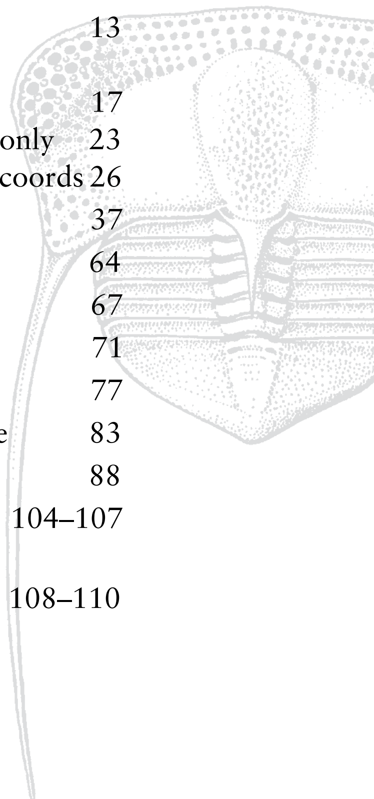
The Palaeontology Newsletter 69



Contents

Reminder: The deadline for copy for Issue no 70 is 23rd February 2009.

On the Web: <**http://www.palass.org/**>

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Association Business

Annual Meeting

Notification is given of the 53rd Annual General Meeting and Annual Address

This will be held at the University of Glasgow on 20th December 2008, following the scientific sessions. Please note that following the October Council meeting, an additional item has been added to the agenda published in Newsletter 68.

Agenda

1. Apologies for absence
2. Minutes of the 52nd AGM, University of Uppsala
3. Annual Report for 2007 (published in Newsletter 68)
4. Accounts and Balance Sheet for 2007 (published in Newsletter 68)
5. Increase in annual subscriptions
6. Election of Council and vote of thanks to retiring members
7. Palaeontological Association Awards
8. Annual address

H. A. Armstrong
Secretary

DRAFT AGM MINUTES 2007

Minutes of the Annual General Meeting held on Monday, 17th December 2007 at the University of Uppsala.

1. **Apologies for absence**: Prof. Batten; Prof. J. C. W. Cope; Dr P. C. J. Donoghue; Prof. M. P. Smith (Secretary of the Publications Board), Dr P. D. Polly and Dr M. Sutton.
2. **Annual Report for 2006.** Agreed, proposed by Prof. Sevastopoulo and seconded by Mr W Fone.
3. **Accounts and Balance Sheet for 2006**. Agreed, proposed by Prof. Edwards and seconded by Dr Sheldon.
4. **Vote of thanks to retiring members**. Prof. Bassett extended a vote of thanks to the retiring members of Council Dr Loydell (Vice-President), Dr Siveter (co-opted as Annual Meeting organiser), and Dr Harper (retires as a Trustee but will remain as handling editor). Dr Palmer

(Executive Officer) and Prof. Batten (Editor in Chief) were thanked for their continuing service to the Association. Prof. Bassett extended a vote of thanks to Sir P. Crane, retiring President.

5. Election of Council: The following members were elected as trustees:

President: Prof. M. G. Bassett

Vice-Presidents: Dr N. Macleod
Dr C. H. Wellman

Treasurer: Prof. J. C. W. Cope

Secretary: Dr H. A. Armstrong

Chairman of the Publications Board: Prof. D. A. T. Harper

Newsletter Editor: Dr R. J. Twitchett

Book Review Editor: Dr P. J. Orr

Newsletter Reporter: Dr A. McGowan

Internet Officer: Dr M. Sutton

Publicity Officer: Dr M. A. Purnell

Editors: Dr P. C. J. Donoghue
Prof. M. P. Smith (secretary of the Publications Board)

Other Members: Dr G. Budd
Prof. S. K. Donovan
Mr W. Fone
Dr C. Jeffery
Dr J. A. Rasmussen
Dr E. Rayfield
Dr T. Servais

The Executive Officer: Dr T. J. Palmer

Editor-in-Chief: Prof. D. J. Batten

Dr Palmer and Prof. Batten will continue to serve Council but are not trustees.
Prof. R. J. Aldridge will attend Council meetings *ex officio*.

6. Association Awards

i. Lapworth Medal to Prof. A. Hallam (Univ. of Birmingham).

ii. Hodson Fund to Dr S. Peters (Univ. of Michigan).

iii. Sylvester-Bradley Awards to Herridge, Dunkley-Jones, Donovan, Challands, Joomun, Popov, Muir, Zanno, Allan and Ghobadi pour Mansoureh.

iv. Mary Anning Award to Mr J. Ahlgren (Mariestad, Sweden).

The Annual Address was presented by Prof. A. Lister (Natural History Museum), and was entitled "Evolution in the Ice Age."

H. A. Armstrong
Secretary

Trustees Annual Report 2007 (Draft)

Nature of the Association. The Palaeontological Association is a Charity registered in England, Charity Number 276369. Its Governing Instrument is the Constitution adopted on 27th February 1957, amended on subsequent occasions as recorded in the Council Minutes. The aim of the Association is to promote research in Palaeontology and its allied sciences by (a) holding public meetings for the reading of original papers and the delivery of lectures, (b) demonstration and publication, and (c) by such other means as the Council may determine. Trustees (Council Members) are elected by vote of the Membership at the Annual General Meeting. The contact address of the Association is c/o The Executive Officer, Dr T. J. Palmer, Institute of Geography and Earth Sciences, University of Wales, Aberystwyth, SY23 3DB, Wales, UK.

Trustees. The following members were elected to serve as trustees at the AGM on 17th December 2007: *President:* Prof. M. G. Bassett; *Vice-Presidents:* Prof. N. Macleod, Dr C. H. Wellman; *Treasurer:* Prof. J. C. W. Cope; *Secretary:* Dr H. A. Armstrong; *Chairman of the Publications Board:* Prof. D. A. T. Harper; *Newsletter Editor:* Dr R. J. Twitchett; *Book Review Editor:* Dr P. J. Orr; *Newsletter Reporter:* Dr A. McGowan; *Internet Officer:* Dr M. J. Sutton; *Publicity Officer:* Dr M. A. Purnell; *Editors:* Dr P. C. J. Donoghue, Prof. M. P. Smith (Secretary of the Publications Board); *Other Members:* Dr G. Budd, Prof. S. K. Donovan, Mr W. Fone, Dr C. Jeffery, Dr J. A. Rasmussen, Dr E. Rayfield, Dr T. Servais. Prof. M. Cusack will organize the Annual meeting in Glasgow, 2008 and was co-opted to serve on Council for two years. *The Executive Officer*: Dr T. J. Palmer and *Editor-in-Chief:* Prof. D. J. Batten will continue to serve Council but are not trustees. Prof. R. J. Aldridge will attend Council meetings *ex officio*.

Membership. Individual membership totalled 1,269 on 31st December 2007, an overall decrease of six over the 2006 figure. There were 754 Ordinary Members (unchanged); 168 Retired and Honorary Members (a decrease of three); and 347 Student Members (a decrease of three). There were 121 Institutional Members in 2007, and 101 institutional subscribers to *Special Papers in Palaeontology*.

Professional Services. The Association's Bankers are NatWest Bank, 42 High Street, Sheffield. The Association's Independent Examiner is G. R. Powell BSc FCA, Nether House, Great Bowden, Market Harborough, Leicestershire LE16 7HF. The Association's investment portfolio of Common Funds was managed by Citi Quilter, St Helen's, The Undershaft, London EC3A 8BB. During the year Morgan Stanley Quilter were taken over by Citi Smith Barney, Citigroup Centre, Canada Square, Canary Wharf, London E14 5LB.

Reserves. The Association holds reserves of £608,086 in General Funds. These reserves enable the Association to generate additional revenue through investments, and thus to keep subscriptions to individuals at a low level, whilst still permitting a full programme of meetings to be held, publications produced and the award of research grants and grants-in-aid. They also act as a buffer to enable the normal programme to be followed in years in which expenditure exceeds income, and new initiatives to be pursued, without increasing subscription costs. The Association holds £52,564 in Designated Funds which contribute interest towards the funding of grants-in-aid, the Sylvester-Bradley, Hodson Fund and Mary Anning awards. Funds carried forward to 2008 totalled £660,650. Following the recommendation of Citi Quilter it was agreed that the Association portfolio should contain up to 5% in hedge funds.

Finance. Subscriptions raised an income of £61,688. The Association gratefully acknowledges the donations from Members which amounted to £1,377. Incoming resources from charitable activities included sales of £165,506 and investment income totalled £20,958. Total incoming resources were £249,529. Charitable activities resulted in publication costs of £154,632, sponsoring scientific meetings £14,752 and grants-in-aid £19,614. Administration costs were £23,550 and governance costs totalled £10,523. Administration and investment management costs totalled £21,072. Total charitable expenditure was £212,548. Total resources expended were £244,143. The Association continues its membership of the International Palaeontological Association and remains a Tier 1 sponsor of *Palaeontologia Electronica*.

Risk. As part of the annual review Trustees noted there were no new risks to the Association, beyond those reported in the Trustees Report 2006.

Council Activities. The Association continues to increase its range and investment in charitable activities, whilst continuing to keep individual membership subscriptions low. Of particular note this year was a major donation by Stuart Baldwin to support amateur activities. It was agreed the Association should supplement this initiative from General Funds to use the donation and any accrued interest to fund an annual programme of speakers for amateur groups.

Increased funds were allocated as "Grants–in-aid" to support workshops and meetings. These included: "Computer Aided Visualisation in Palaeontology;" Paleobiology Database Summer Course in Analytical Paleobiology; 8th International Symposium on the Cretaceous System; III Latin American Vertebrate Palaeontology Conference 2009; for palaeontological symposia within the 20th International Congress of Zoology; IGCP 503, "Ordovician Palaeogeography and Palaeoclimate" and the Charles Walcott Conference. Increased funds were also agreed to support the Lyell meeting in 2008. We have continued to provide funds to support student and speaker attendance at our own and international meetings.

The online activities of the Association continue to expand. Electronic versions of *Special Papers in Palaeontology* were produced and trustees agreed funds to scan abstracts from *Palaeontology* to allow online searching of back issues. The Association now hosts mirror sites for the Paleobiology Database, *Palaeontologica Electronica* and the EDNA fossil insect database. A Members only area was developed and is now running well. A replacement online payment system has been purchased. The Association also provided start up funds for the "Ask a Biologist" website.

Trustees were members of the Joint Committee for Palaeontology: Prof. Bassett (Chair) and Dr Donoghue represented the Association. Dr Armstrong acted as the Association representative on the International Palaeontological Association.

Sir Peter Crane gave, on behalf of the Association, a lecture on the Life of Hooker at Kew Gardens as part of the "Local Heroes" series as part of the Geological Society of London bicentennial celebrations.

Association meetings. Three meetings were held in 2007, and the Association extends its thanks to the organisers and host institutions of these meetings.

The *51st Annual General Meeting* was held on 16–19 December at Uppsala University, Sweden, organised by Dr Budd with much local support. This meeting included a symposium on "The Origin of Major Groups" and comprised a programme of internationally recognised speakers. There were 270 attendees. The Annual Address, entitled "Evolution in the Ice Age," was given by Prof. A. Lister (Natural History Museum) and was attended by 250 people. The President's Award was made to Laura Porro (University of Cambridge). The Council Poster Prize was presented to Martin Smith (University of Cambridge). On the final day field trips were undertaken to visit various sites in Uppsala linked to Linnaeus.

Progressive Palaeontology was held at the University of Bristol on 13th April. The annual open meeting for presentations by research students was organised by Graeme Lloyd.

British Association Festival of Science, Palaeontological Association Symposium: the annual forum for presentations to the public and general scientists was “Shotguns aimed at fossils: total molecular analysis of ancient samples” organised by Dr M. Collins (University of York).

Publications. Publication of *Palaeontology* and *Special Papers in Palaeontology* is managed by Blackwell, who also make sales and manage distribution on behalf of the Association. Volume 50 of *Palaeontology*, comprising six issues and 1,576 pages in total, was published at a cost of £116,440. *Special Papers in Palaeontology* 77, “Evolution and palaeobiology of early sauropodomorph dinosaurs (eds P. M. Barrett and D. J. Batten)”, and *Special Papers in Palaeontology 78*, “Graptolites from the Upper Ordovician and Lower Silurian of Jordan” by D. K. Loydell were published during the year. The cost of publishing Special Papers was £4,512. A *Field Guide,* “Silurian fossils of the Pentland Hills, Scotland,” edited by E. N. K. Clarkson, D. A. T. Harper, C. Taylor and L. I. Anderson, was published in June. The cost of publishing the *Field Guide* was £5,156.

The Association is grateful to the National Museum of Wales and the Lapworth Museum (University of Birmingham) for providing storage facilities for publication back-stock and archives. Council is indebted to Meg and Nick Stroud for assistance with the publication of *Palaeontology Newsletter*.

Awards. The Lapworth Medal, awarded to people who have made a significant contribution to the science by means of a substantial body of research, was made to Prof. A. Hallam (University of Birmingham). The Hodson Award, for a palaeontologist under the age of 35 who has made an outstanding achievement in contributing to the science through a portfolio of original published research, was awarded to Dr S. Peters (University of Michigan). The Mary Anning award, for an outstanding contribution by an amateur palaeontologist, was made to Mr J. Ahlgren (Mariestad, Sweden). The Sylvester-Bradley Fund continues to attract a large number of high-quality international applications and awards totalling £8,702 were made to D. Allen, T. Challands, S. Donovan, T. Dunkley-Jones, V. Herridge, S. Jooman, L. Muir, E. Popov and L. Zanno. Council awards an undergraduate prize to each university department in which palaeontology is taught beyond Level 1.

Governance. The Association continues to improve its administration with further improvements to the *Newsletter* and website. The continuing series of primers on numerical analysis in the *Newsletter* has been widely acclaimed. The Association has continued online provision of *Palaeontology* and Special Papers in Palaeontology, made available free to the palaeontological community. During the year the Association website was re-designed. Trustees allocated resources to the Lapworth Museum (University of Birmingham) to sort and catalogue the archive. Significant items from the archive will be scanned and made available on the website. The Association continues to be proactive in generating publicity for palaeontology with major press initiatives and a continued high profile on television.

The Association is indebted to the Natural History Museum, London for providing meeting venues through the year.

Forthcoming plans. Council will continue to make substantial donations, from both General and Designated funds, to permit individuals to promote the charitable aims of the Association. In 2007, a similar programme of Association meetings and publications will be carried out. The Annual Meeting has continued to develop as one of the major international palaeontological meetings. The 52nd Annual meeting will be held at the University of Glasgow in December 2008. *Progressive Palaeontology* will be held at the University of Manchester in April 2008. The Association will again run a symposium at the annual meeting of the British Association for the Advancement of Science in Liverpool, entitled "Climate change in the past: the latest evidence from fossil plants and animals."

Resources will again be made available from General Funds to support Grants-in-Aid, provided to carry out research into palaeontological subjects, to disseminate findings in print and at conferences, and to support the provision of palaeontological workshops. A new Palaeontological Association Research Grant has been announced and will be instigated in 2008. This is to fund primary research up to the value of £15,000. In future there will be a single funding round per year. A new award, the "President's Medal," a mid-career award, was announced and would be implemented in the forthcoming year.

Funds will also be made available to further development of the website, aimed at encouraging outreach and improving the Governance of the Association. It is intended that one new *Field Guide to Fossils* will be published within the year.

It is recognised that the Association is now one of the premier international learned societies. During the forthcoming year mechanisms will be developed by which the Association can have a greater presence at international geological meetings.

Howard A. Armstrong
Secretary

Grants in Aid: scientific meetings

The Palaeontological Association is happy to receive applications for loans or grants from the organisers of scientific meetings that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organiser(s) of the meeting using the online application form (see **http://www.palass.org/**). Such requests will be considered by Council at the March and the October Council Meetings each year. Completed requests should be made at least six months in advance of the event in question and should be sent by 1st March or 1st October. Enquiries may be made to <**secretary@palass.org**>. If the application is successful, we will require that the support of the Association is acknowledged, preferably with reproduction of the Association's logo, in the Meeting literature.

Grants in Aid: workshops and short courses

The Palaeontological Association is happy to receive applications from the organisers of meetings and workshops for grants-in-aid. If the application is successful, we will require that the support of the Association is acknowledged, preferably with reproduction of the Association's logo, in the Meeting literature. Application should be made by the scientific organiser(s) on the online form (at <**http://www.palass.org/**>). Such requests will be considered by Council at the March and the October Council Meetings each year. Completed requests should be made at least six months in advance of the event in question and should be sent by 1st March or 1st October. Enquiries may be made to <**secretary@palass.org**>.

Nominations For Council

At the AGM in December 2008, the following will be elected to Council:

Vice President: Dr T. Servais (nominated by Council)

Newsletter Editor: Dr Richard Twitchett (nominated by Council)

Chair of the Publications Board: Professor Paul Smith (nominated by Council)

Ordinary Members:

Dr T. Vandebrouche (University of Ghent): Co-opted as Annual Meeting organiser

Dr G. Harrington (University of Birmingham): Co-opted as Annual Meeting organiser

Dr C. Underwood (Royal Holloway and Bedford New College): Prof. S. Donovan and Dr F. E. Fearnhead

Dr D. Schmidt (University of Bristol): Dr J. Young (NHM) and Dr K. Johnson (NHM).

Dr C. Buttler (National Museum of Wales): Prof. M. Bassett and Prof. J. Cope

Professor David Harper will be co-opted onto Council as a representative of the IPA and will be responsible for co-ordinating the organisation of IPC 2010.

Dr Charlotte Jeffrey-Abt will replace Dr Paddy Orr as Book Reviews Editor.

Howard A. Armstrong
Secretary

ASSOCIATION MEETINGS

52nd Annual Meeting of the Palaeontological Association
Glasgow, Scotland *18 – 21 December 2008*

The 52nd Annual Meeting of the Palaeontological Association will be held at the University of Glasgow (<**http://www.gla.ac.uk/**>), organised by members of the Department of Geographical & Earth Sciences and the Hunterian Museum.

Abstract submission is now closed, but late registration will continue until **21st November**. Registration is via the Palaeontological Association website (<**http://www.palass.org/**>) from where the Second Circular can be downloaded. A Third Circular will be available in late November. The conference lecture theatre has a capacity of 300 and the number of registrants will have to be capped at this figure, even within the registration deadlines if necessary, on a 'first come first served' basis.

Accommodation

Please note that accommodation is not included in the online registration form and must be booked separately. Rooms were reserved for the conference in a variety of hotels at a range of prices and within easy reach of the University up until 17th October. Some may still be available in these establishments, although this can no longer be guaranteed. Rooms there and elsewhere can be booked through the University via the Annual Meeting pages on the Pal. Ass. website (<**http://www.palass.org/**>). Links providing information on cheaper, hostel-style accommodation are also provided on the website and there are many other hotels and Bed & Breakfast establishments in the West End of Glasgow, where the University is situated, and in the city centre.

Meeting Format

The meeting will commence with a **field excursion** on Thursday 18th December to explore some of the fossiliferous Carboniferous rocks of the Midland Valley of Scotland. This will be followed by a **half-day symposium** on the afternoon of Friday 19th December starting at 2pm and entitled **'Biominerals – the hard part of palaeontology'**. There will also be an **evening drinks reception** on Friday 19th December hosted by Glasgow City Council in the City Chambers. The **conference proper** will commence on Saturday 20th December with a day of talks and posters, the **AGM** of the Association and the Association's **Annual Address**, which will be given this year by **Prof. Jenny Clack** of Cambridge University (see abstract below). In the evening there will be a **drinks reception** in the Hunterian Museum hosted by the Museum and the Geological Society of Glasgow, followed by the **Annual Dinner** in the Bute Hall, the main ceremonial hall of the University. Sunday 21st December will be a full day of **talks and a dedicated poster session**.

The time allocated to each talk will be 15 minutes including questions; there will be no parallel sessions. Oral presentations should be prepared in PowerPoint and posters should be prepared at A0 (portrait) size – *i.e.* 84cm wide, 119cm tall.

The **President's Prize** will be awarded for the best talk at the Annual Meeting by someone under the age of 30 who is a member of the Association; this is a cash prize of £100. The **Council Poster Prize** will be awarded for the best poster at the Annual Meeting by someone under the age of 30 who is a member of the Association; this too is a cash prize of £100.

Symposium

The speakers and their topics at the half-day symposium '**Biominerals – the hard part of palaeontology**' on the afternoon of Friday 19th December will be:

Prof. Steve Weiner (Weizmann Institute of Science, Israel): *Common mechanisms of biomineralization and the implications for the evolution of hard tissues*

Prof. Steven Stanley (University of Hawaii, USA): *The history of biocalcification in the sea: observations and experiments*

Dr Kazuyoshi Endo (University of University of Tsukuba, Japan): *Multiple origins of animal skeletons and dynamic adaptive evolution documented by molluscan shell matrix proteins*

Prof. Jan Veizer (University of Ottawa, Canada): *Isotope record of Phanerozoic seawater as recorded by fossil shells*

Prof. Peter Westbroek (University of Leiden, The Netherlands): *Trend in limestone formation from the Archaean to the Present*

Registration and costs

The cost for registration is now £55 (ordinary & retired members) and £45 for students; non-members pay £65. The final date for registration is **Friday 21st November**. No refunds will be considered after that date. The field excursion costs £15 which includes a packed lunch. The cost of the Annual Dinner is £42. Buffet lunches will be available on Saturday 20th and Sunday 21st December at a cost of £6 each day. There is also a wide range of eateries close to the University.

Travel grants to help student members (doctoral and earlier) to attend the Glasgow meeting in order to present a talk or poster

The Palaeontological Association runs a programme of travel grants to assist student members presenting talks and posters at the Annual Meeting. For the Glasgow meeting, grants of **up to £100** (or the Euro equivalent) will be available to student presenters who are travelling from outside the UK. The amount payable is dependent on the number of applicants and the distance travelled. Payment of these awards is given as a disbursement at the meeting, not as an advance payment. Students interested in applying for a PalAss travel grant should contact the Executive Officer, Dr Tim Palmer (<**palass@palass.org**>) once the organisers have confirmed that their presentation is accepted, and **before 8th December 2008**. Entitle the e-mail 'Travel Grant Request'. No awards will be made to those who have not followed this procedure.

Summary of dates and deadlines

21 November 2008	**Late registration deadline**
8 December 2008	**Student member travel grant application deadline**
18 December 2008	Field excursion
19 December 2008	Half-day symposium 'Biominerals – the hard part of palaeontology' Civic Reception – Glasgow City Chambers
20 December 2008	Technical sessions, AGM and Annual Address Reception hosted by The Hunterian Museum and Glasgow Geological Society Annual Dinner
21 December 2008	Technical sessions

Contact

The meeting organisers are Prof. Maggie Cusack and Dr Alan Owen of the Department of Geographical & Earth Sciences and Dr Neil Clark of the Hunterian Museum, University of Glasgow. We can be contacted at <**glasgow2008@palass.org**>.

We look forward to seeing you in Glasgow.

Annual Address: The emergence of tetrapods: how far have we come in the last twenty years and where can we go in the next?

Jennifer A. Clack
Museum of Zoology, Downing Street, University of Cambridge CB2 3EJ.

Twenty years ago, only three genera of Devonian tetrapod were known: one, *Ichthyostega*, was known from extensive specimens though incomplete descriptions, but carried the burden of being an icon for early tetrapods; another, *Acanthostega*, was known from two partial skull roofs; the third, *Tulerpeton* was known from a single partial skeleton and seemed anomalous in several ways.

From the 'fish' side of the spectrum, a single genus, *Eusthenopteron*, was available as the model from which tetrapods evolved. Many scenarios were postulated to explain the fish – tetrapod or water–land transition – including several 'hypothetical ancestors'. Today, the skeletal anatomy of *Acanthostega* is almost completely known; *Ichthyostega* is seen as radically different from its iconic image; and *Tulerpeton* is thought to fit the emerging picture of polydactylous Devonian tetrapods that lived in marginal marine conditions. We have much more detailed knowledge of tetrapodomorph fish with the discovery of *Tiktaalik* and reinterpretations of *Panderichthys*.

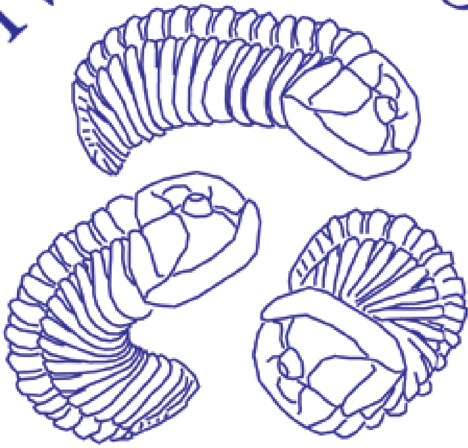
These have allowed us to construct consensus phylogenies from which we can infer sequences of character acquisition that then lead on to more testable hypotheses of when, where and howcome tetrapods evolved. We see that the 'hypothetical ancestors' have been proved incorrect in many respects, because they were based on preconceptions about evolutionary drives that are probably invalid.

Ecological information is now coming from many more sites for fossil stem tetrapods and tetrapodomorphs, resulting from the increasing range of taxa now available to represent the transition world wide. Studies of climate change and plant evolution in the Devonian link with morphological changes to the stem group.

We are increasingly able to exploit a range of new technologies to explore the fossils in greater and greater detail, allowing histological, microarchitectural, biomechanical and morphometric analyses. Studies of appropriate modern analogues point the way to inferences about how stem tetrapods adapted their physiology and sensory systems, that further suggest features of their skeletal anatomy to re-examine.

The interface with evolutionary developmental biology has recently been embraced by both sides, with more 'evolutionarily interesting' taxa being studied developmentally, with the input from fossils feeding into a more coherent picture. Probably most signficant of all, exploration of new geographical areas is uncovering potential sites for collecting more fossils.

