to determine how paleosols might record both subtle and major relationships between soil ecosystems and global changes in paleoclimates and biogeochemical cycling in deep geologic time.

Our session contained an array of presentations that covered major topics ranging from the perspectives on the early evolution of Paleozoic continental ecosystems to the use of stable isotopic analyses of pedogenic features to interpret precipitation and climate through the Phanerozoic. A synthesis is presented here, and we thank all those who contributed to the session. The earliest evolution of Paleozoic continental ecosystems points to the interactions and adaptations of rudimentary microbial, plant, and animal life to air, light, water, and the physical environment. The ecological dialectic accentuated the acquisition of light, CO_2, water, and nutrients for photoproduction and the use of these in primary, secondary, and tertiary consumption, balanced by the recycling of CO_2, water, and nutrients. All of this was also balanced against the physical and chemical factors in terrestrial and freshwater settings, and, hence, a feedback system of sorts was initiated by producers and consumers on radiation, photorespiration, and dehydration. This established a foundation for the diversification of plants and metazoans in the continental realm, which continues to be dominated by a nitrogen-rich atmosphere. With the evolution of terrestrial and freshwater ecosystems well underway by the Devonian, organism-substrate and organism-organism interactions had an impact on global climates through their carbon-oxidizing and carbon-sequestering behaviors in soil ecosystems through the Phanerozoic. For the most part, the abundance and widespread distribution of soil invertebrates and plants at the sediment-rock-air boundary fueled the cycling of atmospheric gases, shaping ancient ecosystem and climates. Because of ever increasing studies of continental deposits, we now recognize that ichnofossils represent biodiversity that has gone unrecorded in reconstructions of ancient terrestrial and freshwater biodiversity and ecosystems. Also, understanding the details of organism-substrate interactions and the taphonomic as well as preservational biases allows us to assess better the controls on the distribution of body and trace fossils or, for that matter, the lack thereof. The ichnofossil diversity and abundance indicates primary productivity, the intensity of pedogenesis, soil-water budget, and overall paleoclimatic setting. The nature and extent to which organisms' behaviors change or control the abiotic and biotic characteristics of the paleoenvironment determine the degree to which they can engineer the paleoecosystem and influence global geochemical systems.

To further extract traces of information recorded in paleosols, modern soils can be analyzed for the controls and processes that form them from different parent materials in specific environmental conditions and climosequences. Studies of such modern soils as vertisols, hydromorphic alfisols, andisols, and calcic inceptisols demonstrate that the distribution of ichnofossils combined with analyses of biocycled and hydrologically sensitive elements leads to better estimates of Phanerozoic paleoclimates because together they indicate the specific climatic and atmospheric conditions under which they formed. For instance, pedogenic sphaerosiderites are traces of ancient water-logged soils that record the $\delta^{18}O$ composition of local mean annual precipitation during soil formation from the equatorial to polar region in the Late Cretaceous. In another example, stable isotopic compositions of pedogenic carbonate nodules and soil organic matter record the formation of Pliocene soils during warm-wet and cooler-drier conditions, while ranges of C_3 and C_4 grasses shifted across the area. Thus, microbial, plant, and animal interactions in different environments have manifested themselves as soil ecosystems that have engineered patterns of biodiversity, nutrient dynamics, water balance, carbon and nitrogen cycling, and other biogeochemical cycles. To various degrees, these have influenced paleoclimates and biogeochemical cycling throughout the Phanerozoic.

Insects and Terrestrial Arthropods in the Fossil Record: Are So Many Really Represented by So Few

by Robert Nelson (convener)

Virtually the entire age range of terrestrial arthropod assemblages was represented at this session of the GSA Annual Meeting in Boston, from the middle Devonian to fossils possibly as young as Pliocene. Due to last-minute difficulties encountered by one speaker, who was thus unable to attend the meeting, the Quaternary was unrepresented. Talks were arranged for the most part in geochronologic order, with older faunas presented earlier in the session.

Bob Nelson and Bob Gastaldo and their students from Colby College presented preliminary results of their studies of Early Middle Devonian (Eifelian) arthropod remains from the Trout Valley Formation of north-central Maine. Rare three-dimensionally preserved specimens are entirely graphitized but only slightly flattened. Further material is being processed and the search for new specimens continues, while work also continues to put identifications on the specimens thus far recovered.

Cary Easterday of Ohio State presented the results of his studies on an arthropod fauna of Pennsylvanian (Desmoinesian-Missourian) age from eastern Ohio. His materials included a trigonotarbid, millipede, and a large number of cockroaches, including a specimen of the largest known Paleozoic species at approximately 10 cm in length.

Jorge Santiago-Blay of the Smithsonian Institution and Roanoke College presented two new fossil scorpion records, one of Cretaceous age from Brazil and one of Tertiary age from Mexico. Coauthors on his presentation included Victor Fet of Marshall University, Michael Soleglad, Luis Garibay Romero of Universidad Autonoma de Guerrero, Mexico, Patrick Craig, and Shiahn Chen of the University of Virginia. He has been able to document that numerous Mesozoic scorpion clades survived the terminal Cretaceous extinction event.

Steve Hasiotis, University of Kansas, discussed the rich ichnofossil record that insects and terrestrial arthropods have left, and noted that much of it has remained relatively ignored until recently. Many trails, burrows, and the like are exceptionally well preserved because they were not merely excavated, but positively constructed and reinforced.

Conrad Labandeira discussed the Middle Jurassic (Callovian) Sundance fauna of northern Wyoming and southern Montana, a rich but strictly aquatic insect fauna dominated by Heteroptera and Coleoptera, preserved in a limy shale. His coauthors included Jorge Santiago-Blay and Louis Pribyl of the Smithsonian Institution, Carol Hotton of the National Institutes of Health, and Larry Martin of the University of Kansas.

Following a break, Conrad Labandeira returned to the podium to offer his invited presentation on the "Terminal Cretaceous Devastation of Planet-Insect Associations." Based on intensive analysis of floras from 106 levels in the Williston Basin of North Dakota, he and his coauthors were able to conclude that "(t)he most specialized associations, which were diverse and abundant in the latest Cretaceous, virtually disappeared at the boundary along with their plant hosts, and failed to recover in younger strata even as generalized associations regained their Cretaceous abundance." Coauthors on this presentation were Kirk Johnson of the Denver Museum of Nature and Science, and Peter Wilf of the University of Michigan.

This talk was followed by a lively discussion by Tony Martin of Emory University, on trace-fossil evidence for insect-on-insect parasitism in the late Cretaceous (Campanian) of Montana. Numerous puparia that he has found in the Two Medicine Formation show minute, rimmed exit holes too small for the adult in the puparium to have formed, but entirely analagous to modern parasitoid exits. Some of the puparia also appear to have multiple parasitoid egg cases attached.

Sara Lubkin of Cornell University was scheduled to follow this with a discussion of work she is doing on Cretaceous insects from New Jersey, but she instead presented some preliminary results of her thesis research into the fossil record of the Archostemata. This suborder of beetles, relatively rare in the modern world, was apparently both very diverse and abundant in the Mesozoic.

Dena Smith and Amanda Cook of the University of Colorado discussed some of the taphonomic biases in arthropod faunas, in noting how the character of the sedimentary environment itself can influence patterns of coleopteran (beetle) diversity in the fossil record.

Jorge Santiago-Blay returned to the podium to present Patrick Craig's and his results from an Early Miocene brackish-water fauna preserved in amber from Chiapas, Mexico. (Patrick Craig had been scheduled to speak but was unable to attend the meeting.) Though not a terrestrial fauna, this non-marine assemblage included a barnacle, tubeworm cases, an oyster and a freshwater clam. The fauna has been tectonically uplifted by 600-1200 m since deposition.

Allan Ashworth, North Dakota State University, presented an Antarctic fauna of possible Pliocene age, that includes weevils related to modern species occurring at the margins of South American southern beech (*Nothofagus*) forests, as well as the posterior portion of a puparium of a cyclorrhaphan fly. These are significant because the known modern insect fauna of the entire continent of Antarctica consists of just two species of midges (Diptera), augmented by mites and springtails as the only other terrestrial arthropods on the continent.

The session succeeded in bringing together a number of people working in different parts of the world, on faunas of different ages, and many of whom were unaware of the work being done by the others. New potential collaborations have emerged as people became acquainted with one another. It is hoped to make a similar session an annual event at the national GSA meetings.

Evolutionary Synthesis Center

by David Jablonski

Over the past year, two NSF-funded workshops have been held to discuss bringing an initiative to NSF concerning an Evolutionary Synthesis Center. This Center would be modeled roughly along the lines of NCEAS (National Center for Ecological Analysis and Synthesis), currently in full operation at Santa Barbara. The results of the two workshops, which were organized and run by Margaret Riley (Yale University), are posted on the Web at: http://esc.eeb.yale.edu/. Peg and the rest of the steering committee for these workshops (David Maddison, University of Arizona, Elizabeth Kellogg, University of Missouri, and Martin Feder, University of Chicago) were eager for a paleontological component to the discussions, and invited Charles Marshall (Harvard University) to attend the first meeting and me to attend the second. The meetings were very productive and I'm delighted to say that there was broad interest in including paleontological perspectives in both the design and the operation of the Center.

Please have a look at the Web site and express your opinion in the 'Comments' section. Peg is continuing to refine this proposal based on feedback from the evolution community, for final submittal in November, and so this is the time to send responses. Please pass the word along to other societies or working groups that are interested in evolution. Each of the workshop participants is targeting various societies so we're hoping to reach the widest possible range of evolutionary biologists and paleontologists this summer. If you are running a meeting this summer, feel free to download the executive summary (given below) for distribution in registration packets.

The senior management at NSF had its science retreat in early April, and heard about the need for more synthesis centers. There is a strong possibility there will be a competition in either FY03 or FY04 for an Evolutionary Synthesis Center. This bodes well, and we hope that the evolution community will be able to submit a couple of strong proposals. Many thanks for Peg Riley for her hard work on getting this ball rolling!

Executive Summary: Addressing the need for a national center for evolutionary synthesis

Evolution has long served to unify the study of biology. Today, evolution has taken on an even greater role, as it serves to inform and direct data acquisition, analysis and interpretation across the life sciences. This transformation comes in part from an explosion of raw data, from sources as far ranging as whole-genome sequences and phylogenetics to long-term behavior studies and functional morphology. Such data and metadata can only be interpreted using advanced mathematical and statistical approaches built on evolutionary concepts and depends on highly developed database management and analysis tools.

As formerly disparate fields of biological research converge, evolutionary biology is providing the common language. Evolutionary biology is poised to serve as the focal point for the synthesis and interpretation of these massive and growing data sets. Evolution can, and should, play a similarly central role in addressing a suite of critical national concerns. For example, evolutionary biology has a pivotal role to play in combating the evolution of infectious disease, in understanding the emergence and spread of antibiotic resistance, and in the application of population genetic tools to trace lineages of bioterrorism agents. To accomplish this mission, however, requires the coordination and communication between a diversity of scientists, government agencies, policy makers, medical doctors, epidemiologists and others.