PROGRESSIVE PALAEONTOLOGY



2009

- BIRMINGHAM -

27th – 29th May 2009

School of Geography, Earth and Environmental Sciences
University of Birmingham

Progressive Palaeontology is an annual conference for postgraduate students who wish to present their results at any stage of their research. Presentations on all aspects of palaeontology are welcome.

The itinerary will include an evening icebreaker reception in the Lapworth Museum of Geology, one day of oral and poster presentations, the annual dinner, and a field trip to a local fossil locality.

Further information can be found at **<http://www.palass.org/>**.

If you have any specific questions, please email **<birmingham2009@palass.org>**.

The Birmingham organising committee are:

Helen Hughes, Phil Jardine, Sarah King, Andy Rees, Lil Stevens, and Andrew Storey.

news

Darwin in the Field: Collecting, Observation and Experiment

Cambridge, England *11 – 12 July 2009*

In July 2009, the Sedgwick Museum of Earth Sciences, University of Cambridge will open a new Heritage Lottery funded permanent exhibition titled 'Darwin the Geologist'. This will showcase many of the rocks, minerals and fossils brought back by Charles Darwin (1809 – 1882) from his travels onboard HMS *Beagle*.

As part of the bicentennial celebrations of Darwin's birth, we are organizing a multi-disciplinary conference focusing on Darwin's work in the field. We invite papers from earth scientists, zoologists, botanists, museologists and historians of science on some of the following suggested themes:

- Collecting practices
- Experimental / Identification practices
- Systems of naming and classification
- Theorizing using collected specimens
- Field notebooks and drawings
- Early scientific education and mentors in scientific practice
- Use of Darwin's collections and/or specimen theorizing in historical or contemporary scientific practice

If you are interested in presenting a paper, please submit a title and an abstract of no more than 500 words by Friday **23rd January 2009**.

For further information, please contact Dr Lyall I. Anderson, Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, e-mail <**land07@esc.cam.ac.uk**>.

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Dear Paleontologists and Geologists,

Fifty years ago, R.C. Moore established an endowment to support the compilation and publication of the *Treatise on Invertebrate Paleontology,* to be compiled by the Paleontological Institute at the University of Kansas and jointly published with the Geological Society of America, who also was responsible for marketing and distribution. This has been a beneficial and rewarding relationship that sustained the *Treatise* for most of those 50 years.

In recent years, however, the need has become ever more pressing for the *Treatise* to be put into digital form and, perhaps more importantly, to become a living document for students and research paleontologists. There has been a general sense that this must take place quickly.

Recently, we met with leaders in the paleontological community (see below), and it became clear that the *Treatise* will need to be reinvented in some very real senses. Because of the urgency and because of the magnitude of the task of reinvention, those of us involved in the business end of the *Treatise* (the co-signers below plus Jack Hess, Executive Director of GSA; Jon Olsen, Director of Publications at GSA; and Jill Hardesty, Managing Editor of the *Treatise*) concluded that the current relationship between the Paleontological Institute and the Geological Society of America may be more of a hindrance than an advantage at this point in time. Therefore, we have decided that the best way forward, at least for the time being, is for the Paleontological Institute to take over all operations with respect to the *Treatise.*

This should in no way be construed as a lack of commitment on the part of the Geological Society of America to the paleontological community and to the *Treatise.* Indeed, it was GSA that called the leadership meeting, and we note that the current President of the Geological Society of America herself has very close ties to the paleontological community and has published numerous papers with paleontological and paleobiological content, and some 20% of GSA members are paleontologists. Rather, GSA is assuming the same role as paleontological societies and other geological societies as an interested parties to whom the Paleontological Institute might look for intellectual and financial support as appropriate to those societies. This was necessary to allow the Paleontological Institute to proceed unfettered and to perform the reinvention of the *Treatise* with the greatest speed. GSA would like to emphasize that the door remains open for the *Treatise* to utilize GSA's expertise in publication, distribution, and education and outreach at some future date if such expertise would be beneficial.

We believe that the future of the *Treatise* is bright and are looking forward to seeing its reinvention as a 21st century resource.

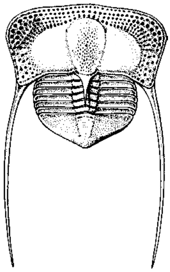
Regards,

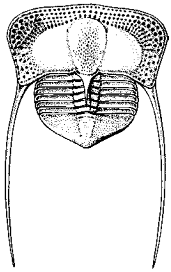
Judith Totman Parrish
President
Geological Society of America

Paul Selden
Director
Paleontological Institute

Robert H. Goldstein
Chair and Professor
Dept. of Geology
University of Kansas

Participants:
Warren Allmon, GSA *Treatise* Committee
Doug Erwin, President, Paleontological Society
Bob Goldstein, Chair and Professor, Dept. of Geology, KU
Joe Hannibal, GSA *Treatise* Committee
Jill Hardesty, *Treatise* Managing Editor
Howard Harper, SEPM Executive Director
Jack Hess, GSA Executive Director
Steve Hasiotis, SEPM
Jon Olsen, GSA Director of Publications
Tim Palmer, Palaeontological Association
Lisa Park, GSA *Treatise* Committee
Judy Parrish, GSA President
Paul Selden, Director, Paleontological Institute, KU
Paul Taylor, Palaeontographical Society
Roger Thomas, Paleontological Society
Richard Twitchett, Palaeontological Association



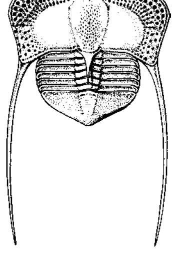


Forthcoming Major Meeting

Third International Palaeontological Congress

28 June – 3 July 2010
Imperial College and
Natural History Museum, London

Following the highly successful meetings in Sydney and Beijing, the third International Palaeontological Congress will be held in London in 2010, based in venues in and around Imperial College and the Natural History Museum. The meeting will be hosted by the Palaeontological Association and partner organizations. For further information and regular updates check the IPC3 website: <**http://www.ipc3.org/**>.



From our Correspondents

Here be dragons

It's funny what kind of thing is taken to heart in this science of ours. Take the classification business, for instance. In the last few years, one argument has been whirling around my bewildered cranium that might be regarded as downright formal, to the extent that, as one engages in discussion of it, the faint clatter of angel-borne clogs may be heard reverberating off the head of any nearby pin. This particular argument, pertaining to the notorious Quaternary question, got plenty of airtime at the 33rd meeting of the International Geological Congress: an assembly of some six thousand geologists that swept, this Summer, across the little suburb of Lillestrøm on the outskirts of Oslo, bringing sea-monsters with them.

Or to be more precise, *a* sea monster. One, in the singular. And, as the immortal Groucho might have put it, you ain't never seen a more singular sea monster than that one. Fifteen metres long, with a hide of plastic, and innards of air. The air was packed in by royal decree (perhaps) and certainly by royal index digit, that of King Harald V of Norway, no less, who pressed the button for the ceremonial inflation of said leviathan at the opening ceremony of the Congress. It's a task that he may long recall with a shudder or an amused smile, depending on philosophy and temperament. The monster was a full-scale model of the biggest pliosaur yet unearthed, in the previous Summer on Svalbard (a discovery of which the Scandinavian organizers were rightly proud), its mortal remains having been winched from its penultimate resting place by helicopter. Gaily painted and tooth-lined jaws agape, the reptilian simulacrum adorned the lawn in front of the conference centre during the meeting, a reminder that the spirit of Phineas T. Barnum lives on, even in the most unlikely of settings.

Phineas T. was no stranger to controversy, so he would have recognized in the 'Quaternary question' the kind of show that would pack in the paying customers for years. And this show is, indeed, running still, though the curtain might, with luck, yet fall on it, before we become much older and greyer. The background is simple (ish): in living memory, the Quaternary has been regarded as the period, or, to be more precise, *Period* of time that encompasses the current Ice Age. The full bipolar Ice Age, that is, for while Antarctica has been largely ice-covered for more than thirty million years, it is only when the northern hemisphere became seriously icebound, about two and a half million years ago, that the world took on its present aspect. So far, so good.

But then, a few years ago, the Quaternary disappeared off the formal stratigraphic column, to general consternation (especially among those who termed themselves Quaternary scientists). There were reasons for this, such as its archaic name: for instance, nobody uses Primary or Secondary any more, while the Tertiary was removed a couple of decades ago (though may be making a comeback – a formal comeback, that is, for informally it never really went: certainly not from my undergraduate lectures).

There was a certain amount of to-ing and fro-ing, with suggestions that the Quaternary might remain informal, or even become a Sub-Era. Well, so far as I understand, these suggestions have come to naught and the Quaternary is set to remain a Period, period. There are a *lot* of Quaternary scientists out there (over a thousand in the UK-based Quaternary Research Association alone), while in terms of global scientific hierarchy, the International Union of Quaternary Research has equal status to the International Union of Geological Sciences: in a sense, therefore, one might say, the international scientific community regards the Quaternary as valuable as all of the rest of the stratigraphic column put together. To put it like that is much nearer nonsense than sense, but it does underline the contemporary reach of this term. It may have ancient – indeed, archaic – roots, but its branches are flourishing today, like billy-o.

So the Quaternary Period is here to stay. But when did it begin? This was the main question that exercised a substantial array of the world's stratigraphers at Oslo. The base of the Pleistocene (the Epoch that makes most of the Quaternary Period by volume, as it were) was fixed in 1948 at a level in strata at Vrica, Italy that we now know is about 1.8 million years ago. It was not then a golden spike, strictly speaking, but was formally gilt subsequently. This level marks a local, Mediterranean faunal change – but not the more widespread changes (such as the main onset of loess deposition in China) that we now know took place about 2.6 million years ago. So – what to do? Maintain the current definition, and thus stability of nomenclature? – or shift the boundary to make it more convenient for most – but not all – scientists working on this time interval?

It's a tricky one. I think that the boundary (of both Pleistocene and Quaternary) should be lowered. Here speaks, though, you must understand, a landlubber geologist, who remembers working on the Crags of East Anglia years ago and trying (and generally failing) to find a sensible 1.8 million year boundary within that mess of shelly sands. The 1.8 million year boundary behaved here like a tight-fitting shoe – yes, one could work with it, sort of, with appropriate use of question marks on correlation lines, but the 2.6 million year one would have nicely encompassed pretty well all of that Crag succession. Now had I been working on deep marine strata, my perspective might have been different: the 2.6 million year change in that realm is less well marked. But, in any case, should so many words be expended on this question?

After all, the location of the boundary does not alter in the slightest the (geologically) short but adventuresome course of this segment of our planet's history.

The answer here should logically be 'no'. But then, science is a human interaction with natural phenomena, with all the orneriness and quirkiness that that entails, amplified by the many lives' work devoted to understanding those phenomena. That kind of thing breeds a little attachment to the lineaments of one's science. And then, the Ice Ages are a bit special, and were recognized as such centuries ago.

Take, for instance, Baron Georges Léopold Chrétien Frédéric Dagobert Cuvier (né, for good measure, Johann Leopold Nicolaus Friedrich Kuefer). The strata that we now regard as Quaternary were where that supreme anatomist of the early nineteenth century most closely demonstrated the fact of extinction. Cuvier, mind, was regarded as supreme by himself as well as by others, as Martin Rudwick wryly notes in his *Bursting the Limits of Time*, but as an interrogator of bones he really was without peer. The mammoth, thus, he showed, was very like an elephant, even if it was not exactly an elephant. The mammoth is no longer alive – and so he rested his case: creatures on this Earth have appeared and then disappeared.

And as for what killed this strange not-quite-modern fauna, and led to the modern one? Here, Cuvier, was on shakier ground, and probably knew it. He was a catastrophist to his boots, and spent much of his life pushing for an Earth history dominated by intermittent total revolutions – out with the old and in with the new! Here, proposing a means of extermination is the easy bit. Cuvier was well aware of the remarkable boulder-strewn deposits that the mammoths and their like were associated with. He opined that the last of his prehistoric revolutions was unleashed by some kind of enormous tsunami. He was quite particular about what this hyper-tsunami did and did not do. It was deadly to lowland faunas, yes – but not high enough to overtop mountain peaks. It swept the carcasses to their resting places, but not from far continents (the remains were not sufficiently broken up). And it certainly wasn't something that a be-Ark'd and zoologically encumbered human community could have lived through.

The Hollywoodesque tsunami in this role functioned quite as nicely as, in other detective stories, does the butler lurking malevolently outside the library. And Cuvier's idea of this final revolution was strengthened by news from Russia. Not, in this case, of any grumblings against Tsardom, but by news of the discovery of permafrosted mammoths, complete with flesh and woolly hide. Their demise and rapid refrigeration therefore were, to his thinking, part and parcel of the sudden catastrophe.

There did loom the problem of repopulating the killing fields with the new assemblage of species, and here the good Baron was understandably vague as to how that might happen. Yet, even as he worked, the total revolution concept was being undermined. The extinct Ice Age behemoths were increasingly found together with animals – horses, hyaenas and such – that are definitely still of our time. The complexity of this event began to overtake the simple general formula that Cuvier was trying to apply to it.

The bones of mammoths and of giant cave bears, though, were only part of the story of the strange final revolution. There was physical evidence too, the early study of which was again detailed by Rudwick. The problem of the large slabs of rock – the 'devil's rocks' that were far from their source bedrock and strewn seemingly haphazardly across the landscape – was furrowing many a savant's brow. Many of these blocks – house-sized, some of them – were perched high on the hillsides. Even the most extreme river floods could not account for them. So what could, then? Ideas varied from the hyper-violent – that Deluge again, the tsunami to end all tsunamis – to gentle, the blocks slowly sliding down a hypothetical inclined ancient surface, hypothetically long since eroded. My particular favourite is that of Jean-André de Luc, intellectual mentor to Charlotte, wife of George III. He saw the blocks as ballistic missiles, fired from the mountains by powerful but mysterious explosions. A marvellous notion, and too bad that he was born too early to be able to await Hollywood's call.

But the idea of ice, now… For some time, I've lived with the story (so vividly told by John and Katherine Imbrie in their *Ice Ages*) of the glacial hypothesis germinating in the early nineteenth century among those Alpine pioneers, Jean-Pierre Perraudin, Ignace Venetz and Jean de Charpentier, before the idea was picked up and broadcast by Louis Agassiz, taking a break – a rather risky one, as far as his reputation was concerned – from fossil fish. In Rudwick's considerably more magisterial tome (2.4 kg to be exact, including cover but excluding bookmark; a pocket version would doubtless be viewed with dismay by bespoke tailors everywhere) the plot, naturally, thickens. There was the schoolteacher Erhard Wrede, for instance, with his notion of ice-rafting blocks of distinctive igneous rock from Scandinavia to his native East Prussia. A near miss as an idea, that one. And then Leopold von Buch a little later, mapping out trains of blocks from the Alps southwards. Von Buch was admirably thorough in his data collection, but he was a cautious man as regards speculation. It really was, he said, as if the blocks had been fired from some giant cannon, but – after making some calculations made on whatever passed for the back of a beermat in those days – the velocities needed, he affirmed, simply weren't credible. Thus he exploded de Luc's explosion idea, though remaining thereafter stumped (before being drawn by a colleague to muse on the possibility of some sort of mudflow, which is a little away from a bullseye as an explanation).

There were also Sir James Hall's 'diluvial waves', likewise disinterred by Rudwick's admirable researches: giant tsunamis (once more!) generated by areas of the sea floor suddenly popping up like blisters. Preposterous? Well, Sir James liked controversy, and an idea like that served admirably to stir things up to his own amusement and satisfaction. And this isn't really so far from what really happens in grim tectonic reality, as a subduction zone suddenly and violently readjusts.

After that, Charpentier *et alii* got to work, and the rest is history. However, other characters were coming in from the wings, and some considerable figures are given only bit parts even in Rudwick's extended pageant of savantry. Take the Ice Ages as a term. It is wonderfully evocative, an instant stimulus alike for science – and its public understanding – and for science fiction. (It is the central metaphor in Anna Kavan's *Ice*, for instance, that heroin-fuelled nightmare in which the spread of world-invading ice is as sudden as that which overwhelms *The Day After Tomorrow*, but which has within it no seeds of any happy ending.) It seems that the term – as *Eiszeit* – came, fittingly, from the most universal savant and wordsmith of his age, Johann Wolfgang von Goethe. He seems to have rivalled Mark Twain in the variety of trades that he undertook. In 1776, for instance, he became superintendent of the mines of Ilmenau in the Duchy of Weimar, and became an enthusiastic student of minerals (hence the naming of the mineral goethite –

though whether it is fitting to put the name of an imperishable poet to what is essentially rust is another matter) and of mountains. Goethe, like Perraudin and de Charpentier, associated erratic blocks with a great expansion of the valley glaciers that he was familiar with. But Goethe was less interested in the particulars of particular problems than in deciphering the underlying pattern and harmony of the entire natural world, as the Rudolf Steiner archives on his life and work make clear. He later broadcast the *Eiszeit* as a phenomenon in his novel *Wilhelm Meister*, thereby reaching out to a wider, and a different, audience than the one Agassiz would attempt to convince of an ice-covered world a few years later.

There are more distant echoes of this tumultuous past in our own human chronicle. Until recently I had thought that the business of constructing deep histories from fossil remains was a post-Renaissance thing, with the thread running from the likes of Conrad Gesner through to Cuvier and his successors. And so it did, in the sense that we now understand those histories. But, of course, there is more than one way to gaze upon a graveyard of old bones. I recently came across (well, filched, to be more precise; but my intentions were pure; or, at least, moderately pure; or if not even that, then purely temporary as regards malfeasance committed) Adrienne Mayor's splendid *The First Fossil Hunters*. This comprises explorations of what the ancient Greeks and Romans might have made of the monstrous fossil skeletons that, here and there, came to light in river bed and cliff, amid the Tertiary and Quaternary strata of the Mediterranean. Now, Mayor is a classicist; or, more precisely, a classical folklorist, and so her perspective digs as deeply into the Graeco-Roman mind as into niceties of zoological interpretation.

She sets out her stall from the beginning. These bones played a significant part in constructing the worldview of people then. For, once disinterred by flood or by cliff-fall, they gave thrilling – and incontrovertible – evidence of a vanished world peopled by giants and monsters, and by heroes too. Pull the jumbled bones of a mammoth or a mastodon out of some river-cliff – massive limb bones, ribs, vertebrae – and lay them out. To a mind attuned to the myths and legends passed down by word of mouth by fireside in impressionable and unlettered childhood… there would appear, in the awed imagination, the mortal remains of a giant.

This might be, say, the ogre finally bested by Heracles: Antaeus, whose bones were said by proud villagers to be buried in a great mound near Tingis (now Tangier). Plutarch relates how a sceptical Roman commander, Quintus Sertorius, ordered the mound dug up – only to discover the bones of a giant, thirty cubits high, he said (a bit more than 25 metres, while a bipedal mammoth would be not much more than ten cubits: the story likely grew in the telling). Or the bones of the mythic hero, Pelops (Heracles' great-grandfather), kept in the Temple of Artemis at Olympia: the giant shoulder blade was dispatched – or so Pausanius relates – to the battle-weary Greek army at Troy, as the talisman that would finally bring them victory. Now, a good properly permineralized mammoth scapula would weigh in at up to 50 kilograms – an inspirational relic, indeed. Or the sacred bones of Theseus, unearthed on the island Skyros by the Athenian general Kimon in 476 BC, and triumphantly brought to Athens.

Mayor makes a persuasive claim that fossil bones were among the celebrity items of the time: sought after, enshrined, even at times fought over in a kind of bone rush of the day. Like actors, they could take many roles: as heroes, as giants and ogres, as monsters, according more to narrative demand than to taxonomic likeness. There was thus the Monster of Troy, a legend re-told by Homer, of a fearsome beast arriving on the Trojan shore to prey on humans; the King's daughter, sent for sacrifice, is rescued (and the Monster duly despatched) in the nick of time, by (once more) that hard-working Heracles. The story is painted on a 6th century vase made in Corinth, and generations of art historians have sneered at the artistry applied to depicting the Monster's head (a 'hideous white Thing' according to one); Mayor, however, noted the striking – and to me, entirely convincing – similarity of this image to the skull of such a creature as *Samotherium*, a Miocene giraffe. An inoffensive vegetarian, this, and so mightily traduced *post portem* by a representative – however artistically inclined – of a far more rapacious species.

In those far-off days, a wary traveller could not regard a giant bone lying on the ground as the remains of a monster long dead and thus safely dead. In a mostly unexplored world, where danger from carnivores both human and non-human lay around every corner, what might such a traveller think on passing through, say, the mountains of Asia en route to the Scythian gold mines and encountering large skeletons scattered on the ground? Safest to assume, surely, that the flesh and blood descendents are around the corner, waiting to pounce. Thus does Mayor make the connection between the fabled griffons (likened by Aeschylus to 'silent hounds with sharp, cruel beaks') and the *Protoceratops* skeletons that in places litter those desolate hillsides: skeletons that became, much later, among the relics retrieved by those legendary journeys of modern times, the dinosaur-hunting expeditions to the Gobi Desert.

The echoes from this Earthly past have certainly resonated along unexpected pathways. There's more to stratigraphy than the classification of rock strata and fossils and, indeed, of time and its divisions. The nature and classification of the Ice (and other) Ages is, for sure, a large question. And yet, one is drawn, yet again, to the real mammoth in the room, the biggest topic of this day and any day still, even as banks tumble and Wall Street plunges: the change, almost in real time, of the Earth system around us. I was about to quote the disappearing act of the Arctic ice as the most shocking example, only to read this morning that the annual rise in atmospheric carbon dioxide levels, between the last decade and this, had jumped from 0.9% to 3.5%, which is faster than the worst-case scenario of the Intergovernmental Panel for Climate Change.

Will the Ice Ages last long enough for us to finally demarcate their beginning? Of course – but perhaps decisions on Quaternary classification and such should be made a touch more briskly, so we can then focus on the science that really matters. Otherwise, the shade of Baron Cuvier might be justified in considering his grand idea as the only one in town.

What might arise, then, after the next revolution? The return of dinosaurs in some distant future was something that Charles Lyell considered, nearly two centuries ago, when he contemplated the slow cycles of oceans and mountain chains and of life itself. It was a fancy that Henry De La Beche famously chided, in penning a satirical cartoon showing a Professor Ichthyosaurus, flipper pointing to a fossil human skull, teaching infant neo-dinosaurians about the curious life of the humanoid past. Dinosaurs won't return: but who knows what kind of dragon might stride across the future Earth?

Jan Zalasiewicz

For a very specialized audience only

There is really nothing quite like the pleasure derived from publishing some hard-earned research results in a peer-reviewed journal. However, the pleasure that may emerge at the end of the submission process is often not simply the pure pride and satisfaction of a job well done. Rather too frequently the submission process is tainted with more than a tinge of the other common meaning of the word, as authors are forced to submit to suggestions embedded in the various blends of interest, sympathy, incompetence, disagreement and indifference that comprise the average bunch of referee reports. Inevitably, the pleasure that comes with the final acceptance of a manuscript often contains a degree of sheer relief from the exasperation of being forced to consider the weak points of your own work, or having to point out the obvious rigour of your work to particularly unreceptive referees.

Nevertheless, even if you have cleared the necessary hurdles thrown up by your average pack of referees, you might not yet be in the clear. The very last sentence of the editor's comments on a manuscript that we recently submitted to a general journal for evolutionary biology reads "as it is written, the paper seems to focus on a very specialized audience." We were stumped. Such a comment stops you dead in your tracks. What does it mean? How could we have prevented such a paralysing remark? Consideration of these questions brings some interesting issues into focus.

First the meaning of the comment itself. It implies the existence of different categories of readership for different types of work. These categories can be aligned along a scale, with at one extreme a category that might be labelled the "omnivorous general audience," and at the other extreme the "very specialized audience," which the editor thought to be the proper home for our work. I have no doubt about the existence of such categories, but the problem is that it is near impossible to draw meaningful boundaries between these categories in anything but grotesquely arbitrary and *ad hoc* ways. Although it can be defined theoretically, the category of the "omnivorous general reader" is likely to be extremely sparsely populated. No working scientist has fought him- or herself sufficiently free from professional myopia to merit membership in this group. Some very broadly oriented scientists with a focus on integrative or synthetic research may come closest among the professional populace. I am thinking of the likes of Geerat Vermeij, Jared Diamond, or Ernst Mayr, but even these towering intellects are unavoidably limited by their interests, or simply by the available opportunities to read in a frantic research life. Retired scientists who are enviably possessed of more leisure time to fill with reading may overcome the latter obstacle to a degree. And as far as science is concerned, we can confidently assert that omnivorous readers are not, or are at best very rarely, to be found among the general public. Even the most exciting scientific findings of general importance are without doubt less likely to be read by Joe and Jane Public, especially in the primary literature, than any of the works of celebrated writers; *Lolita* undoubtedly finds a wider readership than Nabokov's scientific work on butterflies.

What kind of criteria could one use to determine *a priori* the audience of a scientific publication in evolutionary biology? I think that the two most important criteria are taxonomic scope and methods used. All subject matter encompassed by evolutionary biology is taxonomically restricted. That means that all research that deals with particular organisms has very definite spatiotemporal restrictions. The size of the taxonomic scope of a study could conceivably form the basis of a criterion by which to judge how many people would be interested in reading about it: a smaller readership for Placozoa than for beetles, and a broader readership for research on the central tenets of evolutionary theory than for ideas about host-parasite relationships. So it may be a good idea to choose a broad taxonomic scope for your research to enhance your potential readership. However, this criterion is rendered effectively useless by the utterly unquantified and barely quantifiable subjective criteria that individual readers and journal editors may use to decide what is of interest to them. For example, it certainly helps if your organisms are possessed of a sufficiently high "glamour quotient," which in the real world often translates into being furry, fierce, endangered, a model organism, or having commercial value. Being blessed by any one of these largely cosmetic traits can effortlessly promote an obscure organism into the scientific limelight. I have no doubt that 40 years ago it would have been impossible to publish a paper on the ecology of a little nematode known as *Caenorhabditis elegans* in one of our beloved tabloids. But since our current knowledge of the Queen of invertebrate model organisms in a laboratory environment far outstrips our understanding of its natural history, it is now only a matter of time before such a paper manages successfully to excite the likes of Henry Gee.