There is no institution or funding agency dedicated to the consolidation, synthesis and dissemination of this broad sweep of evolutionarily relevant information. The National Science Foundation recently funded two workshops aimed at addressing the scientific and national needs for an evolutionary synthesis center and proposing mechanisms to meet these needs. The National Center for Ecological Analysis and Synthesis (NCEAS) provides a successful model for addressing the need for synthesis. NCEAS has implemented a successful scientific/social mechanism, the working group, which brings together scientists who collaborate to produce synthesis of ecological knowledge to address broad scientific and policy questions. A center for evolutionary synthesis modeled on NCEAS would serve first the needs of the evolutionary community by providing mechanisms to foster synthetic, collaborative, cross-disciplinary studies. The center would also play a pivotal role in the further unification of the biological sciences as it draws together knowledge from disparate biological fields to increase our general understanding of biological design and function. Finally, the center would play a critical role in organizing and synthesizing evolutionary knowledge that will inform policy makers, government agencies, educators and society, for instance in the fields of infectious disease, drug design, biological responses to global warming, and bioremediation.

A document reporting the outcome of the two NSF-funded Evolutionary Synthesis Center Workshops is available at the following web site: http://esc.eeb.yale.edu. In order for this document to truly reflect the needs and concerns of the breadth of the evolutionary biology community, we must hear from that community directly. To this end, we announce two avenues for providing input into the development of a final version of this document, which details the need for an evolutionary synthesis center and the mechanisms envisioned by the evolutionary biology community to meet that need. The final document will be submitted to the NSF in November of 2002.

Mechanisms for providing input into the development of the final Evolutionary Synthesis Center document for submission to NSF:

I. The Evolutionary Synthesis Center web site has a comments section. All comments received by October 2002 will be considered by the steering committee during the final phase of document revision.

II. Participants of the two ESC workshops are listed below. These individuals can be contacted directly – email addresses are provided at the Website — for further information regarding the workshops and to provide input into the final document.

ESC Workshops Steering Committee:
David Maddison, University of Arizona
Elizabeth Kellogg, University of Missouri
Martin Feder, University of Chicago
Margaret Riley, Yale University, Chair

ESC Workshops Participants:
Jeanne Altmann, Princeton University
Charles Marshall, Harvard University
Stephen Palumbi, Harvard University
Gunter Wagner, Yale University
Claiborne Stephens, Gennaissance Pharmaceuticals
Douglas Futuyma, SUNY, Stony Brook
Jim Reichman, Univ. of California, Santa Barbara, Director of NCEAS
Laura Katz, Smith College
Scott Edwards, University of Washington
Robin Bush, University of California, Irvine
Susan Mazer, University of California, Santa Barbara
Alison Withey, San Diego Supercomputer Center
Emilia Martins, University of Oregon
Jennifer Wernegreen, MBL, Woods Hole
David Hillis, University of Texas
Robert Dorit, Smith College
Nancy Moran, University of Arizona
Spencer Muse, North Carolina State University
Bette Korber, Los Alamos National Laboratory
David Stockwell, San Diego Supercomputer Center
Ruth Shaw, University of Minnesota

Geeta Bharatan, SUNY, Stony Brook
Michael Lynch, Indiana University
Ward Watt, Stanford University
Mark Schildhauer, NCEAS
David Jablonski, University of Chicago
Tandy Warnow, University of Texas
Gary Olsen, University of Illinois
Hillol Kargupta, University of Maryland
Billie Swalla, University of Washington
Claudia Neuhauser, University of Minnesota
Robert Feldman, Molecular Dynamics, Inc.
Jeffrey Blanchard, National Center for Genome Resources
Peter Midford, University of Arizona
Brian Bettencourt, Pennsylvania State University
Janet Barber, University of Missouri
Scott Rifkin, Yale University

Understanding the Selectivity of Extinction: What does Paleontology have to Offer?

by Greg Herbert, Student Representative

An important debate in paleontology concerns the degree to which survivorship during episodes of extinction in the geologic past reflects ecology (i.e., rule-governed interactions among entities within a community) versus historical contingency (e.g., unpredictable disturbances, geographic location of a group, etc.). The question is central to the study of evolution, for to understand the nature of extinction is to understand a major component of differential evolutionary success in the fossil record. The debate has also begun to pique the interests of many conservation biologists, who seek to develop a predictive model of extinction based on studies of both present and past extinctions.

What does paleontology have to offer on this issue? There is no question that some taxonomic groups have suffered greater rates of extinction than others in the past. However, the fact that taxonomic selection has occurred tells us little about what has been selected for. Disappearance of taxa can be due to the shared possession of a particular ecological trait, concentration of a taxon's members in a single geographic locality that is subsequently perturbed, or even statistically random extinctions within low diversity taxa. Clearly, teasing apart the relative influence of each of these processes requires a detailed understanding of the organisms themselves and their context.

Paleontologists are, of course, in a difficult position, because few traits demonstrated to be good predictors of extinction susceptibility on ecological timescales (i.e., clutch size, age at first reproduction, offspring size, and lifetime fecundity) have ever been documented from fossilized material. Body size has been used widely as a proxy for various ecological and biological traits, including energetic requirements, fecundity, lifespan, and vulnerability to mortality from competition and predation, to name just a few. However, body size is an extraordinarily complex aspect of organismal biology, and its interpretation can be confounded by developmental variability. Two species reaching identical adult sizes, for example, can differ greatly in birth or hatching size, growth rate, age at maturation, and longevity, each of which may affect extinction susceptibility in different ways. I would be willing to bet that studies taking such developmental variability into account when asking whether ecology influences survivorship might find more than a "surprisingly weak" statistical correlation. More to the point, I would expect that in many cases, the developmental processes themselves and not the adult phenotype, will be found to be the primary targets of selection.

The confounding effects of phylogeny are also a problem. Any negative consequences of large size (or any other trait) for species during times of ecological crisis could be mitigated or magnified by other traits (i.e., behavior, life history, micro-habitat, etc.) that are not part of the analysis and whose distribution is influenced by phylogeny. Cross-taxon studies that fail to remove the confounding effects of phylogeny may find no statistical correlations between susceptibility and a particular trait, when, in fact, a real relationship exists.

If paleontology is to contribute in a meaningful way to understanding the processes underlying the selectivity of extinction, there are several obstacles it must overcome. First and foremost, paleontologists need to develop novel means of accessing biologically significant traits from fossilized material. Stable isotope sclerochronology has been used primarily to reconstruct paleoenvironmental parameters, but it can also be used to gather data on season of reproduction, growth rates, age at maturation, and longevity, and could play a central role in addressing the importance of ecology in the fossil record. Second, examining these traits within a phylogenetic framework will pose a major challenge. For most groups, no phylogenies are yet available, and, unfortunately, there is less and less funding available for basic systematic research. Paleontologists also lag far behind neontologists in developing methods for comparative analysis that take phylogeny into consideration; incorporating the element of time into these methods is not a straightforward matter, and there is surely room to progress here. Last, none of our efforts will be worthwhile unless we identify the best time periods, geographic regions, and taxonomic groups in which to test the importance of these traits.

Greg Herbert is a PhD graduate student at the University of California, Davis who is interested in evolutionary responses to climate change, taxonomy and phylogenetic systematics of muricid gastropods, and predator-prey interactions in the fossil record. Currently, Greg is spending a good portion of his time using stable isotope sclerochronology to trace the evolution of life history strategies in Pleistocene marine mollusks.

The Paleontological Society Distinguished Lecturer Program

by Christoper G. Maples, Councilor

Each year the Paleontological Society selects outstanding scientists whose works encompass a wide variety of paleontological topics as Paleontological Society Distinguished Lecturers. Each Distinguished Lecturer has national and international stature in paleontology, has traveled widely, and has published extensively. Each is also known as an excellent speaker who can communicate the interest and importance of their research topics. This program is intended to make available lecturers for inclusion in departmental speaker series or other college and university forums.

The Paleontological Society Distinguished Lecturers, topics, and short abstracts of presentations for the 2001-2003 academic years are listed below. Additional information is available on The Paleontological Society homepage at: http://www.paleosoc.org/speakerseries.html. If your department is interested in inviting one or more Distinguished Lecturer to your institution, please contact the speaker directly. Although financial arrangements must be made directly with each speaker, all Paleontological Society Distinguished Lecturers have agreed to be available on an expenses-only basis.

The Paleontological Society hopes that you take advantage of this opportunity. Paleontology is a dynamic discipline, and these speakers will certainly convey the excitement and timeliness of our science. If you have any questions regarding the Paleontological Society Distinguished Lecturer program, please feel free to contact me at: cmaples@indiana.edu.

ACADEMIC YEARS 2001–2002 DISTINGUISHED LECTURERS

Roger J. Cuffey Phone: 814-865-1293
Department of Geosciences Fax: 814-863-8724
412 Deike Bldg.
Pennsylvania State University
University Park, PA 16802
E-mail: cuffey@ems.psu.edu

Bryozoan Reefs though Geologic Time
Bryozoan-built reefs are scientifically intriguing because they are rare; they represent an ecologic extreme for their phylum, and an exotic contrast to more numerous coelenterate-dominated reefs. Continuing analysis of as many bryozoan reefs as possible is furnishing data on their systematic composition, constructional roles, paleoecology, and evolution. Trends displayed thus far include widely fluctuating abundances, subordinal and specific compositions, compactness of framework, influence of surrounding sediments, and growth in both tropical and temperate waters. Most notably, their history is highlighted by trepostomes in crust-mounds in the early Paleozoic, fenestrates in mud-mounds and frame-thickets in the late Paleozoic, and cheilostomes in reef-veneers and crust-mounds in the Cenozoic. (Semi-technical talk for geologists, biologists, and related scientists.)

Dinosaur Travel in Mongolia
Vertebrate paleontologists traditionally have gone out and prospected new field areas in order to expand the hypodigm or database underpinning evolutionary understandings. However, increasingly, value is also seen in re-visiting classic localities well-collected by early workers. Recent geopolitical changes make it possible for paleontologists (individually or with expeditions) to re-visit Mongolian localities like Roy Chapman Andrews' Flaming Cliffs dinosaur-egg site, and to examine specimens mounted in the Ulan-Bataar museum. (Non-technical general talk for both the public and scientists of

Bryozoans, Battle Wreckage, and Artificial Reefs
Sinking hard materials to form the substrate for artificial-reef growth has recently developed as a useful technique in reef management and conservation. Discovery of sizeable bryozoan crusts on the 138-year-old Monitor shipwreck, and extensive coral heads on 56-year-old sunken ships and planes in Truk lagoon, suggest the possibility of inadvertent artificial reefs eventually developing at such sites. The introduction of metallic substrates is something new in earth and life history, but much can be predicted for future growth by applying paleoecological principles from fossil reefs. (Speculative general talk for geologists, biologists, and historians.)

The Earliest Bryozoan Reefs and the Initial Bryozoan Radiation
Bryozoans first appeared early in Ordovician time. Bryozoan-built reefs developed immediately thereafter (by mid-Early Ordovician in China), and for a while (into the mid-Middle Ordovician in the Appalachians and Mid-Continent) flourish alongside the oldest reef-building corals. These early bryozoan frame-builders are characterized by strong or sturdy or strengthened skeletal morphologies, but small colony size. In contrast, corals soon developed symbioses with certain algae, which resulted in much greater carbonate production, larger sizes, and eventual volumetric overwhelming of the other early reef-builders including bryozoans. Later in geologic history, where local environmental conditions or mass extinctions decimated corals, bryozoan reefs reappeared, sometimes with similar features as their remote predecessors. (Technical talk for paleontologists, geologists, biologists, and ecologists.)

Brian T. Huber Phone: 202-786-2658
Department of Paleobiology Fax: 202-786-2832
MRC NHB-121
Smithsonian National Museum of Natural History
10th and Constitution Ave., NW
Washington, DC 20560
E-mail: Huber.Brian@NMNH.SI.EDU

Deep-Sea Record of the Asteroid Impact that Ended the Dinosaur Era
Life on Earth was dramatically disrupted 65 million years ago when an asteroid 10 km across slammed into the Yucutan Peninsula, releasing an energy equivalent of 108 megatons of TNT. Many workers believe that extinction of numerous plants and animals, including the dinosaurs, was directly caused by this impact event. Yet others disagree, suggesting that the mass extinctions began before the K/T layer and continued afterward, and the impact event was just one of many extinction mechanisms at that time. Deep-sea cores drilled from the ocean floor east of the Florida coast contain evidence that helps resolve this controversy. Chalk sediments determined to be latest Cretaceous in age are overlain by a 17 cm thick layer composed mostly of tektites, which are glassy globules of Earth's crust that melted in the blast and hardened as

they rained down over large areas of Earth. Shocked quartz and other mineralogic indicators of the blast also occur in this tektite layer. Chalk sediments immediately above this tektite bed are composed mostly of new species of planktic foraminifera that are a fraction of the size of Cretaceous species, and much less diverse. Very rare Cretaceous species also occur, but their sporadic occurrence, abnormal size distribution, and different geochemical composition demonstrate that these specimens were reworked from older sediments. The abruptness of this biotic change leaves little doubt that the cataclysmic effects of the bolide impact were the direct cause of the marine microfossil extinctions that have been observed worldwide.

Biotic and Paleoceanographic Changes During the Mid-Cretaceous Supergreenhouse

A growing body of evidence from northern and southern high latitudes has revealed that the Cenomanian-Turonian boundary interval (CTBI; ~95–92 Ma) was a time of the warmest global paleotemperatures the Earth has experienced during at least the past 140 m.y. New oxygen and carbon isotope records from a deep-sea core drilled in the subtropical North Atlantic fully corroborate the high-latitude records. The subtropical benthic foraminiferal oxygen isotope data indicate that middle bathyal waters warmed from 16°C during the middle through late Cenomanian to 20°C during the latest Cenomanian (~95 Ma). This extreme warming of deep waters may have caused a breakdown in the vertical structure of the water column, and could explain the extinction of deep-dwelling planktonic species. On the other hand, sea-surface temperature estimates, based on planktonic foraminiferal $\partial^{18}O$ values (corrected for salinity), remain steady throughout the CTBI, varying between 23 to 26°C. The presence of volcaniclastic sediments at the level of the warmest paleotemperatures is consistent with previous suggestions that the CTBI was a time of anomalously high CO_2 flux into the atmosphere and oceans during a major phase of explosive volcanic activity and large igneous province emplacement in the Caribbean and other regions worldwide. Further investigation of the CTBI is needed to establish whether increased pCO_2 can be accepted as the primary forcing mechanism for the middle Cretaceous supergreenhouse.

Anatomy of an Early Cretaceous Oceanic Anoxic Event

Cretaceous "Oceanic Anoxic Events" (OAEs) can be correlated globally in pelagic carbonate facies by positive carbon isotopic excursions typically near or within dark marls that are enriched in organic carbon. In some cases, OAEs are accompanied by biotic turnover among select planktonic, nektonic, and benthic organisms. The cause of OAEs remains uncertain despite over two decades of intense study. Some authors suggest that tectonic events and widespread transgressions caused stagnation of deep waters and led to creation of a large number of salinity stratified marginal basins. Others suggest that bottom water dysoxia resulted from intensified surface productivity that led to rapid burial and preservation of the organic matter. An excellent record of an early Albian OAE 1b was recovered from an Ocean Drilling Program site on the flank of Blake Plateau. Presence of large pyrite nodules, fine sediment lamination, total organic carbon values above 10%, and impoverished and dwarfed benthic foraminiferal assemblages testify to the extremely low oxygen content of the upper bathyal waters during the peak of this event. Unlike other OAEs, however, benthic and planktonic foraminifera yield surpisingly enriched $\partial^{18}O$ values, suggesting that the upper bathyal and surface waters were relatively cool (~9 and 12°C, respectively) or highly saline. Planktonic foraminifer populations throughout the OAE 1b event are characterized by their unusually small shell size and low species richness, which is typical of modern assemblages from upwelling environments. However, species abundance changes across the black marl interval are minor and the vertical carbon isotope gradient is not as high as vertical gradients typically found in high productivity zones. Results from this study illustrate that the primary factors that caused the Cretaceous OAEs are still enigmatic.

Bruce S. Lieberman Phone: 785-864-2741
Departments of Geology Fax: 785-838-9664
and Ecology & Evolutionary Biology
University of Kansas
Lawrence, KS 66045
E-mail: blieber@eagle.cc.ukans.edu

The Cambrian Radiation: Understanding Biology's Big Bang

The Cambrian radiation is a key episode in the history of life when large animal taxa start diversifying in the fossil record. Geologically, the episode seems incredibly rapid, yet some evidence now seems to be accumulating that this may not be the case. What is the nature of the Cambrian radiation, what are the processes that might have contributed to make this event what it was, what are the current paleontological debates about, and was the radiation really so fast that it challenges Darwin's view on the tempo of evolution? These are some of the topics that will be considered, with special reference to our ability to trace the evolution of groups of species, and figure out what this can tell us about life 520 million years ago.

Natural Selection, Species Selection, and Trends

Natural selection is one of the fundamental mechanisms invoked to explain the trends seen throughout the history of life. This mechanism produces adaptations that govern how fit an organism is in relation to its environment. However, some have suggested selection processes need not solely be for the good of the organism, but rather may be for the good of the species. The debate about whether this process, termed 'species selection,' actually operates has been a particularly rancorous one. The potential validity of this mechanism gets to the issue of what are the evolutionary forces that drive trends. Examples from the fossil record and the extant biota are used to consider whether species selection, and the increased propensity to speciate, govern certain groups' success through time or rather if such trends are best explained by changes in developmental timing or by using standard metaphors of organismal adaptation.

Species and Stasis: Causes and Consequences

Punctuated equilibrium is based on the recognition that species are stable throughout most of their millions of years of existence, and then diverge relatively quickly, in the space of tens of thousands of years, in small, isolated populations. The demonstration that punctuated equilibrium was a fundamental evolutionary pattern in the fossil record is one of paleontology's great recent contributions to evolutionary biology. This contribution is significant for evolutionary theory because whether or not species are stable throughout most of their history potentially has great significance for our understanding of the nature of evolutionary change and adaptation. In this talk, the nature of species as morphologically stable entities over many millions of years will be considered. Further, the processes that may contribute to this stasis will also be explored.

Charles R. Marshall Phone:617-495-2351
Department of Earth and Planetary Sciences Fax:617-495-8839
20 Oxford Street
Harvard University
Cambridge, MA 02138-2902
E-mail: marshall@eps.harvard.edu

A New Paleontological Method for Estimating Times of Origin, and Developmental Perspectives on the Nature of Evolutionary Innovations

Here I explore two aspects of the ongoing "molecular revolution" that have particular relevance to paleontology. The first concerns the attempt to reconcile the often large discrepancies between molecular clock and fossil record estimates of times of divergence of evolutionary lineages, by estimating the stratigraphic ranges of species NOT preserved in the fossil record. I then turn to give a paleontologist's view of the revolution in our understanding of the mechanistic basis of development, key to understanding the variation upon which evolutionary change depends.

More Realistic Ways of Quantifying the Incompleteness of the Fossil Record in Both Local Sections, and in Global Compilations.

Existing methods for quantifying the incompleteness of the fossil record are based on statistical assumptions that are often violated by real stratigraphic data. Here I outline a new (Bayesian) approach for quantifying the incompleteness of the fossil record, illustrated through an analysis of the trilobite extinctions across the Marjumiid-Pterocephaliid trilobite biomere boundary. I will then turn my attention to a group effort that has been working towards removing sampling biases in Phanerozoic diversity curves.

Lisa E. Park Phone: 330-972-7633
Department of Geology Fax: 330-972-7611
University of Akron
Akron, OH 44325-4101
E-Mail: lepark@uakron.edu

Little Things in a Big Lake: What Ostracodes Can Tell Us About Diversification in Rift Lake Systems

The East African lake systems have long been known as areas of megadiversity, particularly with respect to the large, endemic species flocks that originated within various lakes in this geologic and geographic setting. These aquatic island systems and their elevated biodiversity, are unparalleled for their potential to test hypotheses of comparative evolution on large scales. The sedimentary and fossil record of these lakes offers us the opportunity to resolve both evolutionary and ecological changes in their biota at decadal resolution, over hundreds of thousands to millions of years. Recent analyses of cichlid fish, thiarid molluscs, and ostracodes show that diversification patterns are often linked to environmental differences as well as incidences of multiple invasions and subsequent radiations in the lake.

By studying the long- and short-term changes in these lake environments via ostracodes, we can better understand paleoecological and speciation processes operating on many different temporal scales. Documenting and understanding what creates and maintains this incredible diversity has important implications for the longer-term paleontological record, as well as immediate implications for conservation of these extraordinary biotic systems in the face of a wide variety of environmental threats that include siltation due to the deforestation of the watershed, exotic species introduction and pollution from insecticides and fertilizers.

The Neogene of Africa: the Role of Environments in Terrestrial Evolution

Environmental change, particularly that related to climate fluctuations, is widely viewed as an important factor in the evolution of Neogene terrestrial faunas. Paleontological and stratigraphic investigations in East Africa over the last five decades have added greatly to our knowledge of Neogene faunal evolution and ecology, including insights into the origins of the human family and the character of the environments in which they lived. Most of these investigations have focused on sedimentary sequences preserved in the extensional basins of the East African Rift (e.g., Olduvai, Laetoli, Lake Turkana, Tugen Hills Sequence, Omo and the Awash Group).

From these and other studies, various hypotheses have been forwarded to explain the changes recorded in mammalian faunas (including Hominidae) in Africa during the late Cenozoic. The turnover pulse hypothesis (advanced by E. Vrba, 1980–1995) posits that species origins and extinctions were initiated by dramatic climatic change (aridity and cooling) in Africa during the late Pliocene and again in the Pleistocene. The variability selection hypothesis (advanced by R. Potts, 1996–1998) suggests that oscillations, as evidenced in global and regional sedimentary records, were responsible for these significant changes in fauna. In the case of hominids, environmental fluctuations could have had a formative impact on the origin of toolmaking, brain enlargement, and other advances in human adaptability. In the case of large mammals, there are widely documented faunal turnovers during the Late Miocene and Plio-Pleistocene in Africa that may be due to regional and global climatic (i.e. environmental) change. By examining these records, the fundamental question posed by Darwin (1859) regarding the role of physical factors in biotic evolution can be addressed.