A simpler way to boost the potential generality of your research is to introduce, or to extend the applicability, of a method, be it experimental, observational, analytical, or comparative. Developing and presenting a new method that can be unholstered by a large number of researchers readily remedies any taxonomic symptoms your organism may have to limit its relevance. This topic in itself is worthy of an essay. Without proper methods our hands would simply be tied behind our backs. However, an extreme focus on methods can also become a hindrance if not enough attention is given to the relation between question, methods, and answer. In extreme cases this can result in a Tim-the-Toolman-Taylor-Syndrome. Those afflicted may be so beguiled by the seductive glare of a method or tool that they try to apply it willy-nilly, with insufficient concern for whether it is able to produce meaningful insights. One possible example (see my essay in *Pal. Ass. Newsletter* **67**) is the application of molecular branch lengths of an uncritically 'chosen' (read: 'fortuitously available') gene to inform the probabilistic inference of morphological ancestral states on a phylogeny. Yes, this *can* be done, but *should* it be done, and what do the results mean in view of the fact that branch length ratios for one phylogeny can vary enormously depending on the gene of choice?

Yet, introducing and applying a new method is a sure way to gain entry into the category of 'cutting edge' science, which perhaps deserves more general exposure than the humdrum science the vast majority of us concern ourselves with most of the time. Then again, the cutting edge is narrow by definition, and wouldn't we be excused for thinking that perhaps science is not all about innovation, but also simply about information?

So how did we fare with respect to the two criteria of taxonomic scope and methods? Ours is an analysis of the high-level phylogeny within eumalacostracan crustaceans, a clade of over 22,000 species that houses the majority of crustacean diversity, including the commercially and economically important decapods. Using a combination of molecular and morphological data we tried to shed new light on what has been a vexing phylogenetic problem for at least 125 years. By the criterion of taxonomic scope we should therefore expect to fall somewhere else than in the bracket of a "very specialized audience". Moreover, since our paper has a methodological focus, re-analysing previously published molecular data, and refraining from detailed discussions of morphological minutiae that might be off-putting to anyone but specialists, we should at least fall comfortably within the scope of this journal in general evolutionary biology. Based on recent publications in the journal, it is perfectly fine to publish phylogenetic research on puffer fish, a clade decidedly less diverse than eumalacostracans. But perhaps the glamour quotient of puffer fish is higher than that of the lowly shrimp, as they can literally inflate their spiny self-importance. I guess that 'crunchy' hasn't quite made it into the ranks of the furry and the prickly.

In the end I think that the categories of more or less general audiences are at best simply straw men erected by journals in their ruthless quest for the highest possible impact factor. The larger its readership, the more likely it is that a journal becomes highly cited, the surest step towards attaining tabloid status. By claiming to cater primarily to an elusive and ill-conceived "general audience," journals inflate the value of methods over subject matter, and they punish researchers who simply do the best they can in researching biodiversity, irrespective of the size of the chunks it presents itself in. Unfortunately, scientists have to dance to the beat of impact factors, for these are universally wielded to judge who is to be considered successful in a career and who is not. The simplest way to impede your own career development is to publish only in specialist journals with limited readerships, and therefore relatively low impact factors. Yet, it shouldn't be so. The value of research should be primarily determined by the quality of the work, not by whether it caters to an audience of a certain size.

The fact that the journal that we submitted our manuscript to is allegedly an open access journal makes the editor's comment even more puzzling and disturbing. One would think that not being burdened with page limitations, and collecting a large sum of page charges for each published article, would be enough incentive for such a journal to publish without question a paper ok'd by the referees. After all, wasn't one of the great intended benefits of open access journals that the results of research are more easily and widely available? I think that editors of such open access journals do a serious disservice to science and the careers of individual researchers if they raise an argument about the expected size of the audience of a manuscript that has in effect passed the refereeing process. But then again, what am I surprised and upset about? The above makes one thing abundantly clear. Like so much else in the academic world, despite first impressions, the journals aren't there to serve us scientists. We are there to serve them.

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PalaeoMath 101
Size & Shape Coordinates

In the last column I tried to show how the same information we had previously captured using linear distances between landmarks could be captured, summarized, and used for ordination studies based on the coordinate positions of the landmarks themselves. Actually, because these coordinate positions are linked to a common reference—the origin of the coordinate system—any localized feature represented by a landmark is automatically located in both absolute and relative senses to all other features described by landmarks. In other words, keeping your data in the landmark mode of representation allows you to access all contrasts between all landmark locations simultaneously.

One could, of course, ask "Why not simply measure all distances between all landmarks and use that as the basis for your analysis?" Indeed, a morphometric approach exists—Euclidean Distance Matrix Analysis (EDMA, see Lele and Richtsmeier, 1991) that employs precisely this strategy. There's been quite bit of controversy about EDMA in the morphometric literature and this isn't the place to review those issues (perhaps I'll do that in a future column). But one classic and practical concern has to do with the geometries of completely specified measurement networks. Figure 1 shows a completely specified distance network for a landmark set defined for the *Calymene* specimen from the trilobite dataset.

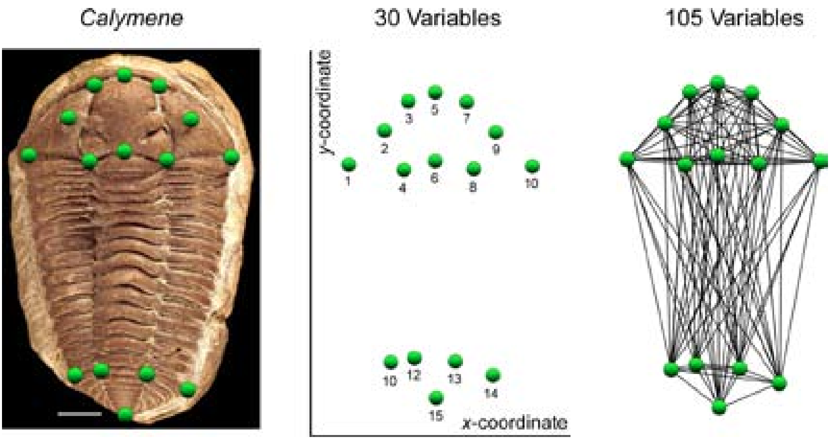

Figure 1. Alternative approaches to the quantification of shape using landmarks. Left: digital image of a Calymene *specimen with the locations of 15 landmarks superposed (scale bar = 7.87 mm). Centre: representation of form using positions of landmark points in a Cartesian coordinate system. This representation specifies the relative locations of all points exactly and requires 30 variables. Right: representation of form using all linear distances between all landmarks. This representation requires 105 variables and contains much measurement redundancy.*

Obviously the coordinate-point representation is much more compact than the inter-landmark distance representation. The former requires only 30 variables for a 15-landmark set (the x and y coordinate values) whereas the latter requires 105 variables to capture the same information. But aside from this, the coordinate point representation is better in that much of the extra information specified by the complete distance network is redundant (*e.g.*, the distance from the tip of the pygidium to the most anterior glabellar landmark is much the same regardless of whether it's being measured to the right or left sides). Also, unlike the coordinate-point data, the scalar values representing inter-landmark distances carry no geometric information about relative landmark placement. Knowing that the distance from landmark 1 to landmark 2 is 2.33mm places landmark 2 somewhere along a circle centred at landmark 1 with a radius of 2.33mm, but does not indicate where landmark 2 is located on that circle. However, if landmark 1 is at coordinate position (7.62mm, 8.16mm) and landmark 2 at position (9.86mm, 7.53mm) the placement of these two points, and the morphological features they represent, has been established precisely.

What we now want to do is develop some means of comparing sets of landmark points with one another that gives us maximum control over the factors responsible for form variation. There are four such factors: position, orientation, scale, and shape. In the last essay I showed you an easy way of gaining control over the positional and orientational aspects of different landmark sets. Fred Bookstein (1986) introduced a simple modification to these equations that allowed sets of landmarks to be brought into common alignment in terms of position, orientation, and scale.

To illustrate this method consider the trilobite pygidium (Fig. 2). The pygidium is a roughly triangular structure whose gross shape, in most cases, can be estimated by specifying three landmarks, two at the lateral maxima on either side of the axial lobe and a third at the distal terminus. This suits our illustrative purposes nicely as a triangle is the simplest geometric figure to have a complete form; to have position, orientation, size, and a shape. Points have positions. Lines have positions, orientations, and sizes (lengths). But only triangles and more complex polygons have all four descriptive form features.

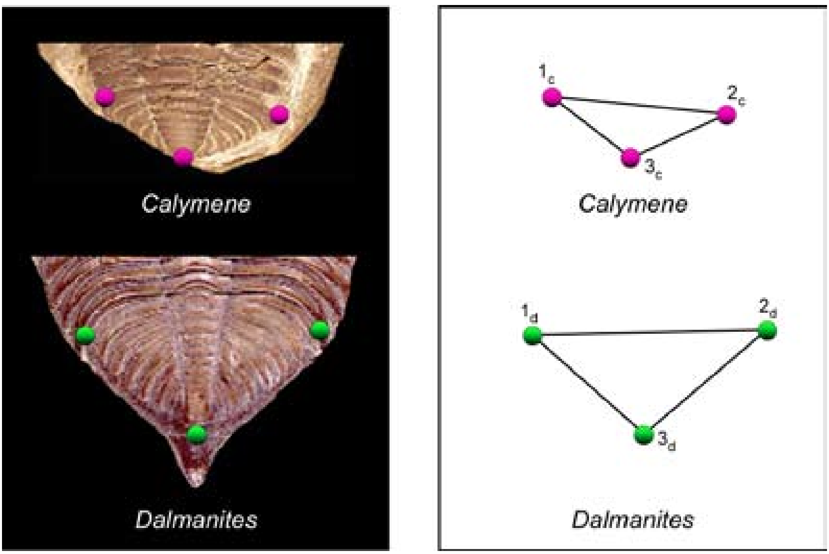

Figure 2. Landmarks used to define triangles that summarize the gross form of Calymene *and* Dalmanites *pygidia.*

Table 1. Cartesian coordinates of triangles shown in Figure 2.

Vertex	x-coordinate	y-coordinate
1_c	1.94	7.77
2_c	4.98	7.47
3_c	3.30	6.73
1_d	1.63	3.65
2_d	5.68	3.77
3_d	3.53	1.97

Table 1 gives the coordinate positions of the two sets of triangle vertices shown in Figure 2. The tools we developed in the last column are sufficient to match these triangles along a user-selected axis or baseline. Bookstein developed the following equations that not only accomplish this operation in a more compact form, but that also adjusts the sizes of the triangles via rigid scaling of the baseline to a unit value.

$$\eta_x = \frac{(2_x - 1_x)(3_x - 1_x) + (2_y - 1_y)(3_y - 1_y)}{(2_x - 1_x)^2 + (2_y - 1_y)^2}$$
$$\eta_y = \frac{(2_x - 1_x)(3_y - 1_y) - (2_y - 1_y)(3_x - 1_x)}{(2_x - 1_x)^2 + (2_y - 1_y)^2} \tag{15.1}$$

In this equation the denominator of the ratios contains the landmarks that define the baseline. For our triangles the most reasonable baseline choice would be the chord joining landmarks 1 and 2. Thus, we can use the equations in 15.1 to analyse the data in Table 1 without having to adjust the notation. Results of these calculations (see *PalaeoMath-101-2* spreadsheet) are shown in Figure 3.

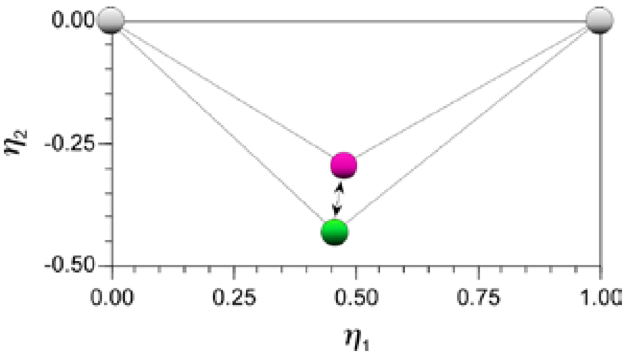

Figure 3. Results of correcting the triangular pygidial shapes shown in Figure 2 for position, orientation and scaling using the baseline (Bookstein) shape coordinate method. Note: all shape differences are subsumed in the position of the free (non-baseline) landmark. Colour codes for genera as in Figure 2.

The comparison illustrated in Figure 3 accords well with our intuition based on a traditional qualitative comparison of the pygidial triangles in Figure 2. The *Calymene* pygidial shape is shallower than that of the *Dalmanites*, at least for these specimens. But note also that we have now removed all variation between the triangles due to position, orientation, and size. What we are left with is a summary of variation due solely to shape differences.

Naturally, variation also exists in the positions of the baseline landmarks (A and B). But because these landmarks serve as the basis of the standardization of position, orientation, and scale, all the shape-difference information in this comparison has been focused on the positional difference in the single non-baseline landmark, landmark 3. This might strike some as arbitrary (what if you're interested in knowing about patterns of variation at landmarks 1 and 2?), but it does have the advantage of greatly simplifying an otherwise complex pattern of variation at three locations into a contrast between two points in space. For this simple system the vector between the *Calymene* and *Dalmanites* landmark 3 positions in the shape space quantifies how much the forms differ, the overall directions of the difference, and suggests a simple procedure through which one shape can be transformed into the other.

The η values on each axis in Figure 3 represent new variables that are produced for sets of landmarks once the effects of position, orientation, and scale have been removed. Since shape is what these variables express, they are termed 'shape variables'. Perhaps the best way to think of them are as transformations of the original coordinate values, in which we've emphasized one aspect of the information present in those original values (shape differences) by removing the effects of the other three.

Because we've used a baseline between landmarks to correct for position, orientation and scaling, and because Fred Bookstein (1986) developed this approach to shape-coordinate calculation, what we've calculated in the *PalaeoMath-101-2* spreadsheet to this point and drawn in Figure 3 are the Bookstein shape coordinates. If we had more than three landmarks in our system we'd still select a baseline and then use the equations in 15.1 to calculate the Bookstein shape coordinates for all the non-baseline landmarks. Similarly, if we had more than two pygidia in our sample we'd be able to plot—and so make comparisons between—a larger number of pygidia in the Bookstein shape-coordinate space. Figure 4 shows these shape coordinates for all the images in our trilobite dataset that include pygidia.

In this ordination the free coordinates form a trace up the centre of the plot because, on the whole, trilobite pygidia are bilaterally symmetrical. *Ptychoparia* exhibits the most flattened pygidial shape in this sample, *Trimerus*, the deepest. Although the distribution in the shape space appears quasi-continuous, in places there is a suggestion that some marked gaps in the shape distribution may also be present. For example, a gap seems to be present between the shallow pygidium of *Ptychoparia* and all other genera, between a set of genera with deep pygidial shapes (*Trimerus-Toxochasmops-Narroia*) and all other genera, and between the intermediate pygidial shape of *Cybantyx* and all other genera. Two more diverse groups of genera with moderately deep pygidia are also evident on this plot. If the gaps between these putative shape groups remained after additional sampling they could be used to more objectively and reproducibly assign these genera to pygidial shape categories, say for a phylogenetic analysis (see MacLeod 2002 for further discussion of this approach to character-state recognition).

To this point we've ignored size variation in the context of shape coordinates. In previous columns dealing with traditional multivariate analysis we've seen that size and shape are often interwoven in complex ways. The mathematical definition of shape is 'the factor that remains

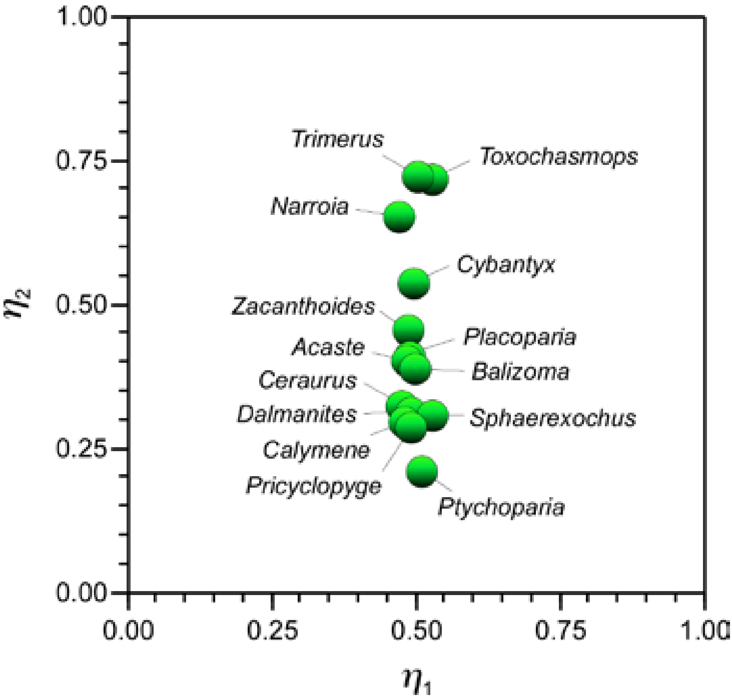

Figure 4. Ordination of the pygidial shape variation in 14 trilobite genera using Bookstein shape coordinates. See text for discussion.

after position, orientation, and scaling factors have been removed.' But that definition begs the question "what is variation due to scaling?".

As was noted in the previous column on allometry and PCA (*Newsletter* **59**), the best conceptual definition of size change is an increase or decrease in the magnitude of linear distances between features (= landmarks) that occurs at the same rate in all regions of the form. Shape change is then a localized increase or decrease in the magnitude of linear distances between features. But regardless of how it's defined conceptually, there are at present, and will likely remain, a multiplicity of operational ways 'size' can be measured or represented (*e.g.*, volumes, weights, distances, combinations of distances). In terms of Bookstein shape coordinates (equations 15.1), the relevant scaling factor is provided by the absolute length of the baseline. Curiously, despite the clear implications of his shape-coordinate method for the specification of size, Bookstein (1986) proposed a radically different morphometric size index: centroid size (*S*).

Since 1986 centroid size has been defined in several different ways. Bookstein originally described it as "the sum of all squared distances between landmarks in pairs" (p. 190). This value was deemed statistically equivalent to "the sum of distances from each landmark to their joint centroid, each distance weighted by its own sample mean." (p. 190). Later in that same article Bookstein introduced the concept of taking the square root of *S* in order to linearize the index and place it in the same units as the original coordinate values. Later authors (*e.g.*, Zelditch *et al.* 2004) have tended to define '*S*' as the square root of the sum of squared distances of all landmarks from their joint centroid, despite the inevitable confusion this causes with the older literature. To avoid this pitfall I'll use the symbol *S'* for the non-weighted sum of squared distances from the joint centroid and 'root centroid size' (*RCS*) to describe the square root of this convenient morphometric size index. The *RCS* corresponds to the following equation.

$$RCS = \sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2 + (y_i - \bar{y})^2} \tag{15.2}$$

In this equation n corresponds to the number of landmarks.

The *PalaeoMath-101-2* spreadsheet calculates all these size indices for the trilobite pygidial dataset shown in Figure 4 to demonstrate that they are all very highly correlated with one another. This gives empirical support to the assertion (made explicitly in Bookstein 1986, but not discussed in Zelditch *et al.* 2006) that the concept behind each is the same. All three size indices proposed for use in geometric morphometrics represent size as the sum of distances between landmark points, thus operationalizing the network shown in Figure 1 as an appropriate procedure for estimating size (but not shape).

Both Bookstein (1986) and Zelditch *et al.* (2006) claim these size measures are uncorrelated with shape. This is correct, but perhaps in more subtle manner than it first appears. Zelditch *et al.* (2006) in particular confuse matters for many readers by couching their discussion of centroid size in terms of isometric shape change. The fact is, the centroid size concept—and the centroid size computation—is entirely agnostic when it comes to the question of isometric or allometric shape change. There is no way to tell from the outset whether landmarks used as the basis for the centroid size computation experience little, a moderate amount, or a great deal of allometric change over a sample. Consequently, centroid size is not an inherently isometric size index (and so uncorrelated with shape change for that reason). Rather, what Bookstein (1986) means when he speaks of centroid size being uncorrelated with shape is simply that any shape described by the same number of landmarks may be compared in terms of its size using the centroid size index.

Centroid size is clearly a better size index than any index constructed from an arbitrary subset of landmarks collected on a form. As shown in the *PalaeoMath-101-2* spreadsheet, the RCS index is conceptually synonymous with (but of course not computationally equivalent to) coordinate-based or distance-based size indices that employ all landmarks to obtain an estimate. This is what distinguishes the RCS from the size estimates we employed in the previous columns on regression and multivariate analyses. In those cases we are always dealing with an arbitrarily selected subset of all possible distances between landmark points. The RCS differs from these in that all information from all regions of the form is employed in the size estimate. It is a simple distinction, but an important one. But does this mean centroid size always corresponds to our intuitive notion of what size represents?

Because centroid size is obtained via summation, it represents a theoretical range of values that is not only unbounded, but is guaranteed to increase if the number of landmarks used to estimate it increases[1]. This leads to some awkwardness and plainly counter-intuitive results. Take, for example, the three identical triangles shown in Figure 5.

[1] I thank Jonathan Krieger for pointing this fact out to me originally and hope he will publish a more complete review of centroid size than I have had space to do here.

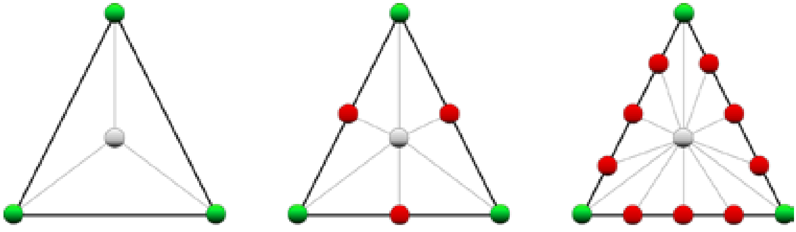

Figure 5. Unbounded nature of the RCS index. The triangles have exactly the same dimensions. However, when the RSC index is used to estimate their size this value is tied to the number of landmarks used to represent the form. Green = landmarks, White = centroid, Red = constructed landmarks.

In one, landmarks have been placed at the three vertices. In another, additional, constructed landmarks have been placed at the midpoints of the sides. And in the last, these half-side chords have been further subdivided into equal-length segments. If the RSC (or S, or S') is calculated for these three landmark sets the size values will differ, substantially. Note that neither the total lengths of the sides have changed, nor the area of the triangle. Moreover, the magnitude of the differences between size estimates will depend entirely on how many landmarks are used to represent the form and on the placement of the landmarks relative to the centroid, even for forms that have exactly the same dimensions. Another problem with centroid size has to do with the insensitivity to shape differences forced upon it by being tied so closely to landmarks (Fig. 6).

These idiosyncrasies of the centroid size index should be kept in mind when designing landmark sets that will be used to estimate size and shape in morphometric studies, and when comparing RCS values for different landmark sets. Suffice it to say, there is no 'perfect' size index, and the decision as to which of the many size indices is most appropriate for a particular study will, in most cases, depend on the details of the forms being investigated and the purposes of the study.

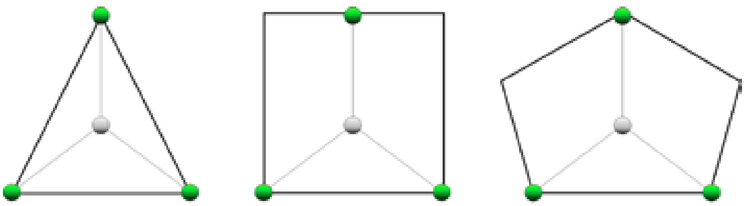

Figure 6. Forms that would be represented as having the same size as measured by a three-landmark centroid size estimate.

Turning now to a consideration of the relation between size and shape for the trilobite pygidial data, we can test the allometry model by performing a multiple linear regression of the two shape variables (η_1, η_2) on RSC (see the *PalaeoMath-101* column in *Newsletter* **58** for a discussion of multiple linear regression). The 3D scatter plot for this regression is shown in Figure 7 and the regression ANOVA in Table 2.

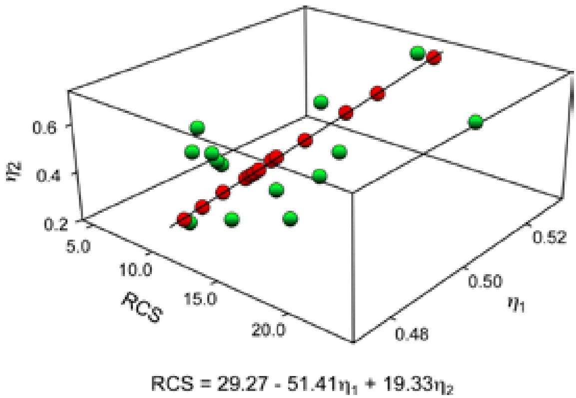

Figure 7. Multiple linear regression scatterplot of the two trilobite pydigial shape coordinates (η_1, η_2) on root centroid size (RCS). Green = observed values, Red = predicted values.

Table 2. ANOVA results for multiple linear regression of shape coordinates on size.

Source	DoF	SSQ	Mean Squares	*F*
Total	13	345.676		
Regression	2	141.269	70.634	3.801
Error	11	204.407	18.582	

Looking up the critical value of the F statistic we find the regression is just slightly non-significant at the traditional 95 percent confidence level ($\alpha = 0.056$), but close enough to be interesting. Inspection of further statistics for this regression indicates that η_1 does not exhibit a significant partial regression slope ($t = -0.747$), but η_2 does ($t = 2.702$). The fact that there is a distinction between the two variables is obvious from Figure 4, but still it's nice to see the significance of η_2 confirmed.

Lastly we can use Bookstein shape coordinates to obtain a picture of relations between taxa in a form space (size + shape), or in a size-free shape space. For this analysis let's go back to an analysis of the trilobite cranidia, using the landmarks for that structure shown in Figure 1. To construct the form matrix we would simply select a baseline (*e.g.*, anterior and posterior glabellar mid-line landmarks), calculate the shape coordinates for all non-baseline landmarks, decide whether we wanted to include information about cranidial left-right asymmetry (if not we should either use only landmarks from the right or left sizes, or possibly reflect one side on to the other and then average the corresponding landmarks), and submit the resulting matrix with a size variable (= form space) or without (= shape space) to a covariance-based PCA (see *PalaeoMath-101* column in *Newsletter* **59** for a discussion of PCA). Results of the first two shape axes for an analysis that averaged left and right landmarks to correct for single-side asymmetry is shown in Figure 8 and Table 3.

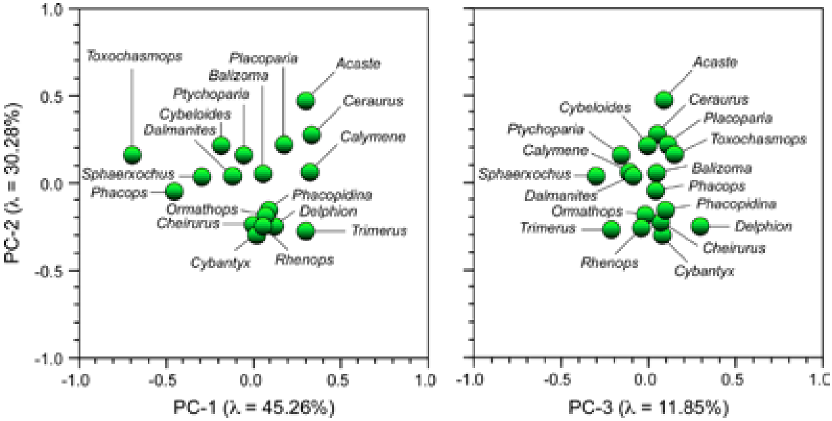

Figure 8. Results from a principal component analysis of non-baseline Bookstein shape coordinates for 18 trilobite cranidia (see Fig. 1 for an illustration of the landmarks used).

Table 3. Principal component loadings for cranidial shape-coordinate variables.

Landmarks	PC-1	PC-2	PC-3
1x	0.841	0.042	0.494
1y	-0.176	0.797	0.04
2x	0.240	0.105	-0.203
2y	-0.129	0.459	0.388
3x	0.252	0.282	-0.486
3y	-0.297	-0.083	0.561
4x	0.183	0.223	-0.107
4y	-0.043	-0.061	0.029

It's instructive to compare Figure 8 with Figure 3B from the previous column (*Newsletter* **68**). In that result we had corrected an analogous set of trilobite landmark data for position and orientation, but not for scale. Obviously the inclusion of size matters a great deal in terms of the overall partitioning of the observed variance. But more to the point, we have now developed a tool that can partition size and shape much more cleanly in terms of the conceptual distinctions between the two, and much more elegantly in terms of the mathematics. Best of all, it makes a real difference when we do this as patterns not evident in the previous analysis have been revealed here.

In particular, note the tight cluster of taxa with scores close to the lower limit on the PC-2 axis, consisting of *Phacopidina*, *Delphion*, *Trimerus*, *Rhenops*, *Cybantyx*, *Cheirurus*, and *Ormathops*. While these specimens have very different sizes—*Trimerus* is the largest specimen in the sample, *Ormathops* the smallest—our shape coordinate results suggest this group shares an underlying shape similarity that we have not seen previously. What is this similarity?

Inspection of the loading table (Table 3) identifies landmark 1 as contributing the most to total shape variance. This marks the position of the posterior peripheral terminus of the free cheek. The importance of this characteristic can be graphically assessed by plotting the shape coordinates and labelling them to show (1) the scatter of points for each landmark location and (2) the identification of specimens as belonging to the putative group of taxa listed above on the basis of a qualitative inspection of the PCA optimized shape space (Fig, 9).

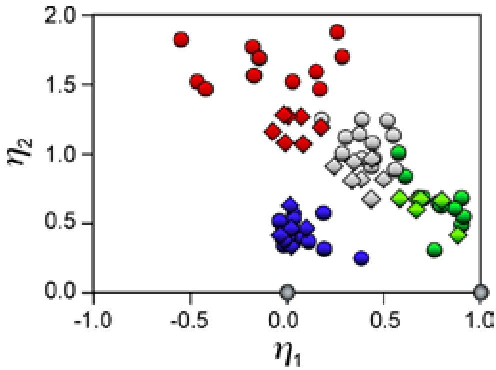

Figure 9. Plot of averaged cranidial shape coordinates. Red = landmark 1; White = landmark 2, Green = landmark 3, Blue = landmark 4, Grey = baseline landmarks (see Fig. 1 for landmark locations referenced to morphology). Diamond symbols mark points included in the Phacopidina, Delphion, Trimerus, Rhenops, Cybantyx, Cheirurus, *and* Ormathops *putative subgroup. See text for discussion.*

Note that landmark 1 exhibits the greatest variance of all the non-baseline landmarks and that it shows a marked separation between those specimens with fixed cheeks whose distal, lateral, posterior termini are located relatively close to the baseline, and those whose distal margins are located further away from the baseline. Landmark 1 and landmark 2, where the same pattern is developed but occupies a smaller range of variation, appear to be the two most important sources of shape variability over the second shape coordinate (η_2). With respect to η_1, landmarks 1 and 3 exhibit the greatest range of shape variation with landmark 1 variation predominating. Taken together it is clear that the pattern of loadings in Table 3 reflects these aspects of variation in the shape coordinate data in a simple, straightforward, and highly informative manner.

Shape coordinates represent a fundamental part of what distinguishes geometric morphometrics from previous approaches. Bookstein shape coordinates were the first type of shape coordinates to be formulated, and much of the early theoretical work in geometric morphometrics was inspired by experiments performed using them. These days the term 'shape coordinate' has become more-or-less synonymous with a different approach to shape coordinate computation, which will form the topic of the next column in this series. Nevertheless Bookstein-style shape coordinates continue to be employed in several different contexts, in particular studies that employ morphometric approaches in the analysis of ontogenetic series (*e.g.*, Webster *et al.* 2001; Kim *et al.* 2002).

Relative to the 'other' sort of shape coordinates, the original Bookstein formulation is mathematically very simple to compute and highly useful in a wide range of situations. Complications do arise when using Bookstein shape coordinates, most notably with respect to the fact that shape variation in the baseline coordinates is transferred to the non-baseline shape coordinates, sometimes in complex ways. A conceptual distinction also exists between this approach to shape specification and use of the centroid size index for size specification. This distinction needs to be kept in mind when using Bookstein shape coordinates and centroid size in the same study, as do the more counter-intuitive aspects of the centroid size index in general. However, as I hope I've shown, Bookstein shape coordinates and centroid size are good places to begin an exploration of what geometric morphometrics is all about, and why it marks such a radical departure from the previous distance-based morphometric approaches.

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Don't forget the *PalaeoMath 101-2* web page, at:

<http://www.palass.org/modules.php?name=palaeo_math&page=1>

Meeting REPORTS

CEE Modern Functional Anatomy Workshop
London, UK *23 April 2008*

According to the principal organiser, **John R. Hutchinson**, this one-day workshop (or wow-shop as later nicknamed) had two main aims: (1) to demonstrate that functional anatomy is alive and well in the 'genomic era', and (2) to showcase the diversity and innovation of research relating to functional anatomy currently taking place (both in the UK and worldwide). It was hoped that these aims would send students and other attendees away with a new-found excitement about the field. With recent advances in technology and the current interest in 3D imaging and functional morphology, such a meeting seemed very timely (*e.g.* Alexander, 2006; Rayfield, 2007; Wickens, 2007; Strait and Evans, 2008; Sutton, 2008; Young, 2008).

The workshop took place at the comfortable Flett Theatre in the Natural History Museum and was structured with two 40-minute keynote talks, nine 25-minute talks and four 15-minute talks. Entrance fees were £3 for students and £5 for others; abstracts from all speakers were available in a free handout. In addition to John, **Adrian M. Lister** ensured the day went as smoothly as possible. Light refreshments and travel costs for non-London based speakers were provided by the Centre for Ecology and Evolution (CEE) (<**http://www.ucl.ac.uk/~ucbtcee/cee/**>). Speakers were asked to pitch their talks at the level anyone with a general biological background could understand, and were encouraged to concentrate on how they obtained their data rather than explanations of what the data meant. Several talks had a distinctly primate-based feel to them but overall a wide taxonomic range was represented (to some extent even plants!). Overall, locomotion was the favoured topic but aspects of feeding also appeared in more than one talk.

John Hutchinson opened the day by speaking of the motivation behind the meeting. He described how functional morphology was now very interdisciplinary and pulled together strands from a wide range of seemingly isolated subjects: anatomy, ecology, evolution, phylogeny, ontogeny and physiology. John argued that the subject was "thriving" in contrast to recent comments made elsewhere by certain high-profile geneticists. He was pleased to announce that the attendance was approaching 100 people and expressed his delight at the range of attendees (*e.g.* amateur enthusiasts, web bloggers, PhD students, postdocs, lecturers, and professors). The first keynote speaker, **Robin Crompton**, presented work from his lab on locomotion and energetics in primates. He explained that, for a long time, his research has relied on taking quantitative data from footage of captive animals in a controlled environment. However, now with the aid of new technology, comparable data can be obtained from wild animals in their natural habitat. In parallel with this approach, computer modelling is used to explore the relationship between parameters using sensitivity analysis. With these models, predictions can be made with regards to the performance of extinct and hypothetical taxa. For example, reverse modelling of the 3.2My old australopithecine, Lucy, suggests that she was quite efficient over short distances. Related work involved a voxel by voxel comparison between 3D computer models of the Laetoli footprints and those made by humans in various gaits. A highlight of this talk was footage of an Orang-Utan walking bipedally along a thin branch supported by arms grasping at higher branches. Similarly remarkable was the footage of chimps, with unusual ontogenetic histories, that could walk bipedally.

Next up was **John Hutchinson** himself who provided his answer to the question of whether reconstructing (non-avian) dinosaur biomechanics, without the aid of a time machine, was a hopeless task. He conceded there are lots of unknowns and the size of many non-avian dinosaurs alone presents problems in finding appropriate living analogues. Correspondingly he encouraged everyone to read Alexander (1991), a frequently overlooked reference. Nevertheless, John argued with due caution that one should pursue an holistic approach, synthesising evidence from anatomy, body dimensions, physiology, locomotor mechanics and computer simulations, with the perspective of phylogeny. Results from this would certainly constrain possibilities. With the pace of current research, John suggested that we may reach the limits of what can be inferred (the "interpretive asymptote") within ten years. He also added that perhaps the biggest obstacle today is the lack of basic knowledge about living animals, for which quantitative anatomy and behavioural information is often of limited availability. This sentiment was repeated throughout the meeting.

The subsequent talk by **Renate Weller** was a lively and very thorough account of techniques used for obtaining 3D anatomical data and subsequent inspection and manipulation with computer software (*e.g.* Amira, MIMICS). This included Computed Tomography (CT), Magnetic Resonance Imaging (MRI), and ultrasonography. The big advantage of such imaging methods is that they are non-destructive, and permit inspection of internal anatomy. However, as Renate emphasised, the most appropriate method depends on a number of factors: available funds, available time, tissue type of interest, detail required, the size of the target object and whether it is still alive or not. These points were illustrated using a number of appropriate and impressive examples.

The organisers and keynote speakers: from left to right R. McNeill Alexander, John R. Hutchinson, Adrian M. Lister, Robin H. Crompton.

This included the imaging of bird wings (feathers and all) using CT after just a small amount of preparation. Renate also told us how she helped to scan the complete skeleton of the 18th century racehorse Eclipse. This has enabled subsequent computer modelling to investigate the extent to which its body proportions contributed to its substantial success on the racetrack in addition to broader questions regarding balance and galloping.

An entirely fossil-based talk was given by **Jenny Clack**, recent recipient of the Daniel Giraud Elliot Medal (US National Academy of Sciences). She related progress made in the understanding of the 365 Ma tetrapod *Ichthyostega*. We were introduced to "Mr Magic", a particularly informative specimen which is preserved in dense sandstone that is very amenable to CT imaging. In combination with classical comparative anatomy, this has uncovered a bizarre combination of specialized features in the ancient taxon. These include paddle-like limbs, an aquatic hearing system and a mammal-like backbone; characteristics that demonstrate the animal was not a simple stepping-stone taxon between 'fish' and more recent tetrapods.

The final talk before lunch was provided by **Paul O'Higgins**, the co-author of *Morphologika* (O'Higgins and Jones, 1998, 2006) a geometric morphometrics software program that featured repeatedly during the day. He described, with enthusiasm, how geometric morphometrics has contributed to our understanding of primate cranial form and ontogeny over the past ten years. He also described the implications of more recent work using Finite Element Analysis (FEA) to assess loading on biological structures such as skulls. Paul then revealed how he has been attempting to combine both these techniques into a single program that will provide comparative anatomists with unprecedented freedom: research questions – previously only open to speculation – will be open to test. However, as Paul stressed, raw data from dissection and Scanning Electron Microscopy (SEM) will be vital for determining basic parameters.

The first talk of the afternoon was presented by the second keynote speaker, the eminent **McNeill Alexander**, who discussed optimisation, a concept that is often misunderstood, and cautioned that the role of optimisation theory is not to demonstrate natural selection but to check our understanding (Alexander, 1997). For example, if some aspect of anatomy fails to meet our perception of what ideally would be selected for, this suggests we do not understand all the factors involved. Interesting examples from recent literature included tortoise shell shape, gut length, and tooth sharpness. A further problem may be that phylogenetic constraints may make theoretical optima unobtainable.

Colin McHenry then described his work with Steve Wroe and other members of the Computational Biomechanics Research Group in Australia (CBRG) (<**http://www.compbiomech.com/**>). They have recently been applying FEA to the skulls of various extant and extinct taxa, using models made up from over four million elements based on data from CT scans. Differences in material properties are estimated using the greyscale values from the CT slices. Calculating absolute performance is still problematic but evaluating relative performance allows a range of hypotheses to be tested. For example, the lab's work indicates that *Smilodon,* the sabre-toothed cat, had a weak skull compared to modern lions and was unlikely to use similar bite forces. Such work was complemented by comparing the cranial shape of different mammalian predators using 3D geometric morphometrics (with the aid of *Morphologika*). Other subjects of their research include the skulls of monitor lizards, pliosaurs, hominoids, and the great white shark.

Mark Purnell described how tooth microwear analysis can be used as a tool to infer feeding behaviour, one that is independent from examination of stomach contents or coprolites, and also of body shape, skull structure, and gross tooth morphology. In its simplest form a section of tooth is imaged using Scanning Electron Microscopy at a set magnification and a software program (such as *Microware 4.02* by Peter S. Ungar) to count the number of scratches and pits. However, three-dimensional methods are becoming increasingly popular, and innovative methods for measuring roughness are looking very promising. Quantitative data obtained from these methods can then be plotted graphically and tested statistically, allowing different taxa, populations and individuals to be compared. These rigorous techniques have been applied to fish, dinosaurs and recent mammals (particularly primates), but Mark urged that the technique should be used more widely still.

The first of two elephant talks was presented by **Charlotte Miller**. She has been examining the feet of these super-sized mammals using CT; more specifically scanning elephant cadaver feet both loaded and unloaded. This has revealed exciting new information about the movement and orientation of the prehallux, an enigmatic cartilaginous structure, during weight bearing. The second elephant talk was given by **Victoria Herridge**, who has been working on fossil dwarf elephants from various parts of the Mediterranean. Victoria proudly announced that her data were gathered using the cost effective method of measuring with callipers. Despite problems with samples of different ontogenetic ages, she showed that different populations dwarfed in different ways and that dwarf elephants are relatively more robust than their larger relatives.

From dwarf elephants, the scale decreased dramatically when **Walter Federle** spoke about how insects attach themselves to substrates and how certain plant cuticles may present special problems. Incorporating data from atomic force microscopy, fluorescence and interference reflection microscopy, he showed that insects use a number of different methods to attach themselves to surfaces, including pads, claws and adhesive chemicals; some of these are passive and others are active. This talk included one of the most memorable moments of the day when Walter showed footage of ants crawling around a carnivorous plant before and after rainfall. The presence of water on the plant cuticle clearly had no effect on some species whereas members of other species fell helplessly to their doom.

Robin Wootton gave a particularly engaging talk on the structure of insect wings. These airfoil-like appendages lack internal musculature but achieve aerodynamic capabilities by passive in-flight deformation, controlled by the pattern of veins present within the body of the wing. This allows the wings of different insects to be modelled and compared using only appropriately folded card and tape. To support this assertion, Robin – like a seasoned magician – produced model after simple elegant model, each with a different series of folds and each mimicking its living counterpart. There was a brief pause as Robin apologised that one of his models was prone to breaking at a particular junction, but this lull was replaced by an audible chuckle as Robin explained that in the living taxon this junction is strengthened with a special protein.

Marc Jones used 2D geometric morphometrics (again using *Morphologika*) to show that, in terms of skull shape, the tuatara (*Sphenodon*) differs significantly from all of its well-known fossil relatives (Rhynchocephalia). He also presented ongoing work in conjunction with Neil Curtis on a sophisticated model of a *Sphenodon* head and neck, built (in Adams and Amira) using data from CT and dissection. **Will Parr** presented his work on primate ankle bones. Their size and rounded

A group photo of those who presented oral communications (and Adrian M. Lister). Photo taken by Manabu Sakamoto.

shape make them difficult to describe, image and measure with most techniques. Nevertheless, Will has used surface laser scanning to provide detailed 3D models of these elements that can, in turn, be compared using geometric morphometrics (and self-written software). This has enabled connections between form and function to be identified.

The final talk was given by **Evie Vereecke** on primate limb musculature. She started by championing detailed historical anatomical descriptions for their wealth of qualitative information but also expressed her frustration at the lack of usable quantitative data. She has been attempting to address this limitation by systematically collecting a range of measurements from unfixed cadavers of various hominoid taxa, producing an impressive dataset of actual values from a variety of soft tissue features (*e.g.* pennation angle, fascicle length, tendon length). In tandem with data from medical imaging of 3D skeletons, this allows rigorous computer simulations for testing hypotheses regarding kinematics and locomotor ability.

The day ended with a demonstration by Materialise (the meeting sponsors – see<**http://www.materialise.com/materialise/view/en/65854**>), and a poster session featuring work by **Philip Anderson**, **Marcela Gómez-Pérez**, **Penelope Hudson**, **Sandra Jasinoski**, **Olga Panagiotopoulou**, **Stephanie Pierce**, and **Manabu Sakamoto**. The vibrant drinks reception, which followed, confirmed the success of the day. After this, several participants continued discussions in the Hoop and Toy where rumours were already widespread that a follow-up meeting may take place in Hull next year.

The meeting was both impressive and enjoyable; evidently a report that functional anatomy is dead "was an exaggeration". We experienced psychedelic computer animations, morphing skulls, rotating elephant feet and walking hominoids. The meeting provided much to be excited and optimistic about. Both of the stated aims were clearly met, but there was also a consensus that comparative anatomy and careful observation still play a vital role underpinning the relatively new and often computer-driven techniques.

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Progressive Palaeontology
Manchester *29 – 31 May 2008*

2008 saw Manchester host *Progressive Palaeontology;* the conference was held in the Kanaris Lecture Theatre in The Manchester Museum and the Visualization Suite in the School of Earth, Atmospheric and Environmental Sciences, University of Manchester.

Prior to the meeting a public open day – *Meet the fossil detectives* – was held in the Discovery Centre of The Manchester Museum. This gave an opportunity for delegates to explain and demonstrate their research to the public, through the use of specimens, posters and computer displays. Public lectures were given by **Professor Mike Benton** (Bristol) on the greatest mass extinction of all time and **Dr Phil Manning** (Manchester), who gave an insight into the research of the dinosaur mummy.

Manchester's own **Karl Bates**, **Peter Falkingham** and **Mark Johnson**, and Imperial College's **Imran Rahman** and **Russell Garwood** showed off their research in spectacular fashion using specimens and computer displays projected on large screens. The other delegates, to great effect, chose the more traditional approach of using specimens and posters. **Marco Brandalise de Andrade** discussed fossil crocodiles with the aid of specimens, **Mark Bell** (Bristol and NHM), **Simon Braddy**, **James Lamsdell** and **Marc Williams** (Bristol) brought gigantism in arthropods to the public with specimens of trilobites and eurypterids. **Phil Jardine** (Birmingham) impressed the public with 60 million year old pollen. **Nick Edwards** (Manchester) amazed people with the possibility of finding biomolecules in the fossil record. **James Jepson** (Manchester) used a display of extinct and extant specimens to demonstrate the exciting world of fossil insects! And finally, **Bernat Vila**, **Josep Fortuny** and **Angel Galobart** (Institut Catalá de Paleontologia, Spain) displayed posters and computer animations of the dinosaurs of Spain.

Marc Williams and James Lamsdell are surrounded by members of the public!

Many thanks to Mike and Phil and all the delegates who took part in this event, and to Anna Bunney, David Gelsthorpe and Dmitri Logunov (The Manchester Museum) for help with organizing and fishing out specimens from the Museum collections to use on the day. The day was well received by the public, with many people e-mailing the museum to say how much they enjoyed this event:

> "I would like to say that myself and my children came today to see the Lindow man which was great but we went into where the scientists were all talking about fossils and dinosaurs etc, this was fantastic! … Can you please pass on a big thank you to the relevant people."

… So – thank you!

The conference proper began after the public engagement event once the Museum had closed, with an evening reception in the fossil gallery at The Manchester Museum, where wine and a selection of nibbles were consumed under the watchful eye of Stan the *T. rex*. The evening was rounded off with a few ales at the Ducie Arms.

The meeting started the next day with a few sore heads and a cup of coffee in the Kanaris Lecture Theatre. With registration complete the delegates took to their seats for a day of talks and posters. The starting session was chaired by **Dr John Nudds**. First up was **Marco Brandalise de Andrade** (Bristol) who described a new specimen of *Goniopholis* from the Intermarine Member of Durlston Bay. **Josep Fortuny** (Institut Catalá de Paleontologia, Spain) demonstrated the use of CT tools in investigating morphology of temnospondyl capitosaur skulls in specimens that would be impossible to prepare mechanically. The third talk was by **Phillip Mannion** (UCL) showing how GIS can be used in palaeontological analysis, using the example of sauropods. A slight switch-around was required in the first session with **James Jepson** (Manchester) taking Nick Edwards' place (beer can have unfortunate effects!); James described the snakefly fauna of the Purbeck Limestone Group and how they hint at a faunal change from the Lower to the Upper Purbeck. The first session closed and delegates were able to peruse the posters while enjoying a coffee in the foyer of the Kanaris; the meeting had a number of excellent posters presented by **Karl Bates** (Manchester), **Nick Edwards** (Manchester), **Peter Falkingham** (Manchester), **Peter Heintzman** (Bristol), **Phil Jardine** (Birmingham), **James Jepson** (Manchester) and **Bernat Vila**, **Josep Fortuny** and **Angel Galobart** (Institut Catalá de Paleontologia, Spain). With the posters all of such a high quality, it was a difficult decision, but in the end **Phil Jardine** won best poster prize for his work on the red hills mine flora.

The second session – chaired by **Dr Phil Manning** – started with **Bernat Vila** (Institut Catalá de Paleontologia, Spain) using 3D modelling to investigate dinosaur nesting behaviour, followed by **Bryony Caswell** (Open University) looking at the Toarcian environmental change and the response of the marine biota. **Roger Benson** (Cambridge) reviewed basal tetanuran dinosaur relationships and the possibility of a faunal turnover between the mid and late Jurassic, and **Nick Edwards** (Manchester) gave an introduction into molecular palaeontology and biomolecules.

A break for a buffet lunch in the Danish Kro Bar was enjoyed by all, before session number three (chaired by **Dr William Sellers**) kicked off with **Mark Johnson** (Manchester) speaking about his comparative work on Owl and Dromeosaur claws using FEA. **Mark Bell** (Bristol/NHM) gave a fascinating talk on trilobite body size through space and time. Finally the short session was ended with **Peter Tickle** (Manchester) presenting the implications of uncinate processes for respiration in birds and dinosaurs.

The last session was a unique visual treat, using the 3D Visualization Suite in the School of Earth, Atmospheric, and Environmental Sciences, not only for the 'holodeck' effect of the presenters' talks, but also for the opportunity to see a group of the finest up-and-coming palaeontologists wearing the most stylish of polarising goggles! **Dr Dave Hodgetts** took the helm and chaired the session. **Jonathan Antcliffe** (Oxford) began the session with Darwin's Dilemma, contemplating the origin of life, looking at the Ediacara biota, and presenting high-resolution laser scans of the enigmatic life. **Imran Rahman** (Imperial) investigated the water vascular system in the carpoid class: Cincta, using 3D models produced using X-ray micro CT. **Peter Falkingham** (Manchester) showed that appearances can indeed be deceiving when looking at dinosaur tracks, by comparing laser scans of fossil tracks with FEA simulations. **Russell Garwood** (Imperial) reconstructed the enigmatic arthropod Thylacocephala in 3D through micro CT and serial sectioning. Ending the programme of 3D talks, **Karl Bates** (Manchester) quantified the unknown in biomechanical modelling in fossil vertebrates, by presenting sensitivity analyses and body mass estimates of a number of Cretaceous dinosaurs.