Judith Totman Parrish Phone: 520-621-6024
Department of Geosciences Fax: 520-621-2672
Gould-Simpson 208, P.O. Box 210077
The University of Arizona
Tuscon, AZ 85721
Email: parrish@geo.arizona.edu

Jurassic Park was not a Jungle

The Morrison Formation, which extends from the southern Colorado Plateau into Montana, is what some people think of when they think of Jurassic Park—it is an extraordinarily rich source of dinosaur fossils. Conflicting paleoclimatic interpretations of the formation have confounded interpretations of the Morrison ecosystem. Integrated work on the plants, dinosaurs, and sedimentary rocks of the Morrison Formation has made progress toward resolving this conflict. The vegetation of the Morrison Formation was predominantly herbaceous, consistent with recent conclusions that some of the largest dinosaurs were probably grazers and low browsers.

Comparison of Humid and Semi-Arid Paleoecosystems

Humid and semi-arid ecosystems differ in the abundance and distribution of plant and animal remains. Humid climates more commonly provide favorable conditions for plant preservation than do semi-arid climates, which makes understanding the vegetation particularly challenging. However, there are some surprising similarities in the preservational modes and in how the vegetation signature is recorded. A comparison of humid paleoecosystems from the Cretaceous of northern Alaska and semi-arid ecosystems from the Triassic and Jurassic of the Colorado Plateau illustrates the differences and similarities.

ACADEMIC YEARS 2002–2003 DISTINGUISHED LECTURERS

Christopher A. Brochu Phone: 319-353-1808
Department of Geoscience Fax: 319-335-1821
University of Iowa
Iowa City, IA 52242
E-mail: christopher-brochu@uiowa.edu

Simultaneous Illumination - Phylogenetic Approaches toward Crocodylian History

Crocodylians are often dismissed as "living fossils" little changed since they first appear in the Mesozoic. Although a limited number of morphotypes have arisen during the group's history, crocodylian phylogeny is much more dynamic than often acknowledged. A phylogenetic approach reveals a complex biogeographic history. By considering both fossil and molecular estimates of divergence timing, the geographic distributions of most extant crocodylian lineages require the crossing of a major marine barrier at least once—for example, three different lineages crossed the Atlantic during the Late Tertiary.

Studies of diversity over time suggest that crocodylian diversity showed two diversity peaks—one in the Eocene, and another in the Miocene. A phylogenetic perspective reveals differences between these peaks. Clades with minimum origination dates in the Cretaceous or Early Tertiary are morphologically uniform, but geographically widespread. Crocodylian faunas during the early Tertiary tend to be phylogenetically composite. In contrast, crocodylian faunas of the later Tertiary tend to be more endemic. Climate change is usually seen as the primary agent behind crocodylian diversity changes over time, but increased separation between continental land-masses during the later Tertiary may have prevented widespread dispersal of specialized clades, allowing multiple endemic radiations to occur. This suggests that tectonics may be partially responsible for an increase in crocodylian diversity early in the Neogene.

A phylogenetic perspective enhances our interpretation of temporal patterns, because the biogeographic details recovered from the calibrated phylogeny are not evident from counts of taxa over time. And re-examination of curated specimens is critical for the recovery of these patterns, as taxonomic philosophies have fluctuated over time, and published classifications may not mirror phylogenetic relationships. (Talk can be given for general, intermediate, and specialist audiences)

The Science of Sue

The skeleton of FMNH PR2081 (popularly known as "Sue") is the largest, most complete, and best preserved *Tyrannosaurus rex* ever collected. It reveals structures thought to be absent from tyrannosaurids and other derived theropods (such as a proatlas arch), but also suggests that some features thought to be present in tyrannosaurids were not present at all (such as the bony sternum). There are several abnormalities, including healed fractures in the trunk ribs and fused caudal vertebrae that appear not to result from fracture. Exostotic bone in the fused caudals grew around caudal muscular bands, preserving a natural mold of the tail musculature. None of the abnormalities on the jaw are healed bite marks.

A high-resolution computed tomographic (CT) analysis of the skull generated 748 2-mm-thick slices. Inspection of both the raw slices and 3-D models generated from them allowed the preparation team to see obscured objects before they were manually exposed. These images reveal internal details not previously accessible in intact tyrannosaurid skulls, such as the ossified medial wall of the maxillary antrum and the internal morphology of the pneumatic recesses, which may have communicated with pneumatic chambers in the neck vertebrae. They also permit the creation of a digital endocast that goes beyond those made through destructive means by preserving nerve pathways all the way through the braincase and internal details of the otic capsule. It reveals an interesting combination of ancestral and derived features relative to the brains of living dinosaurs and other archosaurs. The endocast confirms the presence of a large olfactory nerve and reveals greatly enlarged olfactory bulbs relative to those in other nonavian theropods, suggesting that smell was emphasized in the sensory repertoire of *Tyrannosaurus*.

A chevron bone was found during preparation that fits between the first two tail vertebrae. The absence of this bone was one reason "Sue" was thought to be female. A close examination of other criteria used to sex dinosaurs reveals further interesting complications. (Talk can be given for general, intermediate, and specialist audiences)

Differing Temporal Expectations for Crocodylian Phylogeny: Molecules versus Stratigraphy

Different sources of temporal information—the stratigraphic distribution of fossils and molecular distances between extant species—can yield very different estimates. These do not represent "conflict" in the same sense that different data sets may support different trees, as temporal estimates are limited by known incompleteness (the fossil record) and labile assumptions (a priori estimates of molecular evolutionary rate). Moreover, disparity may result more from failure to address the same phylogenetic question with different data sets.

Different temporal predictions for crocodylian phylogeny illustrate all of these points. In the most famous disparity, fossils have long been used to indicate a Mesozoic divergence between *Gavialis gangeticus* (the Indian gharial) and any other living crocodylian, whereas molecular distances have suggested divergences as recently as 20 million years. Reevaluation of the fossil evidence makes any divergence in the Cenozoic unlikely, and this disparity may result in large measure from an invalid assumption of clocklike evolution over the entire group. Other comparisons calibrated by fossils - especially among caimans—suggest unreasonably high rates of molecular evolution, and indicate the presence of significant ghost lineages in the fossil record. Addition of new fossil information can recalibrate hypothesized rates of evolution, and the degree of revision can depend not only on the temporal distance between fossils, but on the distance between the relevant fossils and the Recent.

Finally, some indicated disparities stemmed from a lack of rigorous phylogenetic hypotheses for some fossil groups. Molecular distances indicated a Late Tertiary divergence within the widespread genus *Crocodylus*, long thought to be an ancient group; close examination of fossils assigned to *Crocodylus* instead suggests a divergence among living *Crocodylus* no earlier than the Miocene. (Talk can be given for general, intermediate, and specialist audiences)

Lucy E. Edwards Phone: 703-648-5272
U.S. Geological Survey Fax: 703-648-6953
Reston, VA
E-mail: leedward@usgs.gov

Coastal Plain Stratigraphy: It Isn't Just Layers Any More (and Probably Never Was)
Studies over the last two decades in the stratigraphy of the Atlantic Coastal Plain have shown that simple models of stratigraphic units (and their related aquifers and confining units) being thicker downdip and pinching out updip are seldom accurate. Discontinuous lenses of sediments are as common as simple continuous layers, and wide thickness variations are the norm. Current work in South Carolina has led me to speculate that anomalous patterns of erosion preserved in Paleocene and Eocene sediments represent scour caused by an eddy system of the predecessor of the present Gulf Stream. I will also bring up any new developments in the ongoing study of the stratigraphy of the sediments filling the Chesapeake Bay impact structure. (Semi-technical, for stratigraphers and hydrologists)

Biostratigraphy, Paleoecology, and Biogeography: What's Signal? What's Noise?
Biostratigraphers love the lowest and highest stratigraphic occurrences of taxa (FADs and LADs). But not all FADs and LADs are created equal. In any given stratigraphic succession, some taxa first occur because they evolved in that area at that time. Others first occur for purely ecological reasons or due to immigration. Instead of bemoaning the ecological misfits, we should use them, but not for biostratigraphy. The technique of graphic correlation is explained. I demonstrate how it easily tests the hypothesis of synchroneity. Nonsynchronous FADs and LADs should immediately be excluded from further consideration for correlation. But they should not be excluded from the overall analysis. A diachronous event cries out for paleoceanographic, paleoecological, or post-depositional interpretation. Dinoflagellates from the Miocene of Florida illustrate concepts such as climatically influenced patterns of immigration. (Semi-technical, for geologists and paleontologists)

Dinoflagellates: My Favorite Fossils
Dinoflagellates are organisms that cause red tides in modern seas. The dinoflagellate *Pfiesteria* has been called the "cell from hell" by the news media. Dinoflagellates are common in the fossil record from the Late Triassic onward. In many instances, when the sediments are too far downdip to have good pollen and too far onshore to have a good calcareous microfossil assemblage, dinoflagellates provide key biostratigraphic and paleoecologic information. (Not too technical, for geologists and biologists, and interested amateurs—everyone will learn something)

Stanley C. Finney Phone: 562-985-8637
Department of Geological Sciences Fax: 562-985-8638
California State University—Long Beach
Long Beach, CA 90840 USA
E-mail: scfinney@csulb.edu

Is the Late Ordovician Mass Extinction an Artifact of Stratigraphic Resolution?
The Late Ordovician mass extinction was contemporaneous with rapid advance and retreat of continental glaciation in Gondwana. Integrated, multidisciplinary, high-resolution study of shelf and basin stratigraphic successions in central Nevada and comparison with data from other tropical paleo-plates indicate that, while habit loss and resulting pulses of extinction were driven by rapid glacioeustatic sea-level and associated oceanographic changes, extinctions were gradual, diachronous, and sporadic. The Late Ordovician was a time of major biotic crises, but not of sudden global extinction.

An Actualistic Model of Graptolite Biogeography
The Finney-Berry model of graptolite biogeography views graptolite biogeography from a new perspective, focusing attention on the habitat in which graptolites flourished rather than on the differentiation of faunas into provinces and biofacies. It emphasizes the dynamic and ephemeral nature of graptolite habitats, in contrast to previous models in which graptolite faunas were segregated laterally by water-mass specificity or vertically by depth zonation into rather static biotopes. Moreover, the Finney-Berry model has important implications with regard to dispersal, provincialism, and the nature of the graptolite record.

Gold, Graptolites, and the Paleogeographic Affinity of the Roberts Mountains Allochthon
Graptolite faunas of the Pacific Province were first de-

scribed in large part by Australian paleontologists of the late 19th and early 20th centuries, because graptolite biostratigraphy was critical for recognizing structures and thus directing exploitation of the Victorian gold fields. A similar situation exists today in the Carlin Trend of north central Nevada where annual gold production approaches 5 million ounces. Gold is hosted largely by Silurian-Devonian carbonate rocks of the lower plate of the Roberts Mountains thrust, but ore bodies in surface outcrops of lower plate rocks have largely been exploited. Future exploration efforts are now in areas where lower plate rocks are covered by the Roberts Mountains allochthon, composed of a thick, structurally complex, poorly exposed, deep-water, stratigraphic succession of Cambrian-Devonian age. Exploration efforts require that these rocks be mapped to determine depth to lower plate rocks and through-passing structures; geologic mapping is dependent on understanding the stratigraphic succession; and graptolite biostratigraphy has proven to be the most effective means of reconstructing the stratigraphy and recognizing distinctive stratigraphic intervals. Reconstruction of the stratigraphic succession and comparison with the coeval rocks of the lower plate demonstrate that the Roberts Mountains allochthon is not an exotic terrane. Its stratigraphic succession accumulated in deep-water outboard of the carbonate platform along the Cordilleran margin of Laurentia, and several distinctive sedimentological event can be recognized in both the basinal and platform successions.

Andrew Smith Phone: (0)207-942-5217
Department of Palaeontology
The Natural History Museum
Cromwell Road, London SW7 5BD
UK
E-mail: a.smith@nhm.ac.uk

Events at the Cenomanian-Turonian Boundary: The Dissection of a Mass Extinction

The Cenomanian-Turonian boundary has long been recognized as an interval of major biotic change, and is coeval with one of the largest rises in sea-level to have occurred in the post-Palaeozoic. The association between mass extinction in the marine realm and sea-level change is well documented, but perplexing, since it seems implausible that sea-level change could actually cause a major extinction. However, large scale cycles of sea-level change can and do alter the ratio of shallow to deep marine continental shelf deposits preserved in the rock record both regionally and globally. Events around the Cenomanian-Turonian boundary in western Europe are reviewed in terms of geographical and ecological patterns and a phylogenetic framework for sea urchins is used to investigate the roles of sampling and extinction in deriving these patterns. This approach introduces a surprising degree of uncertainty about the size, duration and even the reality of the mass extinction event.

Megabias in the Marine Fossil Record and Its Implications for Charting the Geological History of Diversity

Patterns of origination, extinction and standing diversity through time are inferred from tallies of taxa preserved in the fossil record. This approach generally assumes, however, that sampling of the fossil record is effectively uniform over time. Although recent evidence suggests that our sampling of the available rock record has been very thorough, there is also overwhelming evidence that the rock record available for sampling is itself distorted by major systematic biases. Data on rock outcrop area compiled for post-Palaeozoic sediments from western Europe at stage level show a strongly cyclical pattern corresponding to first and second order sequence stratigraphical cycles, and changes in standing diversity and origination rates over time-scales measured in 10s of millions of years turn out to be strongly correlated with surface outcrop area. Many of the taxonomic patterns that have been described from the fossil record conform to a species/area effect. Whether this arises primarily from sampling bias, or from changing surface area of marine shelf seas through time and its effect on biodiversity remains problematic.

The Paleobiology of Echinoids

Echinoids have a wonderfully complex endoskeleton that is a trove of information for palaeobiologists. Their skeletal ultrastructure provides a means of reconstructing soft tissue with confidence and the microarchitecture of structures such as tubercles and pore-pairs can be analyzed in terms of their biomechanical function. This talk will review the sorts of evidence that can be called upon when trying to reconstruct the autecology of fossil echinoids.

Journal of Paleontology Editorial Policy

by the Managing Editors, *Journal of Paleontology*

The Journal of Paleontology is interested in publishing high-quality and well-illustrated manuscripts of the kind described in the policy statement on our inside cover: "...original articles and notes on the systematics of fossil organisms and the implications of systematics to all aspects of paleobiology and stratigraphic paleontology." As demand for space in the *Journal* continues to increase, a higher number of editorial decisions on publication has become necessary. The main arbiter of suitability of manuscripts, beyond scientific quality, is breadth of interest to an international and multidisciplinary readership. We take this opportunity to clarify the criteria used to inform editorial decisions.

1. Manuscripts whose sole purpose is the description of single new species or new occurrence of common groups, with no obvious wider significance, will generally not be considered for publication. This policy is similar to that of the British journal *Palaeontology*, instructions for authors of which read in part: "Preference is given to typescripts with more than local significance; those which describe only one or two new species of common genera are not usually accepted."

This does not mean that papers based on single species will not be published (on the contrary, several such papers are published in each issue). Rather, it is important that authors establish that the fossils have some particular significance - phylogenetic, morphologic, stratigraphic, geographic, paleoecologic, etc., which justifies their publication as a stand-alone paper or note. All new taxonomic data are inherently important, but unadorned systematics of one or two species of well-known groups are better published in regional or museum journals as opposed to an international forum such as the *Journal of Paleontology*.

Where possible, we prefer that systematic works on whole faunas be dealt with through more substantive papers, versus a series of separate short manuscripts on the systematics of single constituent species.

2. Manuscripts correcting recent nomenclatural problems (replacement names for homonyms, etc.) will generally only be published if they deal with papers originally published in the *Journal*. Corrections to papers published in other journals should be submitted to the journals in question.

NEW BOOKS FOR REVIEW

This section of the newsletter includes lists of books and brief reviews received by the Book Review Editor for the Paleontological Society. Volunteered reviews will be accepted if concisely written and of general interest. Books listed may be requested for review with the understanding that the resultant review will be ready for publication in time for the next issue of *Priscum*. Contact the Book Review Editor: Greg Retallack, Department of Geological Sciences, University of Oregon, Eugene, OR 97403-1272: gregr@darkwing.uoregon.edu

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BRIEF BOOK REVIEWS

MESOZOIC AND CENOZOIC SEQUENCE STRATIGRAPHY OF EUROPEAN BASINS, edited by P.-C. de Graciansky, J. Hardenbol, T. Jacquin, and P.R. Vail, 1998. SEPM Special Publication 60, 786 pp., hardcover $175.

Sequence Stratigraphy: The Next Generation

When Vail and his coworkers first proposed seismic stratigraphic models for the passive margins of the Atlantic Coast in the late 1970s (published by Vail et al., 1977, *AAPG Memoir* **26**:49-212), their claims were relatively modest. They argued that large-scale unconformities bounded packages of sediment that they called sequences (forever pre-empting its use in geology in its original meaning), and that these sequences were controlled by eustatic changes of sea level. Their most contentious proposal was the "Vail sea-level curve," with its peculiar saw-toothed pattern that suggested instantaneous regressions and slow transgressions (since rethought, and now called an "onlap-offlap curve"). Their first papers were controversial, but criticism was muted because their data were buried in proprietary Exxon files, and few scientists could determine how they had made their interpretations, or how to test them.

In the 1980s and early 1990s, the claims of sequence stratigraphers grew broader (see papers in Wilgus et al., 1988, *SEPM Special Publication* **42**; Posamentier et al., 1993, *Internat. Assoc. Sedim. Spec. Publ.* **18**; Weimer and Posamentier, 1993, *AAPG Memoir* **58**; Loucks and Sarg, 1993, *AAPG Memoir* **57**). Many of the early tenets of sequence stratigraphy were applied not only to passive margin marine sediments (where there is a plausible link to eustasy), but even to terrestrial strata that were far from sea level. How such stratigraphic packages could be interpreted as having global eustatic control was never fully explained, but geologists applied sequence stratigraphic principles nonetheless. Soon any set of layered rocks could be viewed with "sequence-colored glasses," without worrying whether there was a good theoretical explanation for this interpretation, or what the concept of a sequence actually *means*. Some of the problems of the early "Vail sea-level curve" were ironed out and resulted in the sequence chart of Haq et al. (1987, *Science*, **235**: 1156-1167; *SEPM Spec. Publ.* **42**: 71-108, 1988). This time scale and "sea-level curve" has been widely used and cited ever since, even though it was based on a number of problematic biostratigraphic data which immediately invalidated it (Gradstein et al., 1989, *Science,* **241**: 599-601).

Throughout the accelerating momentum of sequence stratigraphy, a small but persistent minority of geologists (mostly outside the oil industry) continued to point out fundamental flaws in some of the assumptions of sequence stratigraphy (see papers discussed by Hallam, 1992, *Phanerozoic Sea-Level Changes*, Columbia University Press; Prothero and Schwab, 1996, *Sedimentary Geology*, W.H. Freeman; and especially the detailed analysis by Miall, 1997, *The Geology of Stratigraphic Sequences*, Springer-Verlag). Because these critiques were published in widely read and available journals and books, it would seem that the sequence stratigraphers would answer their critics, and strengthen their discipline by learning from their mistakes. Instead, Miall and Miall (2000, *Earth Science Reviews*, **54**:321-348) argue that sequence stratigraphic literature has become essentially a cult belief, a self-contained paradigm with unquestioned, unshakeable assumptions. They show that sequence stratigraphy has become completely self-referential, unwilling and unable to listen to criticism. Miall and Miall (2000) provide a detailed analysis of the recent literature, and indeed it is striking that virtually none of the recent sequence-stratigraphy papers cite anything but other sympathetic papers in the same camp, and never even bother to answer the criticisms that have been leveled. I found the same to be true in my own experience. During the publication of a recent paper pointing out serious problems with sequence stratigraphic correlations tested by high-resolution magnetobiostratigraphy (Prothero, 2001, *Jour. Sedim. Res. B*, **71**:526-536), sequence stratigraphers simply refused to review or even read the paper, let alone constructively criticize it, and I've heard no comment or rebuttal from them even though it was published months ago.

So where is Sequence Stratigraphy: The Next Generation, going? A striking example of the future of sequence stratigraphy is *Mesozoic and Cenozoic Sequence Stratigraphy of European Basins*, edited by P.-C. de Graciansky, J. Hardenbol, T. Jacquin, and P.R.

Vail. As Miall and Miall (2000, Table 4) demonstrate, virtually every paper in this volume cites only papers of sympathetic authors, and rarely or never cite critical papers. Hardenbol et al. (1998, *SEPM Spec. Publ.* **60**:3-13) provided an updated correlation chart that supersedes the grossly outdated chart of Haq et al. (1987, 1988), yet few of the authors in this volume used the more recent chart; 34 out of 45 cite the outdated Haq et al. (1987, 1988) chart. Most of the papers continue to assert the fundamental assumption of sequence stratigraphy: that sequence boundaries are based on global sea-level changes, and that sequences can be reliably correlated to charts like those of Haq et al. (1987, 1988) or Hardenbol et al. (1998). But as pointed out by many authors (e.g., Aubry, 1991, *Jour. Geophys. Res*, **96B**: 6641-6679; summarized in Miall, 1997), the sequence chart is so full of events (119 sequence boundaries in Haq et al., 1987, 1988; 221 in the Hardenbol et al., 1998, chart) that virtually any stratal package with unconformities can be matched to it. As Miall and Miall (2000) pointed out, the global synthesis charts of Hardenbol et al. (1998) continue to add more and more sequence boundaries based on local unconformities, even when the papers in SEPM Volume 60 don't even show those same unconformities in other basins. In other cases, they cite examples (e.g., Deramond et al., 1993, *Geol. Soc. London Spec. Publ.* **71**:193-219) where the correlations were contorted to fit the sequence chart, and when they didn't, circular reasoning and special pleading were invoked to dismiss the mismatch. Clearly, it is unthinkable to question the fundamental assumptions of the cycle chart. Without high-resolution biostratigraphy to test such correlations, it is impossible to tell if these correlations are valid or simply random matching of a busy pattern (e.g., Miall, *Geology* **20**, 787-790). As shown when high-resolution magnetobiostratigraphic tests have been undertaken, such sequence stratigraphic correlations failed miserably, or were misleading at best (Aubry, 1991; Prothero, 2001).