Bernat Vila's talk, with its exquisite but subtle use of animation and high-quality scientific content, won best oral presentation prize.

The meeting ended with the annual dinner in Christie's Bistro, the original Victorian library of the University building. A delicious three-course meal was served, with coffee and chocolates served afterwards. **Peter Falkingham** delivered the after dinner speech and awarded prizes.

The post-conference field trip was to Castleton, Derbyshire, investigating Carboniferous Palaeontology and Geology. A typically grey day (for the Peak District), the trip started with a look at Windy Knoll, a cave where William Boyd Dawkins discovered a variety of Quaternary mammals, many of which are now on display in The Manchester Museum. The geology of Winnat's Pass was then investigated with a look at the limestone and fossils therein. An excellent lunch was consumed at the Peak Inn – a delightful pub in Castleton. After lunch and an ice-cream (and a walk back up Winnat's Pass that seemed twice as long as on the way down), the trip and indeed the conference was wrapped up!

Dr Phil Manning explains that yes, the weather is usually this 'grim up north.'

The conference delegates, satiated by a day of palaeontology and a three-course meal in Christies Bistro.

With 39 delegates from across the UK and abroad, *Progressive Palaeontology Manchester 2008* proved to be a great success, with a sharing of ideas and experience, not only amongst scientific peers, but with the general public too. In particular, it was encouraging to see so many palaeontology postgraduate researchers applying methodologies and techniques from a whole range of disciplines to our science, pushing the boundaries like never before.

We'd like to give a big thank you to all the delegates who attended and presented, all our volunteer helpers, and of course our sponsors. The abstract book is available online in PDF format, at the relevant pages on the Pal Ass website.

Finally, we wish Birmingham all the very best for *Progressive Palaeontology Birmingham 2009*, we're eagerly looking forward to it already.

James Jepson

4th International Trilobite Conference

Toledo, Spain *16 – 24 June 2008*

The Fourth International Trilobite Conference, or 'TRILO08', was held in Toledo, Spain from 16th to 24th June. It was magnificently organised by the Spanish Geological Survey and collaborating institutions, and masterminded – in particular – by **Isabel Rábano**. Over a hundred participants attended, from more than 20 countries.

The conference proper was preceded by a field trip to Arouca in northern Portugal (16–18 June), in what is now a fine new Geopark. Some 30 delegates came on this trip, meeting in the excellent Geological Museum in Madrid, where an enjoyable morning was spent in the collections and displays. There is so much good material here, elegantly set out; we would recommend it to anyone visiting this great city. Then we were taken by coach to Arouca, to visit the new Geopark, arriving late in the evening, and so pleasantly accommodated in friendly hotels. The next morning we went by coach to the great Canelas quarry in the forested hills above Arouca. Here the finely cleaved Middle Ordovician shales are quarried for decorative stone, exported all over the world. ENKC's bathroom floor is made of it! But it is also the source of giant trilobites, which were the object of our visit. There are at least 15 species of these, mainly belonging to normal-sized genera, and some are truly huge (~80cm). These are to be seen round the cutting shed, but the best ones, including quite fabulous clusters, are displayed in the admirable on-site museum. The quarry owner, **Manuel Valério**, does not sell specimens, nor allows them to be sold; they are retained for science. What a wise man.

Our enthusiastic guides **Artur Sá** and **Juan Carlos Gutiérrez Marco** had prepared for us a fine field guide with colour photographs (1), including many showing the specimens in the Museum; it was possible also to buy a more extended treatment (2) by Artur Sá and Juan Carlos Gutierrez Marco, published by the quarry authorities. We spent the rest of the morning looking at the specimens in the Museum. Then came a fine Churrascada barbecue lunch in the open air, close to a new plaque honouring the occasion, with the carved names of all the participants. What a friendly gesture! After lunch we were taken to a pile of quarried boulders from which specimens could be collected, and some fine specimens were found. Later that day, there was some further field work in Ordovician to Lower Silurian, a visit an Armorican Quartzite locality, rich in *Cruziana*, and close by, a Roman gold mine in a crush zone.

Then we were invited to the Arouca City Hall for a reception, after which we walked a short way to the new monument at the Alvarenga roundabout, a fine tall granite pillar decorated with metal versions of giant trilobites, later still an exhibition on Trilobites and Art in the Tourist Office. A port wine reception, dinner and then, for those who still had the energy, a late evening visit to a 10-18th century monastery. But why are these trilobites so large and so numerous? Now there's an interesting question, but we have not the space to debate it now.

The following day entailed a visit to other delights in the Geopark, vast waterfalls, eroded granite hills, and so much else, and then after another excellent lunch we were on our way to Toledo. Thank you, so much, to our admirable leaders, Artur, Juan Carlos and Diego Garcia-Bellido. And let us hope that the Geopark will bring many visitors to Arouca, and thereby contribute significantly to the economy. So we travelled to Toledo, with presents of port wine and trilobite-shaped biscuits, arriving in the late evening.

Toledo – this extraordinary city so rich in history and art (not only El Greco), with its narrow cobbled streets and tall houses, the great cathedral and the vast Alcazar building – was an ideal conference venue. The attractive building where the lectures took place sat on a high cliff above the river. Each delegate was provided with all that was needed, guidebooks for the remaining field days, a fine geological map of the Iberian Peninsula, caps to keep the hot sun at bay, and most particularly the splendid conference volume 'Advances in Trilobite Research' (3), a publication of the Instituto Geológico y Minero de España. The Editorial Board – Isabel Rábano, Rodolfo Gozalo and Diego Garcia-Ballido – had called for papers and posters, long in advance of the meeting. This ensured that they could be refereed, collated and printed, thus available for delegates on the first day of the conference. There are 75 short papers in this book (verbal presentations and posters) – it is a mine of information, and a 'real' publication. What a fine thing it is to have the conference volume published in time for the meeting, rather than having to wait for months or even years after the event!

We have not the space here to write an account of each paper or poster. These are all readily available in 'Advances in Trilobite Research', which any trilobitologist should have. But there were so many highlights. **Richard Fortey**'s keynote address 'Life habits of trilobites, a review' was masterly, as was to be expected. Then came many good systematic papers, describing trilobites from China, Mongolia, Russia, Paraguay, Czech Republic, the Himalayas, Iberia, Korea, and North and South America. Several valuable biostratigraphical studies were also presented here (including acritarch zonation of trilobite-bearing strata). Taphonomic works included a discussion of new pyritised, limb-bearing faunas from New York State, further strange animals from the Silurian Herefordshire (England) and Emu Bay (Australia) Lagerstätten, and there were discussions of trilobite trace fossils and palaeobiogeography. Trilobite assemblages were described from places as far afield as Argentina, Tasmania, Greenland and Norway. Evolution in some trilobite groups was considered, as were species relationships including cladistic analyses, and trilobite biology was approached from many angles. We had studies of growth and segmentation, and growth progression, and of course morphometrics. The eyes of trilobites came in for much discussion, and new methodologies described have yielded important new discoveries, leading to varied interpretations. Analysis of a tiny trilobite eye indicates that it could only have functioned in well-lit waters, the Furongian owner being planktonic. The cephalic median organ is another interesting structure, and it was well considered here also. Some trilobites aggregated in clusters, presumably when moulting, but others are found in linear strings. Were these latter inhabitants of tunnels? Probably so.

There was plenty else besides, ranging from the use of Latin terms, in a sensible attempt to tighten up our terminology, to 'magical' early descriptions of trilobites long before the scientific era. It is cutting-edge research, and it is all set out in the conference volume. Surely each of us can benefit from spending the occasional spare ten minutes reading one or other of the papers. It is quite evident that despite limited funding and a general global undervaluation of palaeontology, there is life in those old trilobites yet, and no lack of keen people to study them. Including many young people, we are very glad to say.

An obvious high point was the conference dinner in the evening of 20th June, which was set in a great, elegant underground hall, and truly excellent. But there was more to come; the Mid-Conference field trip devoted to Ordovician trilobites and trilobite ichnofossils from the Toledo Mountains. These well-preserved faunas were described in Isabel Rábano's classic monograph of 1989 (4), and often the trilobites are complete. We were taken by bus and lorry to a dried stream bed under the hills; here a great quantity of shale had been dug out specially for us, yielding not only trilobites but many other fossils (the bivalves have been described in 'Palaeontology' by Claude Babin and Juan-Carlos Gutiérrez Marco). The fine guidebook, by Isabel and Juan Carlos (5), is another delight, with coloured pictures of the fossils, and eminently useful. On the way back to Toledo, after a late lunch, we saw a house of which the stone walls were composed of *Cruziana* ichnofossils, and we were treated to a show of traditional Spanish dancing, laid on specially for us.

The final day of the conference was mainly devoted to posters alone, very sensibly untramelled by anything else, and in a different building. Finally **Jon Adrain** spoke on his Global Species Database, and updated us on the new *Treatise* of which he is taking over as editor; and the official meeting came to an end. And now our Czech colleagues have agreed to run a Fifth International Trilobite Conference in Prague, in 2012. Something to look forward to!

But there was still the post-Conference field excursion to Illueca, in the province of Zaragoza in NE Spain. And we were given yet another admirable guidebook (6) by **Eladio Linan** and several other colleagues, who accompanied us in the field. We were accommodated in an ancient restored castle, set on a rock high above the town – the birthplace of one of the Avignon popes. From this marvellous centre we visited, on two successive days, Lower and Middle Cambrian localities in the Iberian Chains – the two localities of Jarque and Murero. These localities are classic; they have been intensively researched and were unforgettable, beautifully situated in field and forest. The trilobites were deformed, at least to some extent, but impressive, and very abundant.

So, leaving this delectable place, the coach took us back to Madrid, and it was time to go home. We are immensely grateful to the organisers and field leaders for such a wonderful conference, brilliantly organised, socially positive, and altogether excellent. Our profoundest thanks are due to our Spanish and Portuguese colleagues and to the presenters, who gave us so much to think about. We hope to see you all in Prague in 2012.

Euan Clarkson *(Edinburgh)*

Brigitte Schoenemann *(Bonn)*

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The Paleobiology Database Summer School in Analytical Paleobiology

University of California, Santa Barbara *23 June – 29 July 2008*

This Summer I was fortunate enough to be awarded a place on the Paleobiology Database Summer School in Analytical Paleobiology. The five week intensive course, running from 23rd June to 29th July, was held at the University of California's National Center for Ecological Analysis and Synthesis (NCEAS) in Santa Barbara, and was supported by NESCent, the Palaeontological Association, the Paleontological Society and the Society of Vertebrate Paleontology, this funding covering the cost of both accommodation and travel for all students.

The course is open to applications from undergraduate and postgraduate students undertaking research in any area relating to palaeontology, with particular encouragement given to international and female students. This year 12 candidates were selected, comprising students from Argentina, Britain, Chile, Ireland, New Zealand and the USA. The course was broken into five modules which lasted five days each with an initial three-day introduction to programming and statistical concepts led by John Alroy. The typical format was lectures and discussion sessions every morning followed by R-based programming labs every afternoon.

The first module was Community Paleoecology with **Tom Olszewski** (Texas A&M University). This module was comprised of lectures in the mornings, followed by discussion sessions, and in the afternoons we used the programming language R for applying the techniques we had covered each morning on datasets downloaded from the Paleobiology Database (PBDB). On the first day with Tom we covered transformations, standardizations, and assessment of similarity with community type data. On day two we focused upon matrix algebra and principal components analysis, on day three we looked at the applicability of correspondence analysis and non-metric multidimensional scaling and on day four we covered cluster analysis. The final day of the course was reserved for completion of an individual presentation designed to illustrate the power of the techniques for data analysis we had learnt over the previous four days. We gave our presentations to the rest of the group on the afternoon of the final day.

The second module was Diversity Curves with **John Alroy** (NCEAS). Again, each morning we were involved in lectures and discussion sessions and the afternoon activities were R-based labs using datasets downloaded from the PBDB, followed by presentations given by all of the students to the rest of the group. On day one we covered taxon counting methods and proposed diversity measures. On days two and three we looked at sources of error in diversity data and measures, specifically focusing upon counting methods biases. On day four we covered survivorship analysis and turnover rates and the historical background of these topics. On the final day of John's module we focused upon timescales and biochronology.

The third module was Geometric Morphometrics with **Mark Webster** (University of Chicago) and comprised lectures in the mornings and labs in the afternoons using tpsDig, Scion Image and R. On day one Mark covered the basics of geometric morphometrics with lectures on data acquisition, imaging specimens, landmarks and the theory of shape. On day two we focused on differences in shape between configurations, superimposition methods and allometry; looking specifically at the importance of allometry, how to identify allometry and how to describe ontogenetic shape change. On day three we covered comparisons of ontogenetic trajectories, comparisons of trajectories of shape change and the removal of the effects of allometry. On the final day, the lecture series finished by answering evolutionary questions with geometric morphometrics; such as, disparity, evolutionary modifications to ontogeny and developmental modularity and integration as an evolutionary constraint.

The fourth module was Phylogenetics with **Peter Wagner** (Smithsonian Institution); the format was much the same as the previous three modules with lectures in the mornings and labs with group discussions in the afternoons. On day one Pete started the module with a general outline of phylogenetics, and later moved on to writing cladograms, parsimony optimisation, and parsimony and probability. On day two we continued with parsimony and probability, focusing on likelihood and Bayesian models and taxon sampling. On day three we looked at rates and character structure, character compatibility and inferring phylogenies with compatibility. On day four we focused on evaluating the fossil record with model phylogenies using consistency and gap metrics and relationships between sampling and tree base sampling metrics. Later that day we covered stratocladistics and confidence interval sieving, and on the final day Pete finished the module by focusing upon tree shape, clade shape metrics and identifying rate shifts.

The final module was Phenotypic Evolution with **Gene Hunt** (Smithsonian Institution); again we had lectures in the mornings and labs in the afternoons, on the second day we were instructed to start work upon a project that was to be done in pairs and with a presentation to be given to the rest of the group on the afternoon of the final day. This presentation was not module-specific, and we were encouraged to use any of the skills we had acquired over the previous five weeks. On day one of the final module Gene focused upon evolution on an adaptive landscape, the quantitative genetic basis of traits, decomposition of the phenotype, natural selection and genetic drift. On day two we covered modes of evolution in fossil sequences, tests with a null random walk and modes as statistical models. Gene also gave a refresher on likelihood, which then led us on to likelihood analysis of evolutionary modes. On day three we looked at punctuations, rates and trends. This consisted of a review and extension of maximum likelihood models. We then moved on to punctuations and other heterogeneous models, rates of evolution and evolutionary trends within lineages. On day four we focused upon trends within clades and phylogeny-based methods, phyletic trends and extinction and origination trends. On the final morning we covered phylogenetic comparative methods, discrete traits, Markov models, threshold models, ancestral states and model testing. In the afternoon we gave our presentations in pairs; it was an excellent opportunity for us to reflect on the previous five weeks, as the presentations were a diverse mixture of the techniques that we had been taught from each of the different modules.

We had a total of eight days off in 5½ weeks, and as many of us were students from outside of the US we took the opportunity to explore some of the natural beauty of California. We quickly organised a two-day road trip to Yosemite National Park to see the giant sequoia trees and do some horseback riding. We travelled to the Channel Islands for a spot of whale watching and camping, and naturally we found the time to explore the Foxen Canyon grape-growing region to try a little of one of California's most famous exports, wine!

Half of the group in front of Half Dome, Yosemite

This course was an excellent opportunity to meet some of the most prominent scientists in the field of palaeobiology on a personal level, with hands-on instruction in some of the most state-of-the-art statistical techniques, but it also was really great to meet and learn with other PhD students from the international scientific community. The small size of the group allowed for learning at a level that was appropriate for all of us and enabled us to get to know each other very well, which certainly helped with group discussions and presentations. Being a PhD student in the UK there is little opportunity to take classes past the Masters level, and this course is an experience unlike any you can find in the UK. All of the instructors on the course were extremely helpful and approachable, and all of the modules were very interesting, well organised and highly useful for palaeontology students of all levels of mathematical competency.

For any students who are just embarking upon a PhD in a field related to palaeontology I would wholly recommend applying to this course. It was a fantastic experience and has totally remodelled me from a student who was always rather nervous of numbers and statistics with very little programming experience into someone who now feels they have a solid knowledge base of the statistical techniques and programming ability necessary for a career in scientific research!

Tracey Aze
University of Cardiff

The Last Supper? [photo Daniel Thomas, with assistance from Leonardo da Vinci]

'Fossilized Ontogenies' Symposium at the second meeting of the European Society for Evolutionary Developmental Biology

Ghent *30 July 2008*

In 'The Shape of Life', Rudy Raff (1996, 286–289) stated: 'since so much of evolutionary history is recorded in the fossil record of extinct species, a study of the development of extinct forms would be highly desirable.' A recent symposium entitled 'Fossilised Ontogenies' I organised at the second meeting of the European Society for Evolutionary Developmental Biology ('Euro Evo Devo') explored precisely this desire. Here I report on this symposium, acknowledging the support of PalAss for it and hoping that *Newsletter* readers find something of interest in it.

The symposium took place on 30th July 2008 in the historical town of Ghent in Belgium, within a meeting which hosted 420 participants from 28 countries. Several additional symposia and talks were of palaeontological relevance, such as one on segmentation. The complete programme and abstracts can be read at <**http://evodevo.eu/conferences/2008/**>. The next meeting is scheduled to take place in Paris in 2010.

The first symposium section included three contributed talks about 'fish'. **France Charest** and **Richard Cloutier** (Québec) talked about 'Medial fins modules in osteichthyan fishes – ontogenetic and phylogenetic patterns'. France showed conservatism in fin developmental ossification sequences in a comprehensive series of the rainbow trout. She contrasted these with a large data set of growth series of fossil osteichthyans showing a mosaic of conserved and variable patterns. **Richard Cloutier** followed with his talk entitled 'Developmental patterns and processes in a Devonian osteolepiform fish'. A series of works have been conducted on the growth stages of *Eusthenopteron* by previous authors, such as Stensiö, Schultze and Cote *et al*. Cloutier examined extensive series of appendicular and axial elements of this taxon, identifying the direction of ossification in different regions of the body and commonality with living actinopterygians in the developmental modules. But there were also differences in paired and median fins and thus the preservation of ontogenetic patterns not found in living species. Lance Grande, Andrew Smith and others have suggested that fossils can provide a unique mosaic of phylogenetic characters as well as temporal and biogeographic extension of taxa (Smith 1998). Cloutier indicated that a fourth point should be added to the list: unique ontogeny!

The third talk of the section was by **Matt Friedmann** (Chicago), who could have as well been presenting (and shockingly so) at the 'saltational' symposium. He devoted his talk to a group which comprises one third of vertebrate diversity, the acanthomorph fish. Matt talked about the origin of the asymmetric skull of flatfishes or Pleuronectiformes, characterized by having both eyes placed on one side of the head. Goldschmidt (1933) had stressed the lack of 'intermediate forms' in evolution and suggested the mammalian middle ear and pleuronectid fishes as examples. Concerning the former, the growing record of Mesozoic mammals does provide intermediates (Luo 2007). Now Friedmann (2008) has reported on fossil forms which are pleuronectid intermediates. The presented fossils were adults and not juveniles, so actually no 'fossilised ontogeny' in the sense of this symposium was discussed, although the singular fossils provide a beautiful comparison to the developmental data available from these animals (Okada *et al.* 2001). What these intermediate forms were doing with half migrating eyes remains a mystery.

For the 'invited' part of the symposium, some 70 people attended a series of six talks. **Phil Donoghue**'s (Bristol) main message on his subject of 'fossilised embryos' was that 'we know even less than we thought we knew'. Sounds pessimistic, but defining the boundaries of what we know is certainly fundamental. The beginning of particular attention to fossil embryos was traced to the 1994 paper by Zhang and Pratt and since then many other contributions have appeared. The use of synchrotron technology has brought a breakthrough in permitting the examination of minuscule fossils at the cellular level. The taxonomic and phylogenetic coverage of fossil embryos is very limited, and to cite the work of Donoghue and colleagues "described fossils are a complex melange of biological and mostly diagenetic (geological) features" (Gostling *et al.* 2007). The study of taphonomical processes has provided evidence of what embryological stages can be preserved, for how long, and under which conditions these mostly Cambrian organisms lived. These studies and re-evaluations have brought greater humility – but also well-based hope on what can be achieved.

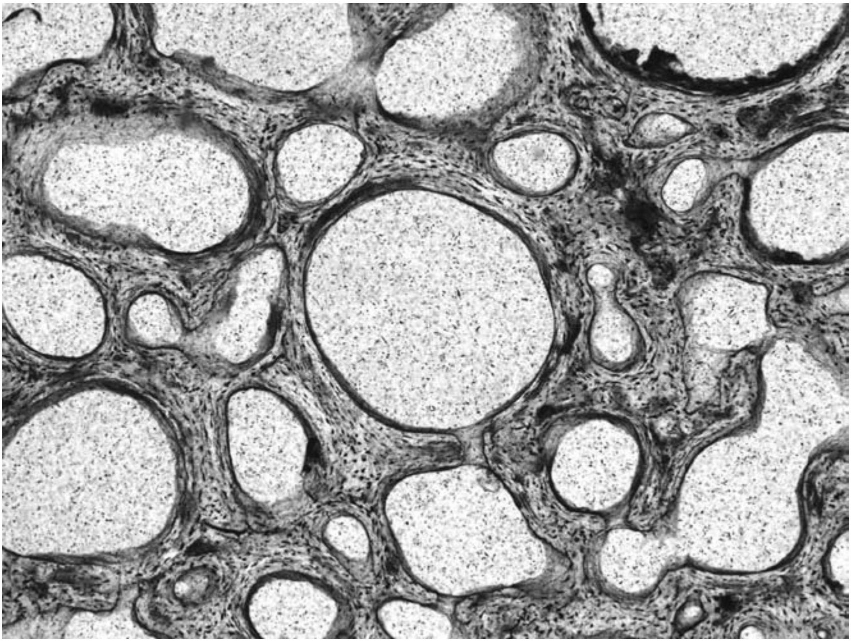
Charles Wellman (Sheffield) gave the only palaeobotanical talk in the symposium, but the meeting in general was rich on botanical subjects. Charlie presented the different lines of evidence examined to test alternative hypotheses for the origin of alternation of generations in land plants. Fossils permit one to trace the ontogeny of spores, as shown by Taylor *et al.* (2005), for plants preserved in the ~400 Ma Rhynie Chert. He summarized previous discoveries of phenomenal preservation of gametophytes of early land plants from the Devonian. With his talk, Charlie demonstrated that studies of fossilised plant ontogeny go beyond the examination of growth rings in wood and that exceptional preservation of gametophytes permits the addressing of fundamental questions on life history evolution.

Nigel Hughes (Riverside) talked about trilobites, while demonstrating with his accent his British roots and with his lively shirt his current Californian residence. Trilobites are a great subject of study because of their diversity and the variation in the number of segments in the trunk, preserving complete evidence of modes of growth. Some trilobite groups exhibit stable numbers of segments, other are highly variable. Achtung! Variation is key to evolvability and evolvability should be, according to some, what evo-devo is about (Hendrikse *et al.* 2007). Trilobites are being used to address a series of fundamental questions: is there declining plasticity across time? (for Nigel's trilobites the answer is apparently yes); is the parallel occurrence of some patterns responding to a 'homologous underlying organiser'?

Severine Urdy (Zürich) discussed the common generative rules among mollusc shells, which because of their accretionary growth present a great model to study ontogeny in fossils. These rules and teratological specimens clearly show the significant co-variation in shell characters. The significance of covariation and modularity and the like for systematic studies of morphology are a growing field of interest (González-José *et al.* 2008). Urdy and colleagues' experiments of raising a living gastropod species and quantifying variation in growth trajectories have important implications for fossils as well – much variation was found, with scary taxonomic implications, and this provided an experimental confirmation of predicted covariation patterns.

Johannes Müller (Berlin) presented a multi-authored paper on amniotes and their vertebral counts. The importance of looking at extinct phenotypes to figure out developmental and evolutionary processes is exemplified by the study of the lower temporal arcade evolution in amniotes, with its implications for the controversial turtle origins (Müller 2003). He started by expressing sincere envy of those working on well-preserved fossil 'amphibian' ontogenies, and provided examples of the contrasting relatively scarce direct record of amniote fossilized development. But there are a lot of fossil amniotes since they appeared around the Upper Carboniferous some 320 Ma, and their diversity is being used by us to examine the evolution of vertebral counts and with that of somitogenesis patterns in extinct forms. There are no universal rules governing segmentation in amniote organogenesis, and the fossil record shows patterns that we would not have seen based on living species alone (*e.g.*, a reduction in vertebral numbers characterizes armoured forms). The next two talks showed how histology of fossil amniote bones can serve in the study of extinct ontogenies.

Torsten Scheyer (Zürich) presented a series of examples in studies of function and phylogeny during growth and skeletochronological studies. These included the histology of turtle shells, of crocodile osteoderms, and of ichthyosaur humeri from the Triassic site of Monte San Giorgio in Southern Switzerland. A remarkable finding in the shell of placodonts was 'postcranial fibro-cartilaginous



Histology is a major subject of study in developmental palaeontology. Here a section of the plastron of the turtle Ptychogaster *sp. (Lower Miocene, Germany). Photo courtesy of Torsten Scheyer.*

bone', unknown to occur in any other amniote osteoderms or armour plates (Scheyer 2007). Another example of fossils showing developmental patterns unregistered in living forms.