The one potentially independent test of the entire eustatic hypothesis would be the global oxygen isotope curve. Such a correlation was rejected in the analysis of Williams (1988, *SEPM Spec. Publ.* **42**:31-37). In SEPM Volume 60, Abreu et al. (1998, *SEPM Spec. Publ.* **60**: 75-80) make a superficial comparison between the newest version of the oxygen isotope curve and the outdated Haq et al. (1987) curve, but there is no rigorous statistical analysis or curve-fitting exercise to establish whether the similarities are non-random, and whether the mismatches can be overlooked. Even more troubling is their suggestion that the rapid eustatic fluctuations in the curve require significant ice volume in the Cretaceous and Cenozoic, an assertion that is not supported by any geologic evidence, and contradicted by the abundant evidence of a greenhouse climate that would prohibit significant ice caps (Eyles, 1993, *Earth Sciences Reviews*, **35**:1-248). However, such hypotheses are required if the sequence stratigrapher believes in all of the "events" on the cycle chart, and believes that they are eustatically controlled, because no other mechanism has been shown to change sea level that quickly and dramatically. The alternative would be to accept that many of the events on the cycle chart are not real, or at least not eustatically controlled, but artifacts of compiling many local sea-level records into a synthetic chart.

So what is the future of sequence stratigraphy? Miall and Miall (2000) argue that it is a "revolution in trouble," and that the field has become almost cult-like in its strict adherence to dogma, and unwillingness to learn from criticism, or to grow and change, seek new directions and incorporate new ideas. Certainly, it seems that the podia of national meetings such as the Geological Society of America were completely dominated by sequence stratigraphic talks only a few years ago. Yet at the 2001 GSA meeting in Boston, there were relatively few of them. Has the bandwagon run its course? Have the limits of the predictive power of sequence stratigraphy been reached? Will its practitioners continue to do the same old thing year after year, or will they find new directions to apply their ideas, and change as the evidence indicates they must? Only time will tell.

Donald R. Prothero
Department of Geology
Occidental College
Los Angeles, CA 90041
prothero@oxy.edu

DINOSAURS-THE ENCYCLOPEDIA; SUPPLEMENT 2, Donald Glut, 2000. McFarland & Company, Jefferson (North Carolina) and London; 685p., library binding $75.00.

Having reviewed the previous two volumes of this series (*Dinosaurs- The Encyclopedia* and *Supplement 1*, by Donald Glut) for *Priscum*, I am compelled to weigh-in on this newest addition to this ever-growing encyclopedia. *Supplement 2* (herein *S2*, following Glut's own abbreviations), picks up where *S1* (published in 1999) left off. What is astounding is that the two supplements, taken together, exceed the number of pages of the original "foundation" volume, which covered all dinosaurs known up to its publication in 1997. The mere mass of information represented by the two supplements underscores not only the amount of new dinosaur material discovered during this five-year (or so) interval, but directly reflects the intensity of interest in these most-bizarre prehistoric beasts.

The book is divided into four main sections: I-Introduction; II –Dinosaurian Systematics; III-Dinosaurian Genera; IV-Nomen Nudum and Excluded Genera; followed by a list of abbreviations; Appendices: 1, Displays, Sites and Attractions; and 2, Further Reading; a Glossary, Bibliography and Index.

The Introduction (Section I) discusses the "Mesozoic Era," only briefly; I found "New Discoveries, Ideas and Studies", which arguably is the most interesting part of this section, to be uneven, presenting only selected discoveries while (perhaps unintentionally) overlooking other equally, and (perhaps) even some more important ones; the "Still Unresolved: Ectothermy or Endothermy?" debate, fueled by interpretations of nasal respiratory turbinates, hepatic-piston diaphragms (in theropods), lines of arrested growth (LAGs), significance of costal and gastralial movement (in theropods), open (uncovered) egg nests, perennial histological arguments and a putative "petrified (*Thescelosaurus*) heart" (which has since been reinterpreted as a lump of minerals; Stokstad. 2001, *Sci.* 291:811.); "The Dinosaur-Bird Debate: Nearing a Resolution?" the question raised is never directly answered, however, reading over the various arguments, information, studies and the like, synthesized by Glut, one would be hard-pressed to conclude that no relationship exists between these two groups; and (finally), "Dinosaur Extinctions", the continuing saga, and great disconnect, between phylogenetic systematists and fundamentalist catastrophists. The last section also reviews the possibility of the existence of Paleocene (non-avian) dinosaurs—which probably have more to do with circular reasoning and/or sample contamination than having any basis in fact. Glut avoids weighing in on any of these contentious issues, staying above the fray in all of the sections discussed herein.

Section II, Dinosaur Systematics, Glut revisits, and reinterprets, the higher taxonomic divisions of the Dinosauria previously outlined, in greater detail in the original volume of *Dinosaurs*: *The Encyclopedia* and *Supplement 1* (*D:TE* and *S1*, respectively). Admittedly, Glut explains the fluidity of the arrangement and definitions of higher taxa, as the direct result of new discoveries and analyses. While many of the higher taxonomic groups are sound (phylogenetically), some of these higher taxonomic categories are not monophyletic and therefore are not considered valid (e.g., "Megalosauridae," "Homalocephalidae"), yet, unfortunately, these taxa continue to be used (cited) as if they were real. Other higher taxonomic categories are just wrong. For example, Glut's diagnoses for the "Coelophysoidea" and "Coelophysiidae" are identical (word-for-word), therefore they are redundant and cannot be distinguished from one another, yet the latter is supposed to be a subset of the former. Within these higher taxonomic groups, Glut presents a diagnosis (for the taxon), age, geographic distribution, and a list of taxa/genera. This latter entry is often incomplete, only listing a few of the genera within a given taxon. Finally, Glut includes notes in various sections where there have been relevant data based on recent studies.

Section III, Dinosaur Genera, is the most important part of the volume. Glut reviews every dinosaur genus that is new, or has been revised, or supplemented by new material, since the publication of his previous two volumes (*D:TE* and *S1*). It is here that Glut demonstrates his mastery of the scientific literature, summarizing many of the salient arguments surrounding various dinosaur genera. Unfortunately, Glut often cites, and uses, unsubstantiated data extracted from abstracts (presented at meetings without accompanying published work) as if these sources have been rigorously scrutinized by the peer-review process. The impression given is that information culled from these abstracts is equally important, like un-weighted characters in a phylogenetic analysis, which I would argue it is not.

Like its predecessors, *S2* suffers somewhat in the arena of figures and photos. Many of them are of poor or of marginal quality, a few photographs are out of focus, and some are just wrong (such as the putative "partial left dentary of an unnamed prosauropod" on page 50 which actually is a photo of an upside-down eucynodont skull!). Stereo pairs of *Triceratops* (same specimen, different venues) from the turn of the (20th) century, while historically interesting, add little to the information regarding this dinosaur. Photos of primitive and poorly executed dinosaur models that appear throughout this volume (i.e., in the "introduction/new discoveries, etc.", "dinosaurian systematics" and "dinosaurian genera" sections), should not have been included. They would have been more appropriate in Appendix 1 ("Displays, Sites and Attractions"). On the positive side, most of the photos are very instructive, especially those that figure real specimens. Reproductions of line drawings, most taken from the primary literature, are also informative, yet some of these appear to be very rough and certainly less than aesthetic. Overall, the primary strength of these three encyclopedias is the figures and photos of original material.

Shortcomings aside, *S2* is filled with much information and is a must have for dinosaur enthusiasts and any professional who works on these marvelous creatures. Glut is to be commended for undertaking such an ambitious project, and despite the inevitable faux pas and sundry other problems inherent in an undertaking of this magnitude, I do not hesitate at all in recommending this volume and its predecessors.

Robert M. Sullivan
Section of Paleontology and Geology
The State Museum of Pennsylvania
300 North Street
Harrisburg
Pennsylvania

DINOSAURS OF THE ISLE OF WIGHT, edited by David M. Martill and Darren Nash. 2001 Field Guides to fossils no. 10. Palaeontological Association, London, 433 p., paperback £16.00.

With all the fuss over the Gobi Desert and Hell Creek, it is easy to forget that dinosaurs also can be found closer to home. Dinosaurs of the Isle of Wight, a short ferry ride from the southern coast of Britain, are not only found conveniently in a place where one can also get a good cup of tea, but are historically important as one of the first dinosaur faunas discovered, paleogeographically important as a fauna at the crossroads of Gondwana and Laurasia, and evolutionarily important as a link between well-known Late Jurassic dinosaurs of Wyoming and Sichuan, and Late Cretaceous dinosaurs of Mongolia and Montana.

Among the most famous of these Early Cretaceous dinosaurs is the small *Hypsilophodon foxi*, based on a relatively complete skeleton found by a fossil hunting curate, William D. Fox (1813-1881). The most common remains of bones and tracks are the well known *Iguanodon*, represented by two species *I. atherfieldensis* and *I. bernissartensis.* Theropods (*Baryonyx* sp., *Neovenator saleri, Aristosuchus pusillus* and *Eotyrannus lengi*) have been little known in this fauna until recently. Some 28 species of dinosaurs and 3 of pterosaurs are described or suggested, along with copious notes on biology and taxonomy of closely allied forms, which include hypsilophodontids, dryosaurids, iguanodontids, pachycephalosaurs, stegosaurs, ankylosaurs, camarosaurs, titanosaurs, brachiosaurs, allosaurs, coelurosaurs and tyrannosaurs. After twenty years of teaching undergaduate vertebrate paleontology, I found it refreshing to catch up on current ideas of dinosaur taxonomy and biology. The pterosaurs include two species of *Ornithocheirus*, and a new species *Istiodactylus latidens.* This book is a mine of information on the taxonomy of these Early Cretaceous fossils, with most name-bearing bones, even the most fragmentary, illustrated, described and discussed. So many popular treatments of dinosaurs focus only on the best understood skeletons. Illustration of odd and mysterious bits of bone not only focuses attention on these small mysteries, but may shed light on the next mysterious fragment to emerge from the sea cliffs.

Articulated skeletal remains are rare on the Isle of Wight, and progress in understanding this fauna since William Buckland first collected bone in 1832 has relied on a small army of amateur and professional enthusiasts. This book will encourage further public involvement

I wish I had this book when I visited the scenic southwest coast of the Isle of Wight more than 20 years ago. The sea cliffs present wonderful exposures of the Wessex Formation of the Wealden Group, with clear sandstone paleochannels, point bars and crevasse splays. My interest was in the paleosols, here illustrated in full color within a section of glossy paper. Although local calcrete nodules have been documented by Paul Wright, much of the carbonate is siderite ($FeCO_3$) and kutnohorite ($CaMg(CO_3)_2$). The clayey red paleosols, with their prominent drab-haloed root traces, are comparable with humid to subhumid forested soils. Soil acids, leaf litter and mold (here documented on bone in the taphonomy section) explain why the Isle of Wight dinosaurs have emerged in such small pieces and why it has taken so long to understand them.

Dinosaurs of the Isle of Wight presents a challenging and compelling puzzle, irresistible for its incompleteness. A new brigade of paleontologists and naturalists, retreating to this book in resort tea houses during summer rain storms, can be expected to reinvigorate the study of this famous and important dinosaur fauna.

Gregory Retallack,
Department of Geological Sciences,
University of Oregon,
Eugene, Oregon 97403

THE ETERNAL TRAIL: A TRACKER LOOKS AT EVOLUTION, by Martin Lockley, 1999. Perseus Books, Cambridge, Massachusetts. 320 p., hardcover $26.00.