Martin Sander (Bonn) reported on the postnatal ontogeny of sauropod dinosaurs. Interest in these animals is obvious, as they were the largest terrestrial animals ever. The histological record of humeri and femora has been used by Sander and colleagues to examine if large sizes were achieved via an increase in growth rate or by an extension of growth and to study metabolic rates. The large Jurassic forms, potentially endotherm, apparently grew fast, and certainly faster than more basal species of the clade. The *Mamenchisaurus* growth curve shows an increase of two tons per year as the

Exceptional preservation of growth series permits studies of allometry in gross and micro-morphology. Here humeri of the Middle Triassic ichthyosaur Mixosaurus *sp. from Monte San Giorgio, Switzerland. Photo courtesy of Torsten Scheyer.*

maximal rate of growth in these animals – a remarkable metabolic accomplishment! Some species show developmental plasticity and even different ontogenetic 'stages' can be recognized based on different kinds of bone histology within a species. Mein Gott! So much to study, so little time.

Zerina Johanson (London) talked about placoderms, that group close to the basal node between jawless and jawed vertebrates. Growth stages of *Cowralepsis mclachlani* preserve portions of the branchial skeleton which because of their topographical relations to hypobranchial musculature and late ontogenetic occurrence are significant – illustrating potential embryonic origins from neural crest and the formation of vertebral elements. Apparently the Merriganowry quarry in New South Wales contains thousand of layers in fined grained shales containing many placoderms – and the expectations for preserved ontogenies are high. The antiarch placoderm *Bothriolepsis* had been the subject of previous studies by R. Cloutier and others thanks to hundreds of well-preserved specimens. It seems that basal vertebrates will continue to be a rich subject of ontogenetic studies of fossils.

In another contributed session, a mammal and a crustacean talk ended the symposium. **Rob Asher** (Cambridge) talked about how delayed dental replacement appears to provide yet another morphological synapomorphy for afrotherian mammals. Preserved ontogenies can be used as systematic characters. His recent work on the potential coupling of morphological features including particular dental eruption patterns, vertebral numbers and clavicles is relevant for the consideration of phylogeny and evolution of living and fossil mammals (Asher and Lehmann 2008). **Caroline Haug** (Ulm) reported on Early Devonian crustaceans from the Early Devonian Rhynie locality (Windfield Chert) in Aberdeenshire. Three-dimensional models of fairly complete fossils show remarkable anatomical details of rarely preserved crustacean larvae.

Raff (1996:269) stated: "Despite the impossibility of doing genetics on defunct animals and the difficulties in approaching development when only static objects are preserved, a great deal of information on reproduction and development can in some cases be reclaimed from fossils." The symposium in Ghent was just a small window of the great potential for the realization of the idea expressed by Raff.

Like much in palaeontology or in science in general, current trends have historical roots or analogous developments in the past. Great palaeontologists have also been great comparative ontogenists, from T. H. Huxley in late Victorian times to O. Rieppel today. Studying fossil ontogenies is a great opportunity for palaeontologists to contribute to the most integrating field in Evolutionary Biology, call it Evo-Devo or whatever you wish. This is something which should surely contribute to our understanding of the evolution of organismal form.

I thank Torsten Scheyer and Massimo Delfino, the 'Fonds zur Förderung des akademischen Nachwuchses (FAN) des Zürcher Universitätsvereins (ZUNIV)' the Swiss National Fond and especially PalAss for support. I also apologize in case I misrepresented here the work of any of the colleagues who kindly agreed to participate in this symposium.

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Palaeozoic Climate Conference

Université Catholique de Lille *22 – 31 August 2008*

The last week of August saw over 120 scientists from over 20 countries convene in the beautiful surroundings of Lille’s Catholic University, France, for a week-long conference on Palaeozoic climates. This acted as the closing meeting of IGCP 503 – “Ordovician Palaeogeography and Palaeoclimates”. However, rather than limit the conference to the subjects covered under IGCP 503, it had been decided to open up the conference to all aspects of Palaeozoic climates.

The conference proper was preceded by a fieldtrip focusing on the Lower Palaeozoic of Belgium. It was led by **Jacques Verniers** (University of Ghent) with the help of **Thijs Vandenbroucke**, **Jan Vanmeirhaeghe** and **Jan Mortier** (all from Ghent, Belgium), and concluded with a legendary multi-course banquet, which became one of the main topics of conversation for the first couple of days of the conference.

After the opening remarks, **Robin Cocks** (Natural History Museum) started the conference with a keynote lecture on Ordovician and Silurian geography. He alleged that “Some see palaeogeography in the Cenozoic as a science, in the Mesozoic as a pseudo-science and in the Palaeozoic as science fiction". However he then proceeded to demonstrate how the lower Palaeozoic was dominated by the vast Panthalassic Ocean and to describe in great detail the evolution of Armorica, Gondwana and Baltica and Siberia through this period, and how they moved and interacted. After a break for coffee and posters came the session on Cambrian–Ordovician palaeogeography and palaeoclimate. First, **Françoise Debrenne** described the global distribution of Archaeocyaths and how their distribution is linked with a discrete shallow marine facies. **Anna Gandin** (Universitá Degli Studi di Siena) elaborated on this picture by describing how microbial-archaeocyath communities may have not just been limited to warm waters but cool deep water settings too. Then **Andrei Dronov** (Russian Academy of Science) discussed the Ordovician depositional sequences of the Siberian Craton. The session was brought to an end by **Steve Kershaw** (Brunel University) who considered the link between the occurrence of microbialites and shifts in marine $\delta^{13}C$. He also pointed out the link between great mass extinction events such as the Permian–Triassic Boundary and the abundance of microbialites; suggesting that their formation may link to ocean stratification and changes in atmospheric CO_2.

Then came lunch which, for those of us who had not opted for the provided lunch, meant searching out a bar for alarmingly large baguettes served with the obligatory glass of red wine. The afternoon was concerned with Ordovician biodiversity and geochemistry. **Dave Harper** (University of Copenhagen) gave a keynote lecture on the links between the great Ordovician biodiversification event and changes in ocean circulation. This was followed by talks on the pulsed diversification of Ordovician cephalopods (**Bjorn Krogen**, Université des Sciences et Technologies de Lille); falls in temperature in the Late Ordovician observed in Baltic basin benthic communities (**Sergey Rozhnov**, Paleontological Institute RAS); and late Ordovician echinoid lagerstätten from Morocco (**Bertrand Lefebvre**, Université de Lyon).

The last two sessions of the afternoon continued on these themes with talks on palaeogeographic controls on blastozoans in the Early Palaeozoic (**Elise Nardin**, Université de Lyon); the link between Ordovician palaeogeography and acritarch microplankton biodiversity (**Stewart Molyneux**, British Geological Survey) and the links between palaeogeographic change and brachiopod communities in western Gondwana (**Jaime Reyes-Abril**, Universidad de Zaragoza). The final three talks of the day were concerned with geochemistry and were started by **Florentin Paris** (Université de Rennes), discussing the various laboratory and source biases affecting $\delta^{13}C_{org}$ values in Palaeozoic marine sediments. This was followed by **Leho Ainsaar** (University of Tartu) talking on using $\delta^{13}C_{org}$ to refine stratigraphy in Baltoscandia. Finally, **Oliver Lehnert** (University of Erlangen-Nürnberg) tracked changes in $\delta^{18}O$ through the lower Silurian linked to the Ireviken event.

The day was rounded off by the icebreaker (which turned out to be the first of three, due to the fact that the beer was not finished on the first night!). Conversation ranged freely from discussion of faunal and floral movements in response to changes in climate; to detailed analysis of the validity of different isotope techniques. All lubricated by bottles of 'La Vauban Cubée Spéciale," a beer especially brewed by students for the conference.

The second day was concerned with the Late Ordovician and Silurian, and started with a keynote by **Jean-François Ghienne** (Ecole et Observatoire des Sciences de la Terre) on using a sequence stratigraphical approach to reconstruct the Late Ordovician Glacial record. This was followed by

Su Wen-bo (China University of Geosciences) reinterpreting the depth of the Yangtze Platform of South China based on *in situ* crinoid holdfasts, and **Martin Keller** (Geozentrum Nordbayern) on the link between increases in volcanic activity and the formation of karsts and by changes in glacial/non-glacial successions. After coffee the climate theme shifted to the Late Ordovician. **Lesley Cherns** (Cardiff University) suggested that there is a periodicity in cooling events throughout the early Palaeozoic, and that the lack of glacial evidence in the early-mid Ordovician is linked to a lull in these cycles. Next **James Wheeley** (University of Birmingham) argued that the appearance of high-latitude limestones in the Ordovician Boda interval does not have to mean that these were warmer-water sediments. **Dimitri Kaljo** (Tallinn University of Technology) discussed the issues related to understanding timescales associated with the Hirnantian event, and **André Desrochers** (University of Ottawa) presented his findings from a fantastic ~200km long belt Lower Silurian outcrop on Anticosti Island, from which Milankovitch, climatic and eustatic cycles can be identified.

Following lunch, **Mikael Calner** unfortunately had to withdraw his talk; however, **Alan Owen** (Glasgow University) stepped into the breach (or at least up to the rostrum) with a talk he just happened to have on his memory stick! He proceeded to regale us with the complexities of Ordovician cyclopygid faunas. **Peter Sheehan** (Milwaukee Public Museum) followed by discussing the fact that the macrofauna of western Laurentia show a long delay in recovery from the Ordovician extinction event. This he linked to physical properties in the off-platform environment. He also drew attention to the fact that after the K/T event there is evidence for large lake formation linked to plant die off and landscape destabilisation. This was followed by **Aicha Achab** (Centre Eau Terre Environnement) who discussed how chitinozoans have been used to correlate the lithologies at Anticosti Island to the global stratigraphy, and **Aurélien Delabroye** (Université de Lille) used new palynological investigations to support the theory that the Hirnantian event may be more due to faunal turnover rather than a mass extinction.

The final session of the day was dedicated to the Silurian world and was started by **Brad Cramer** (Ohio State University) who showed how it is possible even in the Silurian – through the integrated use of conodont, graptolite, and carbon isotope $\delta^{13}C_{carb}$ stratigraphy – to get sub 500,000 yr resolution even in the Palaeozoic. This was followed by a mesmerizing talk by **Stephen Meyers** (University of North Carolina) on using the average spectral misfit method (which he created) to recover Milankovitch cycles from Silurian isotopic records. The rest of the session included **Vincent Perrier** (Université Claude-Bernard Lyon) presenting some beautifully preserved Silurian ostracods which he demonstrated were free swimming above a dysoxic bottom. **Fan Junxuan** (Chinese Academy of Sciences) examined the graptolite recovery after the Late Ordovician extinction. Finally, **André Desrochers** (University of Ottawa) again discussed the glacio-eustatic fluctuations in the Lower Silurian observed in the superb coastal and river exposures on Anticosti Island.

Wednesday saw the climax of the conference. It was kicked off by **Yves Goddéris** (Laboratoire des Mécanismes et Transferts en Géologie) who drew attention to the links between continental drift and CO_2. Using computer modelling he tested the link between atmospheric CO_2 and continental configuration via continental silicate weathering feedback. From this he predicted that times of 'super continents' would produce increased atmospheric CO_2 through weathering and the opposite in periods of continental breakup. **Matt Saltzman** (Ohio State University) continued the over-arching Palaeozoic theme by discussing the causes of $\delta^{13}C$ positive anomalies in the Early Palaeozoic and how they reflect changes in the carbon cycle. He noted how large positive excursions are common during cool periods but rare during established greenhouse climates. He linked this to fixing of nitrogen and its link to productivity. This was followed by talks from **Thijs Vandenbroucke** (University of Leicester) on ground truthing models of Ordovician climate using chitinozoan and graptolite distribution, and **Vincent Lefebvre** proposing that the cause of the Late Ordovician glaciations may hypothetically be due to trap volcanism, although he concedes that no field evidence has yet been found.

After lunch **Michael Joachimski** (University of Erlangen-Nuremberg) continued with a comparison of $\delta^{18}O$ values from conodonts and brachiopods, and what they can tell us about ice build up. He noted that there is often an offset between brachiopod and conodont isotopic composition which

he proposed is due to some brachiopods forming their skeleton out of equilibrium with ambient sea water. This was followed by **Zivile Zigaite** (Université de Lille) presenting the first $\delta^{18}O_{apatite}$ curve from a Pridolian section in the eastern Baltic Basin, indicating a cooling event in the middle Pridoli. **Blaise Videt** (Université de Rennes) presented the first eustatic variation chart for the Silurian of northern Gondwana, and **Domenico Lodola** (Neftex Petroleum Consultants Ltd.) explored the close link between the timing of maximum flooding surfaces and warming periods, and between sequence boundaries and cooling periods.

Finally **Arnie Miller** (University of Cincinnati) convinced us of the importance of the role of epicontinental seas in explaining the dichotomy between ocean facing and epicontinental fossils

in the Palaeozoic and post-Palaeozoic (partially through the cunning ploy of free fridge magnets!). This was followed by the conference meal, which took place at the Dubuission Brewery in Belgium. Before the meal we were treated to a brewery tour given by a highly enthusiastic tour guide. Then, with our meal, we were treated to five different beers, including a cherry beer and *Bush Ambrée*; apparently the strongest beer in the world at a mind numbing 12%!

The last two days of the conference were dedicated to the Devonian, Carboniferous and Permian. **Charlie Wellman** (University of Sheffield) gave the first keynote lecture, on the evolution and diversification of early land plants and how this would have had a dramatic effect on climatic systems. He emphasised that even though the first land plants emerged in the Mid-Ordovician it was the major diversification in the Silurian which would have had most impact on climate, especially the increased terrestrial carbon burial caused by complicated terrestrial ecosystems. **Marco Vecoli** (Université de Lille) emphasised this point by noting how high-latitude Silurian $\delta^{13}C_{org}$ values record inputs of terrestrial-derived organic matter and microspores in marine sections. **Amalia Spina** (Université de Lille) showed how this early plant diversity changed through the Silurian–Devonian through the use of palynology.

After a much-needed coffee break to disperse any after-effects of the previous night's cherry beer, presentations moved on to the Devonian. **Laurent Riquier** (Université de Lille) discussed environmental change across the Frasnian–Famennian boundary, linking them to enhanced continental weathering and reduced ocean circulation. **Sandrine Le Houëdec** (Université Paris Diderot) showed that new Sr/Ca and $\delta^{18}O$ data from conodont elements suggest a glaciation across the Frasnian–Famennian boundary. **Vincent Lefebvre** (Université de Lille) used modelling to postulate a link between the closure of equatorial seaways linking Prototethys to Panthalassa and the climatic variation recorded across this event. Finally, **John Marshall** (University of Southampton) discussed the variation in extensive paleosol sequences from East Greenland and how they relate to precession cycles.

After lunch the focus shifted to Devonian biotas. **Christian Klug** (Universität Zürich) discussed the fact that although the Devonian signalled a decline in overall diversity, it was also a time of ecological fluctuations such as the establishment of land plants and jawed fish. This dichotomy in the marine realm may have been driven by the diversity-saturated benthic habitats as well as the availability of rich planktonic food resources. Then followed **Vincent Dupret** (Université des Sciences et Technologies de Lille) who put forward evidence for the proximity of Gondwana and South China in the Early Devonian based on basal arthrodire placoderms. **Cédric Mabille** (Université de Liège) emphasised the links between ramp clastic evolution and changes in sea level. **Edouard Poty** (Université de Liège) continued the investigation into carbonate ramp formations, noting that the Frasnian–Famennian event is observed in Belgium, but it is linked to a maximum flooding surface rather than an atmospheric cooling event. **Johnny Waters** (Appalachian State University) re-evaluated Late Devonian echinoderm taxonomy and discovered that they rebound faster than previously thought. **Jean-Georges Casier** (Royal Belgian Institute of Natural Sciences) suggests that the negative carbon isotopic excursion linked to the Late Frasnian event is only recorded in brachiopods and not ostracods from across the event. **Esperanza Fernández-Martínez** (University of León) tracks how tabulate coral diversity decreases after the Upper Zlichovian event. The final presentation of the day was given by **Bruno Mistiaen** (Université Catholique de Lille) who showed the link between expressions of growth periodicity caused by seasonal changes in fossil corals and latitude. He then proposed fossil corals as a palaeolatitudinal indicator.

By Friday the many days of discussion and good food had taken their toll. **Johnny Waters** (who was chairing the first session) likened it to the Palaeozoic itself: after a burst of diversity in the Ordovician, by the Permian only the most resilient delegates had survived! The final day's talks focused on the Carboniferous and Permian. **Alberto Pérez-Huerta** (University of Glasgow) discussed the onset of the glaciations in the mid-Carboniferous and the transition towards the Permian "greenhouse state". He encouraged us to "think outside your period" when looking for explanations of climate change, and compared the similarities between Late Carboniferous and Late Ordovician climatic events. Then **Edouard Poty** (University of Liège) enlightened us about the link between global climate and sea level change in the Lower Carboniferous. The final talk of the session by **Eric Armynot du Châtelet** (Université des Sciences et Technologies de Lille) investigated the minimum sample size needed to produce an accurate palaeoecological interpretation for foraminifera. He emphasised the need to use a large sample size otherwise sampling bias will affect the results.

The final two talks of the conference were concerned with the Permian. **Marco Roscher** (TU Bergakademie Freiberg) used palaeoclimatic models, ground-truthed with climate sensitive sediments, to investigate the climate of Pangaea. He focused on variation in the monsoon and wind patterns across the supercontinent. He also argued that climate models must always be tested against what is known from the sedimentological record. Finally, **Tim Kearsey** (University of Plymouth) brought the conference right up to the Permian/Triassic boundary, discussing changes in temperature, climate and CO_2 from paleosols in the southern Urals of Russia.

For those who did not have to return home there was a post-conference field trip to the Upper Palaeozoic of northern France and Belgium. This included stops at Frasnes, Couvin, Givet, Dinant and others, and was guided by **Bruno Mistiaen** and **Benoît Hubert** with the help of **Denice Brice** and **Emilie Pinte** (all from Université Catholique de Lille).

It was thought by all that the conference was a great success, and there was a general consensus that the only way to truly understand palaeoclimate changes, especially in the Palaeozoic, is by a combined approach. On behalf of all the delegates, I would like to thank **Thomas Servais** and all those from the Université Catholique de Lille and Université des Sciences et Technologies de Lille for their tireless work in organising a highly successful, and global, conference and two conference field trips. Thanks must also go to the Palaeontological Association for sponsoring the keynote speakers.

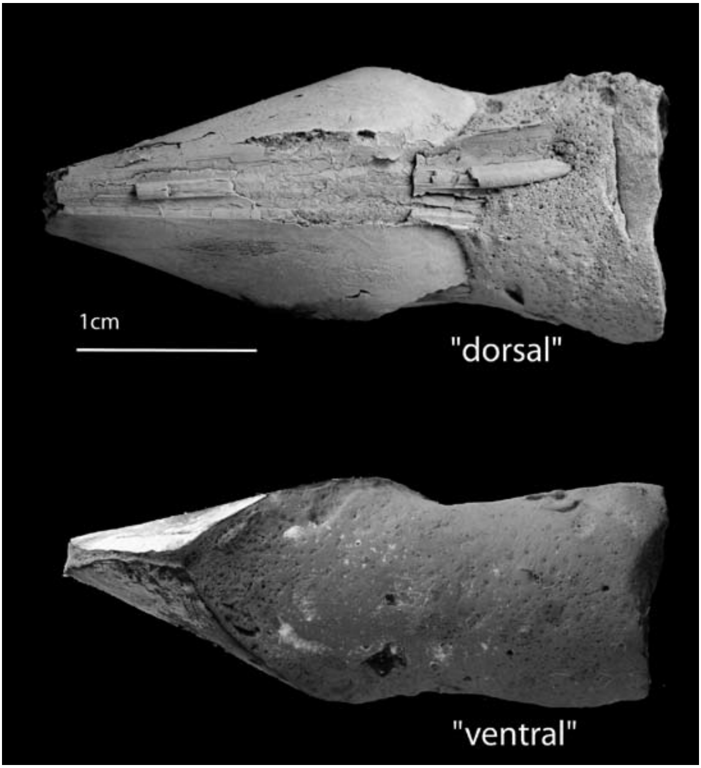
Tim Kearsey
University of Plymouth

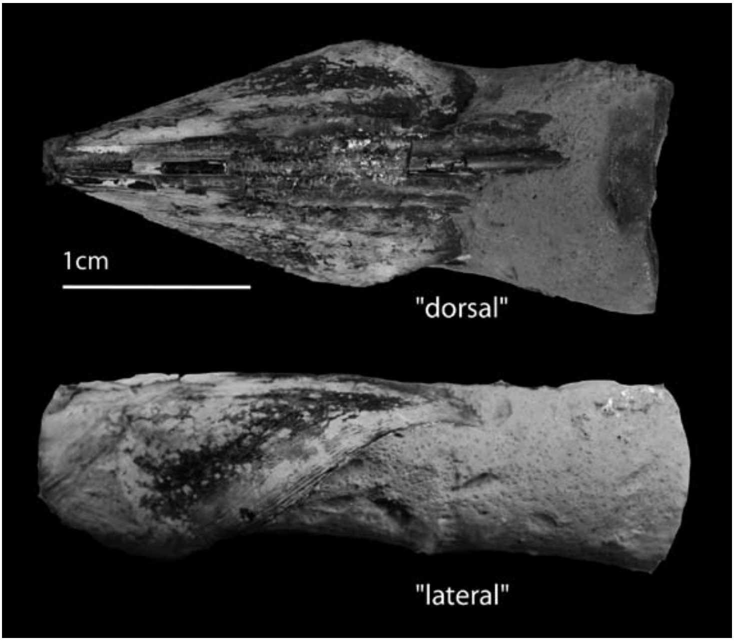
The conference abstracts are online at <**http://www.igcp503.org/pdfs/lille2008_abstracts.pdf**>.

MYSTERY FOSSIL 14

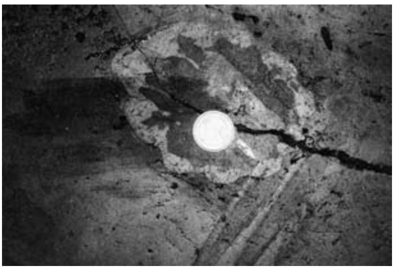
Gérard Breton (Le Havre) needs help in identifying the first mystery fossil of this issue, a fossil from the disused clay quarry of Bully (Seine-Maritime, Western Paris Basin, France). The age is Lower Albian, Bulliensis biozone. Gerard states that “it is preserved in a phosphatized nodule, the same way as the numerous crustacean remains preserved here. Of course, this shape reminds me of something, but I am quite unable to say what. Very frustrating.”

Figure 1 shows the (partly) NH_4Cl-coated specimen in two opposite views that Gerard has termed ‘dorsal’ and ‘ventral’. Figure 2 shows the same views of the uncoated specimen. The fossil is preserved at the tip of a broken phosphatic cylinder, which Gerard says “looks like the burrows found in the same beds. It is a mystery fossil for me and I would appreciate very much the help of any Pal Ass member able to let me know what this is, and so heal my frustration.”





Mystery Fossil 13 – Update



We've had few takers for Mystery Fossil 13 that Ian Rolfe photographed on the step of the Café Birreria. Gérard Breton (Le Havre) thought that perhaps it could be a rudist in cross section, but he regrets that he "has not had the opportunity to go to the Café Birreria to check".

If anybody has any thoughts on these matters, please e-mail them to <**newsletter@palass.org**>.

MYSTERY FOSSIL 15

The second mystery fossil of this issue was sent in by **James Rhys-Williams** (Bristol), and is shown below. It was found 500m east of Llantwit Majors beach, South Wales, making it Lower Jurassic in age, on the underside of an overhanging bed some 10m up in the cliff ("too high up to get a good look at"). It is quite large, with a radius of approximately one metre. The fossil is "a bit rough around the edges". Is it perhaps a trace fossil? A sedimentary or diagenetic structure? Or…?

James has already asked the Palaeontology Department of the Natural History Museum, who "had no idea…" If you think you can do better, please send an e-mail to the Newsletter Editor.

Richard Twitchett

>>*Future* Meetings of Other Bodies

The Micropalaeontological Society – Annual General Meeting 2008
University College London *19 November 2008*

The theme for this meeting, which starts at 1.15 pm, is Microfossils and Extinction. For a downloadable flyer with programme visit the Micropalaeontological Society Website at <**http://www.tmsoc.org/**>.

Antarctic Conference of Gondwanan Palaeontology
Antarctic Peninsula *19 – 30 March 2009*

The first Antarctic Conference of Gondwanan Palaeontology will be held on board the Polar Pioneer as it sails around the Antarctic Peninsula. The conference is to be hosted by Aurora Expeditions in association with The University of Queensland. Conference participants will live on board the ship for two weeks as we visit several important late Mesozoic, Paleocene and Eocene fossil localities in the Weddell Sea area, including Seymour Island, Snow Hill Island, James Ross Island, Vega Island and the Peninsula 'mainland'. For further details see the conference website at <**http://www.uq.edu.au/dinosaurs/index.html?page=79794**>.

First International Congress on North African Vertebrate Palaeontology (NAVEP1)
Marrakech (Cadi Ayyad University), Morocco *25 – 27 May 2009*

This scientific meeting is co-organized by the Faculty of Sciences Semlalia, the Moroccan Society of Herpetology, the Muséum National d'Histoire Naturelle of Paris and the Centre National de la Recherche Scientifique (CNRS, France). NAVEP1 is intended to gather palaeontologists and geologists from all over the world interested by the various aspects of vertebrate fossils from North Africa and/or neighboring regions and their palaeoenvironments. One of the major aims of NAVEP1 is to draw together the current state of knowledge of previous and current studies on North African vertebrate fossils and to promote the conservation and protection of the fossils as an integral part of the natural heritage.

Thanks to the central position of North Africa within Gondwana, and to its rich geologic history (continental drift and break-up, Tethys, Mesogea, Mediterranea), we believe that a meeting on North African Vertebrate Palaeontology represents a good forum to discuss the evolution and radiation of vertebrates in response to palaeogeographical history. NAVEP1 will welcome all research or studies dealing with the various aspects of vertebrate palaeontology from North Africa, including: anatomy, morphology, osteology, systematic, phylogeny, evolution, taphonomy, palaeoichnology, biostratigraphy, palaeoenvironments, palaeoecology, palaeoclimatology and palaeobiogeography.

For further information contact the meeting coordinator Pr. N.E. Jalil, e-mail <**njalil@ucam.ac.ma**>.

Copies of the first circular, in a variety of formats, are available from <**http://www.mnhn.fr/mnhn/mineralogie/histoire/index/congres/congres2009/**>.

Darwin in the Field: Collecting, Observation and Experiment

Cambridge, England *11 – 12 July 2009*

In July 2009, the Sedgwick Museum of Earth Sciences, University of Cambridge will open a new Heritage Lottery funded permanent exhibition titled 'Darwin the Geologist'. This will showcase many of the rocks, minerals and fossils brought back by Charles Darwin (1809 – 1882) from his travels onboard HMS Beagle.

As part of the bicentennial celebrations of Darwin's birth, we are organizing a multi-disciplinary conference focusing on Darwin's work in the field. We invite papers from earth scientists, zoologists, botanists, museologists and historians of science on some of the following suggested themes:

- Collecting practices
- Experimental / Identification practices
- Systems of naming and classification
- Theorizing using collected specimens
- Field notebooks and drawings
- Early scientific education and mentors in scientific practice
- Use of Darwin's collections and/or specimen theorizing in historical or contemporary scientific practice

If you are interested in presenting a paper, please submit a title and an abstract of no more than 500 words by Friday 23rd January 2009. For further information, please contact Dr Lyall I. Anderson, Dept. of Earth Sciences, University of Cambridge, Downing St., Cambridge, CB2 3EQ, e-mail <**land07@esc.cam.ac.uk**>.

An International Conference on the Cambrian Explosion

Banff, Alberta *August 3 – 7 2009*

We invite you to attend a special Conference on the **Cambrian Explosion** to commemorate the **100th anniversary of the discovery of the Burgess Shale by Charles Doolittle Walcott**. We cordially extend this invitation to all geologists, palaeontologists, geochemists and biologists interested in the profound organismal, ecological and environmental changes that occurred during the Precambrian–Cambrian transition. Moreover, we think that this meeting would be of great interest to historians of geology and anyone curious about the origins of animals.

For further details visit the meeting website at <**http://www.geology.utoronto.ca/facultycaron/Walcott2009.htm**>.

International Scientific and Organizing Committee (as of April 2007)
Co-Chairs:
Dr Jean Bernard Caron (Royal Ontario Museum, Toronto), <**jcaron@rom.on.ca**>
Dr Doug Erwin (Smithsonian Institution, Washington), <**ERWIND@si.edu**>
David Rudkin (Royal Ontario Museum, Toronto), <**davidru@rom.on.ca**>
Members:
Matthew Devereux (The University of Western Ontario), <**mdevereu@uwo.ca**>
Dr Stephen Dornbos (University of Wisconsin-Milwaukee), <**sdornbos@uwm.edu**>
Dr Sarah Gabbott (University of Leicester), <**sg21@le.ac.uk**>
Dr Robert Gaines (Pomona College), <**robert.gaines@pomona.edu**>
Dr Charles Henderson (University of Calgary), <**cmhender@ucalgary.ca**>
Dr Paul Johnston (Mount Royal College, Calgary), <**pajohnston@mtroyal.ca**>
Kimberley Johnston (Palaeontographica Canadiana), <**kimberley@paleos.ca**>
Dr George Pemberton (University of Alberta), <**george.pemberton@ualberta.ca**>
Dr Jean Vannier (Université Claude Bernard Lyon 1), <**jean.vannier@univ-lyon1.fr**>
Dr Xingliang Zhang (Department of Geology, Northwest University,Xian), <**xlzhang@pub.xaonline.com**>
Dr Maoyan Zhu (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), <**myzhu@nigpas.ac.cn**>

5th International Symposium on Lithographic Limestone and Plattenkalk
Basel, Switzerland *17 – 22 August 2009*

The 5th International Symposium on Lithographic Limestone and Plattenkalk will be held at the Naturhistorisches Museum Basel (<**http://www.nmb.bs.ch/**>), on 17–22 August 2009. Following the former editions (Lyon, 1991; Cuenca, 1995; Bergamo, 1999; Eichstätt/Solnhofen, 2005), we are pleased to organise the 5th conference in Basel, close to the Late Jurassic fossil localities of Solothurn and Porrentruy (northwestern Switzerland).

The symposium will consist of three days of presentations (plenary speakers, regular sessions, and posters) on 18–20 August. This multidisciplinary meeting is planned to address various aspects in the study of lithographic limestones and plattenkalk deposits, dealing with palaeontology (taxonomy, palaeoecology, taphonomy), geology (stratigraphy, sedimentology, palaeoenvironments), and also mineralogy and petrology of related Fossil-Lagerstätten.

In addition to the scientific sessions, three excursions will be organised in Germany and Switzerland:

- Frauenweiler (Germany), Monday 17th: Pre-symposium excursion to the Frauenweiler clay pit (Oligocene) famous for fossil fishes and the oldest hummingbirds co-organised by Eberhard “Dino” Frey (Staatliches Museum für Naturkunde, Karlsruhe).
- Porrentruy (Canton Jura), Friday 21st: Post-symposium excursion to Porrentruy. Several dinosaur tracksites have been discovered in sub-lithographic limestones (biolaminites) of Late Kimmeridgian age, along the future course of the “Transjurane” highway (<**http://www.palaeojura.ch/**>). In addition, many fish, turtle and crocodilian remains have been unearthed in coeval marls. Aperitif

and dinner will be offered in close vicinity of a dinosaur tracksite and footprints can be observed by night using artificial illumination.

- Solothurn (Canton Solothurn), Saturday 22nd: Post-symposium excursion to Solothurn and surrounding areas. We will visit the well-known outcrops of Solothurn Turtle Limestone (Late Kimmeridgian) and the Lommiswil dinosaur tracksite. Further, a visit is planned to the Natural History Museum of Solothurn (<**http://www.naturmuseum-so.ch/**>) where many fish, turtle and mesosuchian crocodilian remains are housed.

For further details and registration information contact Antoinette Hitz, Naturhistorisches Museum Basel, Secretary Department of Geosciences, Augustinergasse 2, 4001 Basel, Switzerland, tel +41 61 266 55 26, fax +41 61 266 55 46, e-mail <**antoinette.hitz@bs.ch**>.

International Symposium on the Cretaceous System
Plymouth, UK *6 – 12 September 2009*

The International Symposium on the Cretaceous System will be held at the University of Plymouth, on 6–12 September 2009. The conference will be followed by a number of field excursions visiting Cretaceous locations in the UK. Themes for the meeting may include: 200th Anniversary of the birth of Charles Darwin, sequence stratigraphy and sea level change, Cretaceous oil and gas exploration in the N.W. European Continental Shelf, Cretaceous stratigraphy, palaeontology, isotope stratigraphy, biotic and other events, regional geology and palaeoclimates. Papers will be solicited for peer-reviewed publication with submission of manuscripts at the meeting.

For more information contact Prof Malcolm Hart, School of Earth, Ocean & Environmental Sciences, University of Plymouth, Drake Circus, Plymouth PL4 8AA, e-mail <**mhart@plymouth.ac.uk**>, or Dr Gregory Price, e-mail <**g.price@plymouth.ac.uk**>.

For further details visit the meeting website: <**http://www2.plymouth.ac.uk/science/cretaceous/**>

Southeast Asian Gateway Evolution
Royal Holloway, University of London, UK *14 – 17 September 2009*

This major multidisciplinary meeting will focus on the geological and biological history of the Gateway region, and include discussion of geology, tectonics, oceanography, climate, biogeography and biodiversity. For details visit the meeting website at <**http://sage2009.rhul.ac.uk/**>.

The convenors are Robert Hall, Royal Holloway, e-mail <**sage2009@gl.rhul.ac.uk**>, and Ken Johnson, Natural History Museum, e-mail <**sage2009@nhm.ac.uk**>.

Please help us to help you! Send announcements of forthcoming meetings to <**newsletter@palass.org**>.

Reviewing peer-review

Peer-review is perhaps one of the most unusual aspects of being a researcher. Reviewing is a critical quality control mechanism in academic work, but it is striking how little formal training, advice, or standardization there is in reviewing manuscripts. My recollection of the conversation I had with my supervisor when I received a request to review a paper when I was a PhD student runs as follows:

> "What should I be looking for in this paper?"
>
> "Check if what the paper says is supported by the data and analyses."

This simple formula has continued to serve well over many subsequent reviews, yet it amounts to my whole formal training in reviewing. Not an admission to inspire confidence in a system that is held up to the wider world as the bedrock upon which academic knowledge is built.

This perhaps rather exaggerates the position that a first-time reviewer finds her or himself in. Reviewing a paper is an extension of the skills learned through the processes of critical reading and evaluation of published papers that form the basis of degree-level education. By the time an individual is working on a PhD, which is usually the career stage when the first review request arrives, they will have completed a couple of research projects and an extended critical review of the specialist literature in their chosen area of research. The knowledge and skills for reviewing have been amassed – it is just not made explicit that they can as easily be turned to peer-review.

However this doesn't remove the sense of importance attached to reviewing papers. Being put in the position of gatekeeper can be daunting, and I firmly believe that most researchers care about the quality and accuracy of publications in their field, regard volunteering to review manuscripts as part of their 'civic duty' in the academic community, and also regard peer-review as the best system available. They want to do a good job of providing helpful feedback to the authors of work and journal editors while trying to avoid writing a review longer than the manuscript itself.

Editors have to rely on the good will and sense of duty of reviewers to keep the peer-review system running, but often editors are also volunteers with a limited amount of time to devote to each manuscript. Editorial boards find themselves juggling issues of rejection rates, impact factors and ensuring a smooth, swift and fair review process, while not overworking referees.

This short essay will consider how new methods have been used to tackle concerns about the standardization of reviewing and what is expected from reviewers, and how reviewers' efforts might be rewarded, or at least recognized, in a research environment which is becoming ever more dominated by quantitative targets. Next the issue of the potential for bias of various types will be touched upon, along with the use of 'double-blind' reviewing to counter this problem. Finally, the new process of open review, which has accompanied the proliferation of open access journals, will be discussed.

Has online manuscript centralization produced standardization?

The shift towards online submission and reviewing seems to have had two results. A surprising outcome is that there may be more diversity and depth to reviews than in the days when a paper form and thick manuscript arrived by post. A tyranny of tick-boxes does seem to have been avoided. While many journals will have a standard set of questions for reviewers to respond to, the ability to upload material for the editor and/or authors has proved liberating. For editors, this must be an improvement to make sure that reviews cover all the important aspects of the paper for making their decisions. As document-handling programs become ever more geared towards annotating electronic documents, there is more and more scope for detailed commentary, rather than scribbling in the margins of manuscripts, and if your handwriting is as illegible as mine editors and authors will not be best pleased. From my own experience as an author this improves the usability of reviewers' comments and increases the likelihood that issues raised by reviewers will be addressed and suggestions made by reviewers incorporated into the final paper.

One development that is less welcome is the use of automated prompts from journal sites. While it is entirely reasonable for an editor to pursue a recalcitrant referee for a late review, the trend of sending reminders several days before a review is due can be intrusive – and from coffee-time conversations can undermine the goodwill of reviewers. The sending of automated, generic 'thank you' emails is also not a particularly welcome development, as they can often appear to be little more than polite spam.

A noticeable trend in the content of academic CVs is the inclusion of a list of journals the individual has worked as a referee for. A more purposeful 'thank you' for referees might be for editors to contact reviewers on some occasions with an evaluation of their review, watching the watchmen, so to speak. This would hopefully improve the quality of future reviews, and give a document that could be useful in future for job applications. Another possibility might be for a process where authors can feed back to editors about reviews.

GSA has initiated a system of recognizing outstanding reviewers by publishing a list in *GSA Today*. An article by several senior GSA editors discusses this as a means of reminding the community of the importance of a high standard of reviewing in assisting editors to publish high-quality papers in a timely manner (Geissman *et al.* 2007).

Many readers will be unsurprised that quantitative reviewing metrics have been developed, opposing factions have developed, and people have worked out how to manipulate these systems even before their use has become widespread (<**http://blogs.nature.com/peer-to-peer/2008/07/evaluation_of_the_peerreviewer.html**>). Yet in a target-driven world, where the voluntary ethic that has sustained research for so long is regarded as suspect, it seems likely that researchers will soon have to worry about their reviewing index as well as their publication index. We have the opportunity to control how such indices are developed, and should try to ensure that they actually serve to make the quality of reviewing better and strengthen the review system.

Reviewer or copy-editor?

Many reviewers face the dilemma when reviewing of whether to stick to the scientific issues, or to take on some of the role of a copy-editor. Some journals do have dedicated copy-editors, and it is always a pleasure to have material copy-edited as this adds an extra layer of quality control to your manuscripts. To hark back to the advice given to me about checking whether the claims of the paper are supported by the data and analyses, then this is a task one can choose to avoid and leave to editors. However, it can be argued that a reviewer who is a specialist can follow a line of argument that more general readers may not, and it seems only collegial to try to help with wording and structuring an argument where it is not as clear as it could be, so long as it is clear that these are suggestions. While this may involve extra time, it should help both the author and referees improve their writing skills for the future. A simple way that authors can deliver referees from this extra work can be to get a colleague not involved in writing the paper to read it over. Often papers have spent so much time in the heads of the authors that what ends up on the page is perfectly clear to the three people who have been writing the paper, as they have a shared set of assumptions and ideas, yet can be difficult to follow by an outsider.

Are you thinking what I'm thinking? The benefits of sharing reviews

A recent and welcome development among some journals is emailing reviewers with the outcome of the review process, and also including the reviews submitted by the other reviewer(s). *Biology Direct* has the policy of making the reviewers' reports public by publishing the reports together with the manuscripts. I think this is a great development for two reasons. Firstly it allows you to compare your own thoughts on the paper with another person with the same task. In many research areas in which multiple observers are involved, it is the norm to check for agreement among observers; this could be the source of some fascinating future research on how peer-review functions. The ability to check that you agreed with the other reviewer will help to strengthen confidence in your own judgement. Equally, it is helpful to be reminded of areas you overlooked in a paper. A common problem arises when reviewing a paper on a group of organisms that you are familiar with or actively research. Either one gets bogged down in arguments about taxonomy/specimens, or breezes over sections that are clear to you as a specialist, but general readers will not understand or will find irrelevant.

The proliferation of 'journal clubs' which actively debate recently-published papers and often correspond with the authors either directly or through online fora is a major phenomenon in the life sciences, and colleagues in that area report that these serve as an excellent, informal training ground for developing peer-review skills.

Double-blind reviewing: how anonymous is anonymous?

Another interesting development is the generation of double-blind manuscripts, where both the reviewers and the authors are anonymous. The main argument for using this approach is to overcome biases relating to institutional affiliation, gender, ethnicity and even personal issues. For those who think we live in times where such biases no longer occur, the bibliography, containing many peer-reviewed quantitative studies, compiled by the Earth Institute at Columbia University, should disabuse them of such comforting notions (<**http://www.earth.columbia.edu/advance/BiasBibliography.html**>). *Palaeontologia Electronica* is the only journal I have reviewed for that uses this procedure, and I wonder how successful it will be. Reading anonymous reviews sometimes feels like the descriptions of WWII code-breakers, who could recognize individual senders of Morse Code by the 'fist' of the sender, which described the rhythm of individual operators. After a while most researchers become adept at discerning who acted as referees by spotting the personal phrases or points and style of review. McBirney (2003) has also questioned whether it is possible to maintain reviewer anonymity in peer-review.

Given the relatively small size of the palaeontological community, the stripping of author(s) information perhaps conceals even less than unsigned reviews, as a manuscript will contain many more clues about the identity of the author(s). When I had a double-blind MS to review, I recognized it, although I couldn't remember exactly which journal I had previously reviewed it for and who all the authors were. Nonetheless, I contacted the handling editor to declare the potential problem. My intention in relating this anecdote is not to criticize the adoption of this system by *Palaeontologia Electronica* that has been done with the best of intentions, but simply to point out that anonymity is hard to maintain in a relatively small community where many people know each others' work well. Katz *et al.* (2002) reported that about 34% of 880 manuscripts submitted to two radiology journals contained information that compromised the double-blind system, and as this is a large medical field – rather than the smallish field of palaeontology – it is reasonable to expect that the percentage of manuscripts which would compromise the double-blind system is likely to be higher. More positive reports exist on the use of double-blind reviewing, such as Cox *et al.* (1993), and there is evidence that double-blind refereeing can help to overcome bias (Budden *et al.* 2008).

Open review: peer-review 2.0?

Open review is a relatively new concept, although it could be argued that the old tradition of literally reading papers at scientific meetings in the 17th–19th centuries was a form of open review. Open review should not be confused with open access, although a number of open access journals use open review methods. *Nature* is now exploring the potential of open review, which could mark a major shift in the way the journal runs; and given the prominence of *Nature* it would seem reasonable to expect other journals to start to experiment with open review. Open review combines the use of referees selected by the editor with a phase during which the paper is posted online, and additional comments can be made on the discussion board relating to that paper. I am genuinely interested in whether this communitarian approach might be an improvement on the current peer-review system. However, experience as a participant and moderator on various internet discussion sites makes me acutely aware of the perennial problems of 'flame wars' and lengthy, rambling comments with little relevance. Do editors and authors want to be burdened with these? Did all comments made during the open review phase have to be addressed? My cynicism also made me wonder whether it was possible to abuse these systems by bogging down an opposing research group with endless trivial comments.

Having no experience of open review as either a reviewer or an author, I asked my partner about her experiences with an open access journal, Atmospheric Chemistry and Physics (ACP; <**http://www.atmos-chem-phys-discuss.net/volumes_and_issues.html**>), which has been running since 2001, and she has published in. The editorial board of the journal were very helpful in sharing their opinions, ideas and experiences in running the journal. Most of my fears about increased workload for editors in policing behaviour on the discussion boards, and the potential for misuse of the system, were quickly allayed. They have no evidence of misuse of the system and have a standard protocol of making papers available for open review for eight weeks, then making authors address all relevant comments from both the selected referees and from the discussion boards. Many papers do not attract any other comments. A log-in procedure for the boards removes the anonymity that makes comment free, sometimes too free, in other areas of the Internet.

D. Cziczo explained that the handling system for manuscripts is also different from many other journals. Rather than editors being assigned all papers from a given subject area, all editors can see all manuscripts and pick those they want to handle. Thus it is possible for weak papers to be weeded out before full review, as editors will not take them forward. While this might appear capricious, editors do have the option to return papers without sending them to review and such a clear policy can relieve the pressure on reviewers and editors alike. ACP editors also have the option of requesting a content check, which is a short review by a third party if they want a second opinion on the contents of a manuscript.

U. Pöschel, the editor-in-chief of ACP, is a strong advocate of both open access and open review (see Pöschel 2004 for a bold challenge to traditional peer-review and the 'target culture'). He was able to give a broad overview of ACP's performance relative to other journals in the field, which highlighted two important trends. ACP has a higher impact factor (~5 *versus* ~3 for similar journals), but ACP also has a much lower rejection rate (~10% *versus* ~30%). This seems to be an almost magical feat, as most journals enhance their prestige and impact factor by increasing their rejection rate. For example, *Nature* eventually rejects 95% of manuscripts (<**http://en.wikipedia.org/wiki/Peer_review**>).

Another interesting area that ACP touches on is the issue of permanent archiving of preprints. The open review/discussion phase is carried out in ACPD, which acts as a preprint archive similar to the arXiv.org project at Cornell University (<**http://arxiv.org/**>). While this procedure can cause problems in some cases, which are discussed at length on the ACP website (<**http://www.atmospheric-chemistry-and-physics.net/general_information/faq.html**>), there is mounting interest in preprint archives which mean that papers that don't quite make the cut for final publication are available, citable and authors have something to show for their efforts.

Conclusions

Peer-review continues to be a major source of quality control on the work published in scientific journals, and has been central to the ability of the sciences to appear to have a fair and rigorous system for determining what is acceptable for publication.

The first peer-review system in science dates to 1665 and was established by Henry Oldenburg for *Philosophical Transactions of the Royal Society* (<**http://eprints.ecs.soton.ac.uk/13105/1/399we23.htm**>). However, the use of the modern peer-review system, outside of medicine, in its current form really only dates to the middle of the 20th century (<**http://en.wikipedia.org/wiki/Peer_review**>). With this in mind it is perhaps easier to contemplate making changes and modifications to the system to take advantage of new technologies that spread the load of reviewing, and reward reviewers more explicitly in an age where the voluntary ethos of academia is being questioned by a management culture of targets. Similarly if we can change the process to ensure that bias, whether conscious or unconscious, can be eliminated from peer-review then it is right that as a community of scholars we do so. As publishing models change and open access and paid access journals compete, it seems that other aspects of scientific publishing are being called into question. By taking an active interest in the evolution of the peer-review process, hopefully we can improve it in the way that a good review can enhance a paper.

Al McGowan
Newsletter Reporter

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I would like to thank C. F. Braban for directing me to ACP and discussing her experiences of open review. The editor-in-chief of ACP, U. Pöschel, kindly replied to my queries and sent a number of useful papers and references, as did D. Cziczo and one other ACP editor who prefers to remain anonymous.

Sylvester-Bradley REPORTS

Redescription of Drepanopterus abonensis *from the Late Devonian of Portishead*

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Eurypterids are extinct aquatic chelicerates found in Palaeozoic marginal marine, brackish and freshwater environments. Most species are nektonic predators with their posterior appendages modified into swimming paddles, and are often found in large concentrations of moulted exuviae (Braddy 2001). Stylonurid eurypterids show their posterior appendages adapted for walking, and are relatively rare; most stylonurid taxa are known from only one or two specimens and most species are preserved in sandstones as opposed to shales. The phylogeny of the monophyletic Eurypterina is now well-resolved (Tetlie 2007). However, the relationships between the more primitive Stylonurina are still poorly understood; most taxa are so poorly known that they were omitted from previous analyses. Indeed, previous analyses have been so limited in taxonomic scope that they were unable to determine whether the Stylonurina were monophyletic or paraphyletic with respect to the Eurypterina.

The problem is compounded by the suggestion that the hibbertopterids, large sweep-feeding forms that radiated during the Carboniferous, are not even eurypterids (Tollerton 1989). It is clear that much more work is required to elucidate stylonurid relationships.

Drepanopterus abonensis is a eurypterid found in the Late Devonian (Famennian) Old Red Sandstone of Woodhill Bay in Portishead, Somerset. It was first described by Simpson (1951) as a long-bodied animal with a relatively small carapace and elongated telson (Fig. 1). Recent sifting through the vast quantities of material held at the University of Bristol uncovered specimens showing distinct morphological differences to the description provided in Simpson. The intent of the research project was therefore to redescribe *Drepanopterus abonensis* based on a re-evaluation of the existing material and synthesis of the new material held at Bristol.

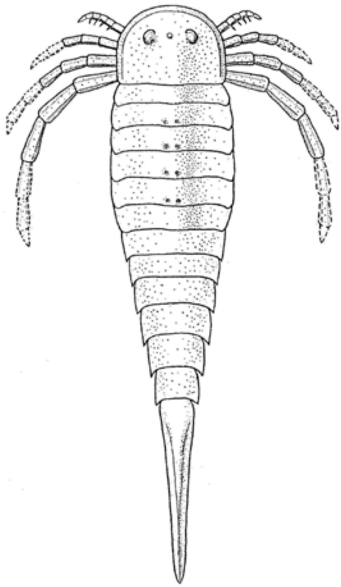

Figure 1. The original reconstruction of Drepanopterus abonensis *(from Simpson 1951).*

The Bristol material consisted of over one hundred and twenty specimens stored in eight crates. It rapidly became apparent that *D. abonensis* had the potential to become one of the most completely known stylonurid eurypterids, with almost every aspect of its morphology preserved in some manner. The cataloguing and describing of these specimens proved to be a time-consuming task, and it was a relief to be able to get out in the field on several occasions.

The Sylvester-Bradley award funded several trips to the Woodhill Bay site and a trip to BGS in Nottingham to view the type material. Woodhill Bay, while supplying numerous fish scales, *Praearcturus* cuticle and *Diplocraterion* and *Cochlichnus* trace fossils, failed to turn up any ever-elusive eurypterid fossils. The trip to BGS was most enlightening, and it was a pleasure to be allowed to nose through the extensive collection of eurypterid material there, following in the footsteps of some true legends (Fig. 2).

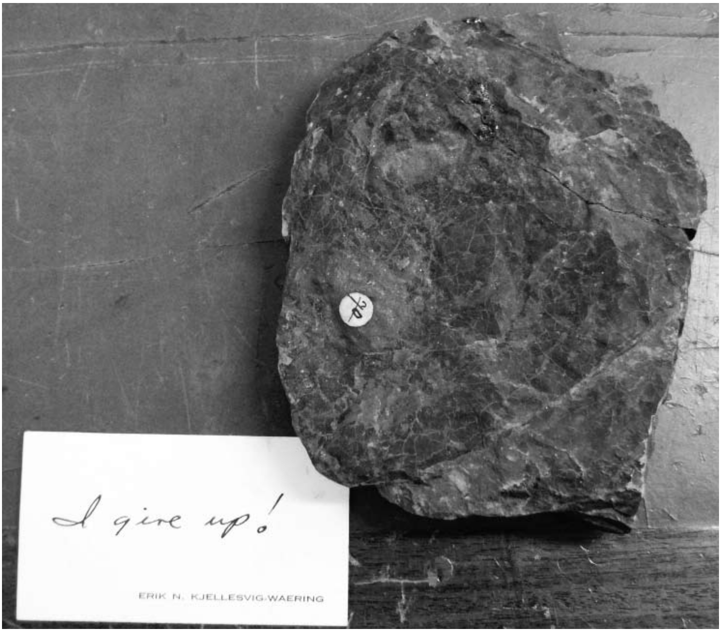

Figure 2. Undiagnostic scrap of pterygotid cuticle, complete with a label by Kjellesvig-Waering from his visit to BGS in 1974.