With a breezy blend of journalistic anecdote and New Age philosophy, Martin Lockley here presents a popular account of tracks and trails from Precambrian submarine tracks and trails and Ordovician terrestrial millipede tracks to the hominid trails of Laetoli. It's not just dinosaur tracks, a research area in which Lockley is well known and widely published, although accounts of dinosaur tracks fill much of the middle part of the book. The text is broken into 2-3 page vignettes, each wittily titled and with introductory quotations. Each reveals a single study in entertaining detail, often placing it within political, geographic or theoretical contexts that are missing in more formal accounts. My favorites include "Sauropod serenade", an account of Dave Thomas' attempt to put the classical Glen Rose sauropod and theropod trails to music. "Individual signatures" relates Phyllis Jackson's discovery of the long narrow feet of Celts, versus short wide feet of Saxons. "Battle of Carenque" outlines Galopim Carvalho's diplomatic and somewhat comical success in conserving a Portugese dinosaur trackway. With humour and humanity, Lockley shows how surprisingly rich and informative the footprint record can be.

So why else should professional paleontologists read this book? What's new and not covered in technical journals? The largest theoretical contribution is a concise explanation of a new way of looking at vertebrate morphology outlined in a little-known book by Wolfgang Schad. This is a holistic view of three-fold adaptive emphases: on (1) sense-nerve as in rodents, (2) respiratory-circulatory system of carnivores and (3) limb-metabolic functions of ungulates. Even within ungulates we can see such emphases: the skittish deer at one extreme, the active antelope in the middle and the placid cow at the other extreme. The narrow, shallowly impressed footprints of deer and be contrasted with the wide deeply impressed footprints of cattle. Lockley uses these principles to good effect to explain comparable evolutionary radiations apparent from dinosaur footprints, not only from narrow theropod to wide ankylosaur traces, but from narrow to wide ichnotaxa within theropods, prosauropods, sauropods, thyreophorans and marginocephalians. The implications of this view are that a variety of other features, such as color and reproductive potential of dinosaurs may correlate with body and foot proportions. Popular portrayal in *Jurassic Park* movies of *Compsognathus* as active and twitchy, and *Triceratops* as placid and bovine, find confirmation in this idea. But is there more? Can these ideas be turned into transfer functions to predict color, litter numbers, egg size?

Other novel contributions include more details on the distinction between crocodylian and pterosaur trails, which provides evidence that putative pterosaur trails were not made by pterosaurs running around with their wings tucked under their arms like chickens. Lockley's pterosaur trails indicate an ungainly motion on the ground. Also developed further here is the apparent geographic separation of Late Cretaceous sauropods and ornithopods evident from trackways, as if they were parts of different ecosystems. My own research on paleosols reveals that ornithopods were found in angiosperm-dominated communities of streamside soils (gleyed inceptisols and alfisols), whereas sauropods preferred open dusty conifer-ephedroid vegetation of deserts (aridisols). Lockley notes again the dinosaur tracks only 37 cm below the iridium anomaly at the Cretaceous-Tertiary boundary in Colorado, indicating living, walking dinosaurs not much time (geologically speaking) before the Chicxulub bolide impact. Finally, Lockley summarizes evidence from tracks for shorebirds well back into the Early Cretaceous, confirming the spate of bird skeleton discoveries in recent years.

Several of the characters we meet along the trail are priests, including the indefatigable French discoverer of Lesotho tracks Paul Ellenberger, the pioneering Italian describer of Brazilian tracks Guiseppe Leonardi, and the French mystic Pierre Teilhard de Chardin, who was first to note Chinese dinosaur tracks. Lockley does quite a bit of preaching himself, besides his admirably even-handed arbitration of many scientific disputes. I found his mystical turns poetic and inspiring, but they stray far from the usual objective stance of science. Judge for yourself from Lockley's own last words. "The touch of our feet on Earth is still a sacred communion, not just symbolically but in the real sense that the interaction is preserved forever in the memory of mind and matter....The eternal trail leads everywhere and nowhere; it is both journey and destination. It is yesterday, today and tomorrow. It is us, our very atomic structure, our mystical consciousness, our vital dance."

The Eternal Trail is easy to read and entertaining, full of captivating ideas. It deserves a place in public, as well as university libraries, because it goes a long way toward explaining the fun, motivation and romance of Earth Science. Lockley has been brave enough to expose a poetic and reverent side to science that many non-scientists will be relieved to discover.

Gregory Retallack,
Department of Geological Sciences,
University of Oregon,
Eugene, Oregon 97403.

LOST WORLDS IN ALABAMA ROCKS: A GUIDE TO THE STATE'S ANCIENT LIFE AND LANDSCAPES, by Jim Lacefield, 2001. Alabama Geological Survey, Tuscaloosa, 123 p. (no longer available there: try PaleoAlabama Project, 251 Loop Road, Tuscumbia, Alabama 35674 phone 2563816301), paperback $25.00

This glossy booklet is the most visually stunning and quickly informative, popular guide to rocks and fossils that I have seen. Its colorful graphic design offers much in the way of teaching aids: full-color, annotated outcrop illustrations, numerous paleogeographc reconstructions, Photoshop-composited environmental reconstructions, and montages of classical fossil illustrations. Alabama turns out to almost have it all: fossiliferous Paleozoic sections in the Cumberland Plateau and Valley-and-Ridge; Cretaceous chalk in the upper Coastal Plain, Cenozoic marls in the lower Coastal Plain and common Pleistocene vertebrates in sinkholes and streams. The work was designed as a resource for Earth Science teachers in Alabama, but is also an easily digested guide to the state for the rest of us.

This booklet breaks the mold of such introductory texts with a variety of new approaches and captivating asides. Geobotanical concepts, such as the limestone indicator species redbud and eastern red cedar, are illustrated in color, and bring home the importance of geology to life. The local Wetumpka Impact Crater brings down to earth the concept of bolide impact at the end of the Cretaceous. The origins of the Suwanee terrane from West Africa and the Wiggins terrane from South America, place Alabama within an international context of Pangea and its subsequent continental drift.

The book also does not shirk terminology or detail. Paleosol, liesegang rings, chernozem, bioclastic, bentonite, rhyniophyte, catagenesis, kerogen are just a few of the words and concepts not commonly encountered in a book pitched to a secondary school audience. There are many fossils and fossil sites illustrated, and this book is a good first guide to fossil hunting and identification in the state. Iron ores, coal, oil and agate are all of public interest, and each gets concise treatment. I would have added a section on nodules and concretions, as these are the main source of pseudofossils brought in for identification. I feel so guilty and unconvincing when I explain that someone's precious heirloom fossil turtle or coconut is really just a nodule. It would help to have an informative, well-illustrated book to recommend for these disappointed, but good-hearted, folks.

You probably won't need this book to help with your research, but if you are driving through Alabama I wouldn't be without it.

Gregory Retallack,
Department of Geological Sciences,
University of Oregon,
Eugene, Oregon 97403.

DINOSAUR TRACKS AND OTHER FOSSIL FOOTPRINTS OF THE WESTERN UNITED STATES, by Martin Lockley with Adrian P. Hunt, 1999. Columbia University Press, New York, 338 p., paperback $19.50.

"'I have been to Devonshire.'
'In spirit?'
'Exactly. My body has remained in this armchair ... and my spirit has hovered over [the Ordnance map of this portion of Dartmoor] all day. I flatter myself that I could find my way about.'"
(Sir Arthur Conan Doyle, *The Hound of the Baskervilles*, 1902)

This isn't a 'new' book. *Dinosaur Tracks* was originally published in hardback in 1995. This paperback edition appeared in mid-1999. By January 2002 it had reached my desk, since when I endeavored to write my review as quickly as possible! Despite being a little long in the tooth, this book still contains much to interest, inform and entertain the reader.

This new edition has not been revised from the 1995 edition, an opportunity missed. As befits the subject, *Dinosaur Tracks* is well-illustrated. The figures commonly have rather minimal captions; more explanation could only make this book more attractive to the reader. Nevertheless, I enjoyed the use of what are obviously redrawn field sketches of tracks and trackways, which I hope will send a positive message to younger paleontologists. The book would have benefited from a glossary of relevant technical terms.

Dinosaur Tracks is highly readable and well-organized, essentially progressing from the Upper Paleozoic to Cenozoic, although the Mesozoic receives the lion's share of attention. Rarely can it be called merely a geographic and geologic survey of the trackways of the western USA. With a dominant theme of vertebrate ecology going through it, there are also detailed discussions of ichnotaxonomic problems. The authors have a field day with the old problems of vertebrate ichnology, such as changing ideas of the identity of producers of many track ichnotaxa. The authors have their own, well-argued views that they put forward forcefully. In many respects this book is not something that the casual reader will pick up and read readily, although they might find themselves enthralled if they did, but for the keen and interested amateur, student or professional it is a gem. It shows that ichnotaxonomy can be an exciting area; what Gould (1989, *Wonderful Life*, Norton, New York) did for the classification of fossil invertebrates, Lockley and Hunt have done for the classification of trace fossils, going, of necessity, by a somewhat different route. Vertebrate ichnology has perhaps a higher public profile than invertebrate trace fossils, but, all the same, this book emphasizes points that I would consider to be of general relevance. *Dinosaur Tracks* thus provides a service for all ichnology.

I make no apologies for starting my review of a volume on vertebrate ichnology with a quotation from the novel that introduced many of us to the importance of tracks - remember Dr. Mortimer's immortal line, "Mr. Holmes, they were the footprints of a gigantic hound!" However, in the centenary year of the publication of Conan Doyle's most famous novel (it had already been serialized in *The Strand Magazine*), it was not the curse of the Baskervilles that came to mind as I read *Dinosaur Tracks*, but rather the trip taken to

Dartmoor by Sherlock Holmes 'in spirit.' I read the bulk of *Dinosaur Tracks* commuting to and from work, on trains and buses. Yet, I was transported 'in spirit' to a succession of fascinating trackway sites in the western USA. I may never visit any of them, yet my understanding of their vertebrate ichnology has been enriched. I recommend this book to anyone with a taste for terrestrial tetrapods (particularly dinosaurs), trace fossils or just readable paleontology. You'll enjoy the experience.

Stephen K. Donovan
Department of Palaeontology
Nationaal Natuurhistorisch Museum
Postbus 9517, 2300 RA Leiden
The Netherlands

COLBERT'S EVOLUTION OF THE VERTEBRATES (fifth edition), by E.H. Colbert, M. Morales, and E.C. Minkoff, 2001. New York: Wiley-Liss, 560 p., hardcover $145.

I knew and liked Ned Colbert, and loved the early editions of this once-classic book. He passed away on November 15, 2001, shortly after this edition appeared, which makes it difficult to be honest and frank. But this is necessary, because this is a clear case of a publisher trying to push an outdated, badly conceived project on the market, and few but professional vertebrate paleontologists will realize how problematic this book has become.

In its first edition (written in 1955), Colbert's *Evolution of the Vertebrates* was an excellent, non-technical review of vertebrate evolution as it was known, almost 50 years ago. The second (1969) edition and third (1980) edition began to become more and more outdated, since Colbert retired in the 1960s, and became less and less connected to the latest developments (both in discoveries and in philosophy) that had occurred in vertebrate paleontology. By the time of the fourth edition (published in 1991), the publisher brought in Mike Morales as a younger co-author, but it made no difference—the book was badly out of date in both its approach and its facts. Most of us hoped that this would be its last edition, because there was little that could be done to salvage it. But in this edition, they have added a third author, Eli Minkoff, a biologist who is not a vertebrate paleontologist and who clearly has not kept up with the important developments that have occurred in the past decades. Consequently, the book is full of errors of both omission and commission in every chapter, and should not have been published, let alone used by anyone to teach a modern course in fossil vertebrates.

The problems are so numerous that I cannot list them all in a brief review, but I will mention a few of the more important ones here. It starts with the authors' ambivalence toward the cladistic revolution, which in the past 20 years has completely transformed the way we think about fossil vertebrates. In places, they attempt to be current by paying lip service to cladograms, but their fundamentally old-fashioned philosophy is unchanged everywhere else. On page 16, they mention (but never explain) cladistics in one brief paragraph, and throughout the book they place Colbert's 50-year-old diagrams (with no resolution of phylogenetic relationships) side-by-side with a cladogram of some of the same taxa—or use one of the outdated diagrams with no attempt to show more recent hypotheses at all. Again and again, they make anachronistic statements suggesting that we can't know anything about phylogeny because of a lack of a suitable ancestor, or statements like "no clear indication of relationships among gnathostomous fishes can be determined from their stratigraphic order of occurrence in the rocks" (p. 48)—as if it ever could in a group with such a poor fossil record!

Certainly, they have a right to disagree with the prevailing philosophy in their profession if they so choose, although they end up painting a very unrepresentative and inaccurate picture of what we have learned as a consequence. Even more disturbing is the clear evidence that none of the authors kept up with the new discoveries made in past 20 years. Certainly, I haven't seen any of them at the meetings of the Society of Vertebrate Paleontology during that time, and apparently they don't read the journals, either. It is jarring to read, page after page, statements, ideas, or taxonomic concepts that have become grossly outdated, and should have disappeared long ago. Among the numerous examples are: the discredited notion that jaws are derived from gill arches (p. 38); Romer's idea that tetrapods left the water to escape drying pools, or chase prey, when all the recent discoveries of *Acanthostega* show that the tetrapod limb appeared in fully aquatic animals long before there was any need to crawl out on land (p. 85); the idea that anthracosaurs like *Seymouria* had anything to do with amniote origins, when recent discoveries like *Westlothiana* (not even mentioned in this book) have shifted the focus elsewhere (p. 105); the failure to note (p. 154) that the latest fossils show that snakes are descended from mosasaurs; a grossly antiquated approach to Mesozoic mammals and their relationships in Chapter 19, with almost no mention of the last decade of amazing discoveries; a carnivore "phylogeny" (p. 379) that treats "Fissipedia" as a natural group, and fails to show that pinnipeds are clearly descended from bears, not from the carnivoran stem; no mention (p. 394) of *Ambulocetus* and all the other recent spectacular transitional whale discoveries (all published long before this book went to press); the outdated notion (p. 428) that protoceratids are related to tragulids, rather than camels; the idea that perissodactyls have anything to do with phenacodonts (p. 452), instead of the recent discoveries of Chinese taxa like *Radinskya*, which point in a whole new direction; the outdated idea (p. 467) that brontotheres survived the Eocene (thanks to revisions of the time scale completed a decade ago), or that chalicotheres dug up roots (p. 469) with their peculiar claws (debunked by Coombs 20 years ago); the complete failure to mention (p. 480) all the new primitive elephants like *Numidotherium* and *Phosphatherium*, which push proboscideans back to the Paleocene of North Africa. The list could go on and on, but these are among the more glaring examples of a failure to recognize or incorporate any of the past 20 years of discoveries.

Equally jarring is the repeated use of taxa that were manifestly unnatural even in 1955, and have not been used by vertebrate paleontologists in many years. The examples are too numerous to mention, but it feels like going through a time warp to read about "chondrosteans," "holosteans," "labyrinthodonts," "thecodonts," "Prototheria," "eupantotheres," "condylarths," "palaeodonts," as if anyone still practicing vertebrate paleontology took those taxa seriously.

Symptomatic of this problem is the use of the archaic term "mammal-like reptiles," a misnomer that reflects several serious misconceptions. Synapsids (the "mammal-like reptiles") and the true reptiles are two distinct lineages that originated separately and simultaneously in the mid-Carboniferous, so synapsids have never been members of, or descended from reptiles (in even the broadest sense of the word). Call them "protomammals" if you will—but they are not, and have never been, reptiles!

These problems might not matter if this were just a trade book intended for the popular audience, who might not care if it is accurate or up-to-date in every detail. But I know of several institutions where paleontologists (not vertebrate paleontologists) still use this book to teach classes in vertebrate evolution, completely unaware of how grossly outdated this book had become. Nor is it the only choice on the market written at this level. Michael Benton's *Vertebrate Paleontology* (2nd edition, 2000, Blackwell) is fully up-to-date and much more affordable (especially since Wiley is charging $145 for this book!). Clearly, the editors at Wiley-Liss are trying to extend their franchise long beyond its useful life, and instead of consulting with qualified vertebrate paleontologists who could have made the book up-to-date, they foisted this sad shadow of a former classic on the unsuspecting profession.

Donald R. Prothero
Department of Geology
Occidental College
Los Angeles, CA 90041

NAPC to Canada

by Jere Lipps

At the last Association of North American Paleontological Societies (ANAPS) meeting in Boston (at GSA), one proposal to host the next NAPC meeting was received. This was from Dalhousie University in Halifax, Nova Scotia, and was presented to us by Dave Scott and two of his students. They laid out a good facilities and staff plan, indicated a host of interesting field trips, and felt they would organize the meeting much like the one we had at Berkeley. Dave proposed holding the meeting in 2005, four years after the latest one. The ANAPS representatives present accepted this proposal. Dave Scott will become the new Chair of ANAPS and will communicate further with you about dates and details. He should provide shortly a brief write-up of the plans for your newletters.

Thanks for all the help over the past six years. Both Bill DiMichele and I will be stepping down from our positions of Secretary and Chair, respectively. Dave will appoint a new secretary.A Chronostratigraphy Database

A Chronostratigraphy Database

Paleontologists, stratigraphers, paleoecologists, and paleobiogeographers have expertise, data, and applications that potentially will be served by a database system outlined in November 2001, at the University of Massachusetts. An integrated chronostratigraphic database system, provisionally called *Chronos*, is envisioned for future Earth Science studies. The *Chronos* system would provide efficiency of data gathering and of metadata synergy. Diverse research and applied studies include time-scale construction, correlation of reservoir and source-rock strata, paleoenvironmental analysis, paleoclimatology, paleoceanography, and paleotectonics. For teachers, students and every person *Chronos* would provide a readily accessible source of information on topics of general interest, such as evolution, human origins, and history of catastrophic events, as well as facilitate studies of modern issues, such as climate change and biodiversity. Thirty quantitative stratigraphers and database specialists from diverse research teams met during November, 2001 for a three-day workshop to discuss methods and strategies to achieve these goals as guests of the University of Massachusetts Geoscience Department, sponsored by the University of Purdue Department of Earth and Atmospheric Sciences, and funded by NSF. For more information contact Jim Ogg, jogg@purdue.edu, or Paul Sikora, psikora@egi.utah.edu.

Upcoming Meetings of Paleontologic Interest

2002

July 6-9	The First International Palaeontological Congress, Sidney, AUS http://www.es.mq.edu.au/MUCEP/ipc2002/index.htm
Sept. 12-22	I.U.G.S. - International Subcommission on Jurassic Stratigraphy, Sixth International Symposium On The Jurassic System http://www.dst.unito.it/6thisjs
Oct. 7-10	VIII Congreso Argentino de Paleontologìa y Bioestratigrafia. Corrientes, ARG garralla@arnet.com.ar
Oct. 27-30	Geological Society of America Annual Meeting. Denver, CO
Nov. 29-30	Reunión Anual de Comunicaciones de la Asociación Paleontologica Argentina. Diamante, ARG cidzucol@infoshopdte.com.ar

2003

March 12-14	GSA South-Central and Southeastern Section Meeting, Memphis, TN
March 23–25	GSA North-Central Section Meeting, Kansas City, MO
March 27–29	GSA Northeastern Section Meeting, Halifax, Nova Scotia, Canada
Apr. 1-3	GSA Cordilleran Section Meeting, Puerto Vallarta, Mexico
May 7-9	GSA Rocky Mountain Section Meeting, Durango, CO
June 3-8	Bioevents: Their Stratigraphic Records, Patterns and Causes, Caravaca de la Cruz, Spain

Nov. 2-5 Geological Society of America Annual Meeting. Seattle, WA

PALEONTOLOGICAL SOCIETY PUBLICATIONS, 1980-2002

Paleontological Society Papers (PSP)

PSP #1 BIOLOGY AND PALEOBIOLOGY OF CORALS, Stanley, G.D., Jr. (ed.), 1996, 296 p., $10.00

PSP #2 LEARNING FROM THE FOSSIL RECORD, Scotchmoor, J., and McKinney, F.K. (eds.), 1996, 348 p. $20.00

PSP #3 GEOBIOLOGY OF ECHINODERMS, Waters, J.A., and Maples, C.G. (eds.), 1997, 355 p., $20.00

PSP #4 ISOTOPE PALEOBIOLOGY AND PALEOECOLOGY. Norris, R. D., and Corfield, R. M. (conv.), 1998, 285 p., $ 20.00

PSP #5 THE EVOLUTION-CREATION CONTROVERSY II: PERSPECTIVES ON SCIENCE, RELIGION, AND GEOLOGICAL EDUCATION, Kelley, P. H., Bryan, J. R., and Hansen, T. A. (conv.), 1999, 252 p., $20.00

PSP #6 PHANEROZOIC TERRESTRIAL ECOSYSTEM, Gastaldo, R. A., and DiMichele, W. A. (eds.), 2000, 306 pp. $ 20.00

PSP #7 BRACHIOPODS ANCIENT AND MODERN: A Tribute to G. Arthur Cooper, Carlson, Sandra J., and Sandy, Michael R. (eds.), 2001, 257 p., $20.00

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SCN #6 MOLLUSKS, Bottjer, D.J., Hickman, C.S., and Ward, P.D. (org.), 1985, 305 p., $20.00

SCN #7 LAND PLANTS, Gastaldo, R.A. (org.), 1986, 226 p., $20.00

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SCP #7 MAJOR FEATURES IN VERTEBRATE EVOLUTION, Prothero, D.R, and Schoch, R.M. (conv.), 1994, 270 p., $20.00

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SP #4 PALEOTECHNIQUES, Feldmann, R.M. Chapman, R.E., and Hannibal, J.T., 1989, 358 p., $20.00

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SP # 9 EVOLUTION: INVESTIGATING THE EVIDENCE, Scotchmoor, J., and Springer, D. A. (eds.), 1999, 406 p.,$25.00

SP # 10 GUIDELINES FOR THE MANAGEMENT AND CURATION OF INVERTEBRATE FOSSIL COLLECTIONS INCLUDING A DATA MODEL AND STANDARDS FOR COMPUTERIZATION, Russell D. White and Warren D. Allmon (eds.), 2000, 260p., $20.00

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