As well as resulting in a full redescription of *Drepanopterus abonensis* (Lamsdell *et al.*, in review), integration of the data into a phylogenetic matrix has resulted in a well-resolved stylonurid phylogeny (Lamsdell *et al.*, in preparation) which will be submitted to the *Proceedings of the Royal Society B*. Major results from this research includes: 1) a redescription of *Drepanopterus abonensis* from all known material; 2) a well-resolved stylonurid phylogeny consisting of 25 taxa and 50 characters; 3) revising the higher taxonomy of stylonurid eurypterids utilising the new phylogeny; and 4) examination of palaeobiological patterns evident throughout the stylonurid evolutionary history.

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Inferring Mesozoic conifer diversity from analysis of cuticle under Scanning Electron Microscopy and determining the family affinity of form genera

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Conifers have been studied throughout the history of palaeontology but their taxonomy and phylogeny is mostly attributed to variation in the sexual organs (Miller 1999; Raubeson and Gensel 1991). Without these sex organs, it is harder to assign them to family, genus and species level. By studying the microstructure of conifer cuticles under Scanning Electron Microscope (SEM) it is possible to place plants into families (Kendall 1949; Alvin and Dalby 1987; Ewin 2004). The cuticle remains well preserved and unchanged over geological time; the quality of the preservation is such that the cell structure below is preserved (Guignard *et al.* 1998). Many characters exist which allow us to define plants to families within the cuticle, including stomatal arrangement, aperture orientation and presence of florin rings (Ewin 2004), and many previous studies have used cuticle level characters to identify family affinity (Stockey 1986; Raubeson and Gensel 1991; Cantrill 1992; Zhigan 2000; Van der Ham *et al.* 2003).

The project aims to analyse, for the first time, fossil conifer cuticle of species yet unstudied with SEM in order to identify the family affinity of these species from cuticular data and to constrain familial affinity in an effort to investigate more fully the diversity of Mesozoic conifers. It is also hoped that new characters, which define these species, will be discovered that will in turn help to refine the phylogenetic tree. The data will be added into a dataset that includes extant and extinct conifer species from the literature in an effort to see what relationships are observed based solely on cuticle characters.

Specimens of the form genera (*i.e.* genera that have been grouped together based on leaf morphology rather than a natural classification) *Brachyphyllum* and *Pagiophyllum* were taken from the Bristol City Museum and Art Galleries (BCMAG) and sections of the specimens were manually removed from the matrix. The sections removed were macerated in Hydrochloric acid, Schultz solution and Hydrofluoric acid before being mounted on a SEM stubs using acetone-based glue (Alvin and Boulter 1974; Watson 1988). The specimens were described in detail and coded into a phylogenetic matrix. In addition, specimens of *Brachyphyllum* and *Pagiophyllum* from the Natural History Museum, London (NHM) were examined under transmitted light microscope and the specimens from BCMAG were compared with these specimens to enable a species-level identification (Harris 1979).

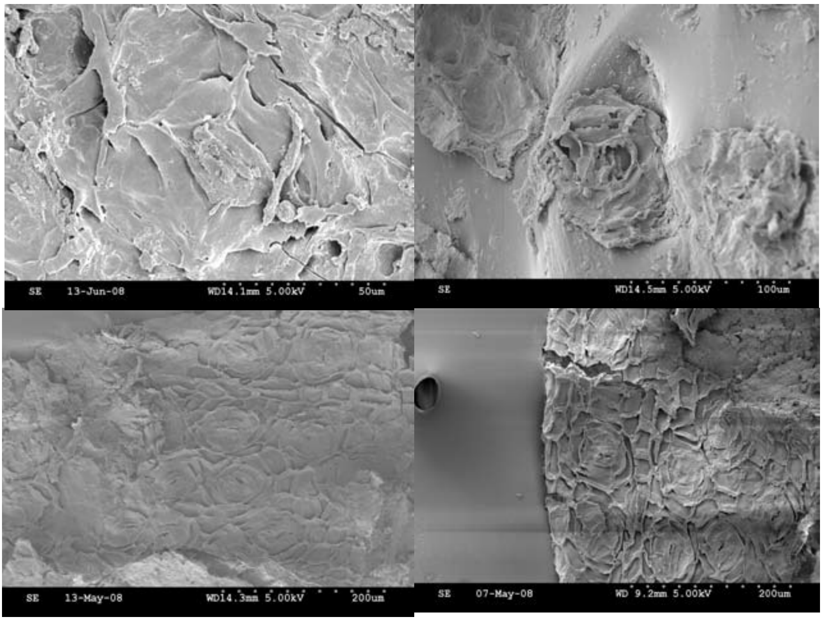

Figure 1: Select SEM images of Brachyphyllum desnoyersii *from BCMAG; all the specimens show the distinct multiple rings of subsidiary cells which had previously never been observed or described.*

The study demonstrated that characters do exist which enable the identification of fossil conifers to extant and extinct families. Analysis of the specimens from BCMAG demonstrated that *Brachyphyllum desnoyersii* is part of the fossil family Cheirolepidiaceae; this is supported by the relatively random arrangement of stomata and random orientation of apertures (Ewin 2004). Both the *Pagiophyllum* species *Pagiophyllum kurrii* and *P. maculosum* have been placed as fossil members of the modern family Araucariaceae, due to the presence of stomata in rows and apertures orientated diagonally to the direction of the leaf apex (Ewin 2004).

The orientation of the stomatal apertures has a large effect upon the family affinity and has proved to be an important character in family-level identification. At the stomatal level, all the stomata are surrounded with 4–6 large subsidiary cells, have square epidermal cells, and the cell walls are similar, which suggests that these characters are not useful for determining family affinity between Araucariaceae and Cheirolepidiaceae. However, stomatal-level characters are of use in separating other families. The phylogenetic analysis did not show what is assumed to be the correct relationship of *Brachyphyllum* and *Pagiophyllum* and their relative positions to the families that they were grouped with from cuticle characters. However, the phylogeny did group the extant families together, showing that there are some phylogenetically useful cuticle characters. The fossil taxa examined grouped relatively near to their extant families. In addition to the above data, analysis of *Brachyphyllum desnoyersii* showed new diagnostic characters; *e.g.* the multiple rings of subsidiary cells viewed under SEM, which may be a new generic-level character, and the high density of stomata, which is supported by analysis of the type specimens from NHM and which records twice the number of stomata per unit area, compared with *Brachyphyllum crucis* and *B. expansum*.

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Soapbox

On the mathematics of life

We readers of the *Newsletter* are greatly indebted to one of our correspondents for presenting us with such a comprehensive review of the powerful methods of mathematical analysis applied to the biometry of 18 named genera of trilobites, and doing it in such a humane, user-friendly style. I am also sure I am among the many who have firmly resolved to make best efforts to master these methods, just as soon as we can find the time and energy to do so. But wait: they are methods, means to ends, not ends in themselves. The ends are problems to which we seek solutions. And in palaeontology, as in the rest of science, the first move in trying to solve a problem is to formulate it, to cast it into the form of a question.

What are the questions about trilobites that we are trying to answer?

I first became acquainted with biometry applied to fossils over half a century ago – gosh! – when pipe-trenches were dug to provide the future residents of Kidlington *ville neuve* (oy vey) with basic sanitation. The excavation on the Bicester Road, in front of the *King's Arms*, 20 mins by bicycle north of Oxford, struck Lower Oxford Clay: minutely stratified, with a breath-taking profusion not of trilobites but of ammonites (and lesser fry), being dug by hand. Back to the library, to try to identify them – **Question #1**: what are they? Almost nothing described, apart inevitably from some good but desultory figures in S.S. Buckman's *Type Ammonites*. What about the stratigraphy, then? Even less – except by Arkell in his *Jurassic System in Great Britain* (1933, pp.352–4, still relevant today), who drew my attention to Brinkmann, 1929, Peterborough *Kosmoceras*. And there I found what I was looking for – **Question #2**: what were their ages, measured against some standard calendar of reference?

But whereas Arkell was interested primarily in the standard chronostratigraphical classification at chronozonal time-resolution of the Oxford Clay as a whole, Brinkmann was interested in much finer time-resolution, for quite different purposes. This he cast into the form of a description of some 13 m of clays with details of lithology recorded with cm precision and ammonite biostratigraphy based on a collection of some 3,000 specimens. For my immediate purpose, that now translated into the question of precise time-correlations between Kidlington and Peterborough based on the ammonites as guide-fossils. And it worked: provided the correlation was based not on comparisons of single specimens but on *assemblages* of *N* specimens. But what to compare? The tools were the statistical parameters determining the distribution-functions of selected (*sic*) morphological characters, derived as best fits to measurements of those characters in *N* specimens. To show me how this is done, Brinkmann had opened his exposition with a brief summary of the statistical methods he had used (inspired by Francis Galton), which were those of simple, unidimensional normal (first-order Gaussian) distributions. They seemed perfectly adequate for my purposes; and the bigger *N*, the greater the precision, obviously. But I quickly learned where the killer lies: it lies in the *square-root* of *N*, the Law of Diminishing Returns.

What were the purposes of Brinkmann's study? He stated them clearly at the outset in the form of two questions. **Question #3**: what was an ammonite species, seen as a natural unit, and how was it related to our only source of information, its fossil remains? **Question #4**: how did species evolve phylogenetically? These continue to be fundamental questions in palaeontology, the questions for which Buckman (1893) coined the term 'palaeo-biology'. Question #4 had to be addressed largely in histogram representation, for his careful discussion of the sedimentology of the Lower Oxford Clay led him to recognize that the succession of some 25 beds separated by clear partings into which he had subdivided the range of clays under study included non-sequences – beds absent – at time-gaps perhaps at least as long as the sedimentary time recorded in the beds present: there was no simple relationship between age and stratigraphical height, between time-duration and bed thickness – **Question #5**: how complete is the phylogenetic record? Hence there was no point in introducing phylogenetic time overall as a second independent continuous variable in statistical tests of the continuity of evolution or otherwise, involving such concepts as orthogenesis, gradualism or punctuated equilibria, other than perhaps in short runs.

What were Brinkmann's conclusions? Firstly, that the kosmoceratids at any one level – what we have come to call a faunal or biohorizon – at Peterborough represented four independent biospecies, whose biometric parameters, expressed in terms of means, standard deviations and standard errors of the means, he listed for up to ten morphological characters. These biospecies he then named in conventional Linnéan style. Question #3, the (time-static) representation of natural biospecies, seemed therefore to be comprehensively answered.

Secondly, successive assemblages could be effortlessly joined in stratigraphical succession as the temporal transients of four phyletic lineages evolving in parallel: A, B, C, D, say, in order of decreasing relative abundances; for the gross morphological features differentiating the four biospecies at any one level were retained almost unchanged over the whole succession. The answer to question #5 was therefore that the level of completeness of the record, although certainly imperfect, was adequate. These lineages he labelled with the existing names of four (morpho)genera reduced in rank to subgenera of *Kosmoceras*. Through the discovery and dynamical representation of four evolving lineages in over 20 transients, spanning a time-duration by today's estimates of perhaps 2 Ma, the dynamical question #4 seemed also to have been spectacularly answered. These lineages provided by far the most detailed demonstration of Darwinian evolution in terms of (stratigraphically) punctuated gradualism to have emerged by 1929 and retain much of their paradigmatic force even today. The demonstration was powerfully reinforced by a series of beautiful drawings by Mme. Kyropoulos of selected shells taken at various points in the succession. Two of them grace the front cover of Raup & Stanley's famous text (second edition, 1978). More extensive reproductions of lineages A and B may be found in one of the Geological Society's Special Publications (Callomon, 2001, p. 247, fig. 6).

Now to the $64k question: is it all true? Although Arkell reviewed Brinkmann's work at some length (1931), he confided in conversation in his later years at Cambridge – from which Peterborough was easily accessible in field excursions – that he retained some residual doubts. Digging the Oxford Clay by hand is exceedingly hard work and he just could not imagine how Brinkmann and his assistant could have obtained so many specimens in just the six weeks they spent on it. There was only one way to test the data: to do some more digging, to see how reproducible they were. Some effort in this direction soon proved successful. It turned out that Brinkmann's description of the section (Question #2) was precisely correct, as was his logging of the ammonite biostratigraphy, at least as far as could be judged from samples taken at selected successive levels. In particular, some of the abrupt changes in morphology that he had recorded at certain facies-boundaries marked by partings were entirely reproducible. So any doubts about the reality of what Brinkmann had achieved in the field were groundless.

But when it came to testing the reality of the distinctions he had drawn between the representatives of the four lineages occurring side by side in the same bed, there were problems. New material confirmed the clear distinctions between lineages (A, D) on the one hand and (B, C) on the other. But A and D seemed to intergrade, as did B and C. These impressions were however not based on yet further biometric analyses – that square-root on *N* made this impractical. Instead, recourse was made to another very powerful technique of palaeontology, that of Ocular Morphometrics (OM). Its software has evolved over long eons and comes pre-installed in the hardware; and its applications are familiar in many mundane examples, such as identifying images of our political and cultural leaders in the popular prints (try identifying them holding the pages upside-down), preventing fraud by printing familiar images of historical figures on bank-notes, or preventing deception by putting images of their owners into passports. The power of ocular morphometric programs (OMPs), such as those applied to the identification of fossils, lies however in an inbuilt self-referencing routine that stores input images in a memory with which subsequent images are compared, a bit perhaps like the spell-check program in Word whose vocabulary you can augment as you go along. The consequence is that the power of an OMP increases with application – what we loosely call experience. An OMP operator has to be trained.

So, back to Brinkmann. Where lies the origin of the conflict between the four-species description based on biometry and the apparently only two-fold diversity suggested by OM? Brinkmann could not have been wrong, because Raup and Crick (1981, 1982), re-analysing Brinkmann's original data in the notebooks he allowed them to see, did not challenge his specific diversities (Question #3). They were more concerned with the relationship between temporal changes and lithostratigraphical discontinuities (Questions #4, 5). I finally discovered the source of the conflict. It lies in just two lines in Brinkmann, on p.27, lines 8–9 down, where he tells us how he proceeded. After extracting a new specimen, the first move was to record its precise level. The next move was *to assign it to a species*, something that rarely posed any problems. Only then was it measured up. Finally, in most cases, it was discarded. So, that is where he put in the answer: right at the beginning. It was reassuring, therefore, to find the biometric analysis confirming it.

OM of the (A+D) and (B+C) dual-lineage assemblages immediately reveals two other features of these assemblages. Firstly, in the assemblages of intergrading (A+D) combined, and (B+C) combined, the morphological variability of what we now deduce to have been single biospecies can be enormous, compared with that of almost any other contemporaneous marine organisms. It encompasses combinations of many of the characters of sculpture measured by Brinkmann, but not all. The most conservative and closely-defined character turns out to be the end-diameter of the adult shell. And the components D and C in the lineage-couplets turn out to be merely the extreme end-members in the distribution-functions of the variability in some of the characters of morphology, namely just those most striking to the human eye at first glance. Attempts to capture the variability and its distribution-functions in a biospecific transient quantitatively might indeed be a worthwhile biometric exercise and Brinkmann's data, suitably regrouped, might be a good starting-point. But one feature is already clear from OM. The distribution-functions are highly asymmetric. Such asymmetry can also be characterised by the extension of Gaussian statistics to higher orders, and Brinkmann did give the formulae for these: for asymmetry in terms of the cubes of the deviations from the means, for tests of bimodality in terms of their fourth powers. He even applied the tests for asymmetry to one or two of his sets of data, but they were barely significant. The reasons were again the killers: now the *cube* root of *N* for asymmetry.

(To halve the uncertainty of a value of an asymmetry-parameter derived from ten specimens you would have to measure 80!).

The second feature recorded by OM is so obvious that it needs no emphasis, and Brinkmann's analysis fully reflected it. It is the persistent differences between the two lineages (A+D) and (B+C). They mark the classical expressions of sexual dimorphism in ammonites: large forms, macroconchs, (A+D), with simple final peristomes, and smaller forms, microconchs, (B+C), whose adult peristomes are armed with long, projecting lappets – features that are so well preserved in the kosmoceratids at Peterborough that Brinkmann duly measured them. The dimorphic size-ratio is close to 2:1. But even more telling, another character that Brinkmann recorded was an apparently insignificant minor feature of the secondary ribbing, the recombination of secondary ribs in pairs or bundles at tubercles at the external margin of the shell. It sets in near the top of the succession studied by him – and does so more or less simultaneously in both macro- and microconch lineages. They are genetically coupled. Brinkmann did consider sexual dimorphism as a possible explanation for the persistent duality of his lineages, but expressly rejected it – baffling.

There is much more on ammonites, but enough. (I know of at least two other grandiose ventures into statistical analyses of huge data-sets (reference on request), but either they did not even get past Question #2 or they pre-inserted entirely subjective selections at Question #3. Pure GIGO). Grand conclusion: the kosmoceratids of Peterborough (and everywhere else) represent a single genomic lineage of morphologically highly variable, sexually dimorphic biospecific transients that evolved more rapidly with time than did those of any other contemporary marine organisms. Such general conclusions can today be seen to apply to perhaps the majority of Jurassic ammonites as a whole. They owe most to the combination of stratophenetic methods and OM (– field-work and trained eye-balling to you and me), little to quantitative statistical biometric analysis. Questions #3–5 seem to have received satisfactory answers. (And taxonumerologists and biotic cataclysmologists note: 80% or more of the nominal genera and species in the literature are pure artefacts and have no natural reality).

Are there, then, any further non-trivial questions about the palaeobiology of ammonites to which one would like to see the answers? I can think of several. **Question #6**: why did Brinkmann's 3,000 specimens apparently include not a single demonstrably juvenile example? **Question #7**: how and why did the Kosmoceratidae, in common with so many other ammonite biospecies, subtend such wide ranges of morphological variability (in marked contrast to those of *e.g.* trilobites) and retain them over such long times yet changing in form? Conversely, **Question #8**: what made them apparently immune to selection-pressure from any plausible and independently testable environmental factors? Hence, **Question #9**: what was the functional role of the sculpture of the shells, if any? Then, more widely, **Question #10**: is the observed widespread geographic endemism of ammonite biospecies and phylogenera a reflection of true speciation in the phylogenetic branching sense or merely racial segregation at subspecific level? And so on; but, all questions to the answers of which I can see mathematical methods making very little contribution. When we have the full molecular genomes of the ammonites, now, that will be the time to think again. But what about those trained and experienced in the identification of ammonites by conventional methods, they who will tackle those unanswered questions? How many are left? And where are their successors?

And so, to wrap it up, back to the beginning. Those 18 trilobite genera: what were the questions we were setting out to answer? Why those genera and not others? Who identified them? Does it matter? What were the answers? What interesting questions about trilobites are there still to be answered? Otherwise, what did those poor innocent trilobites do to deserve such heavy artillery fire? Or were they just cannon-fodder?

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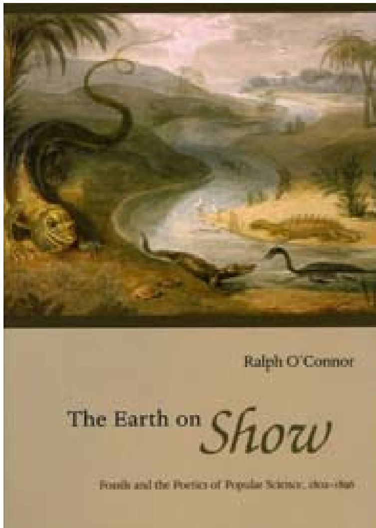
Book Reviews

The Earth on Show. Fossils and the Poetics of Popular Science, 1802–1856

Ralph O'Connor (2007). The University of Chicago Press, Chicago and London. xiii+541pp. ISBN 978-0-226-61668-1 (Hardback) $45.00 US.



Geology had a golden age during the latter half of the nineteenth century, where in Britain it emerged from the 'dark ages' of the eighteenth century where geological studies comprised biblically-influenced books and tracts, punctuated by valuable scientifically rigorous contributions by a small band of devotees led by some members of the Royal Society.

By the 1850s geology was firmly entrenched in the mindset of the scientific classes as well as in the minds of the general public as a subject that was worthwhile studying for pleasure as well as for sound economic and academic reasons. Why and how did this happen? The zeal and energy of such popularisers of geology as Roderick Impey Murchison, Director of the Geological Survey of Great Britain, and Charles Lyell, a one-time Professor of Geology in London and successful geological author, are well known. Murchison lectured to thousands of admirers assembled in a cave in the limestones at Dudley, while Lyell reached many thousands through his celebrated lecture-tours in North America in the 1840s and through his books *Principles of Geology* (1830–33) and *Elements of Geology* (1838). Both volumes ran to many editions which testify to Lyell's popularity, and as a useful spin-off they made him a great deal of money.

The Geological Society of London that had been established just over two hundred years ago in 1807 also helped place geology on a professional footing, and through its publications aided the development of geology in the early 1800s. However, it drew its membership from a rather limited base, albeit a base that was financially well-off, and as a result its influence did not reach the masses clammering for knowledge.

So how did the general public receive its geological information if not through the Geological Society? O'Connor brings the readers on a journey through the geological literature but in general avoids the mainstream publishing outlets and focuses on the side streets of poetry, the popular press and popular literature. The Romantic poets Keats, Shelley and Byron play an important but unintentional role in the advancement of geology. Their works were read and loved by many, and the genre adopted by others who wrote on geological topics in the same style. Some poets such as Thomas Rodd (1820) simply added geological details as part of their lyrical story:

But far below the earth pursue my way,
Through regions inaccessible to day;
The high-arched cavern tow'rs above my head;
While in the terrible abyss below
Rush the wild waters, thundering as they flow.

While other scribes such as William Buckland deliberately parodied earlier works by others, and Gideon Mantell produced his own somewhat more serious verses.

Likewise the epic poets led by Alfred, Lord Tennyson were also popular and again this style was adopted by others directly for geological use; for example the 1811 poem *The Giant's Causeway* by William Drummond ran to over 100 pages.

Printing had by 1800 become faster and books cheaper and more accessible. This led to a proliferation of titles on geology. *The Little Geologist* and *The Little Mineralogist* by Samuel Clark published in 1838 and 1840 were priced for the lower end of the market, as were Mantell's *Thoughts on a Pebble* and books by Maria Hack, one of many women writers of popular science. Clark's books cost 1s each while by contrast Murchison's *Silurian System* (1839) was £8 8s.

Another expensive volume was Thomas Hawkins' *Memoirs of Ichthyosauri and Plesiosauri*, but this relied for impact on its large Imperial-sized illustrations; his text is very odd and one would imagine difficult for even those that dominated the intelligentsia. However, the volume is important as it demonstrated the importance of visualization in geology. Books such as James Parkinson's *Organic Remains of a Former World* (1804–11) and Louis Figuier's *The World before the Deluge* allowed glimpses into Deep Time without which geology may not have been embraced nor understood by the populace.

O'Connor also travels through the various institutions that showed off the new science – institutions such as the Literary and Scientific societies that were being established in many mid-sized towns in Britain, and museums including both the public and private. Of the latter, that of William Bullock was housed in a building on Piccadilly known as the Egyptian Hall and it drew in many visitors. He also draws our attention to the use of theatre in geological outreach, and provides an illustration of Robert Barker's premises on Leicester Square in London, and of the Colosseum in Regent's Park in which viewers were treated to panoramic views of London and other landscapes.

It is now difficult for us to comprehend just how popular geology had become by 1850, but a reading of *The Earth on Show* demonstrates the variety of media that popularisers used to get the geological story across to the voracious public. This is a scholarly and wonderful book, long at 541 pages, but difficult to put down once started. O'Connor has successfully woven together numerous strands of geological inquiry and produced a readable and highly entertaining book. It is easy to handle and well illustrated with eight colour plates and numerous half-tones. I congratulate the author for filling a niche in the literature of the history of geology and science, and recommend without question this book to palaeontologists, literary historians, geologists and to those who enjoy books on popular science.

O'Connor was recently awarded the British Society for Literature and Science's annual book prize for 2007 for this book; it may not be the last accolade it garners.

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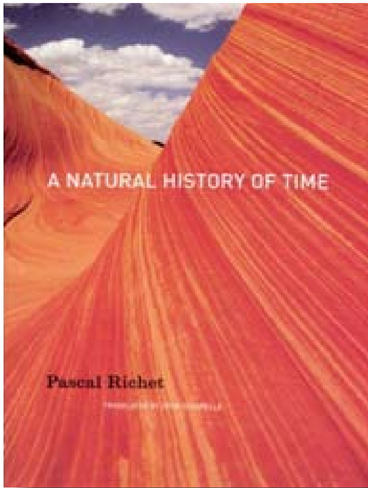
A Natural History of Time

Pascal Richet. (2007, translated from the French 1999 edition by John Venerella). University of Chicago Press. 471 pp. ISBN: 978-0-226-71287-1. $29.00.



As scientists, we take for granted the immense and virtually incomprehensible dimensions of our universe (or is it a multiverse?) in space and time. We all know something about James Hutton. But of his precursors, and of the climates of thought in earlier times regarding the nature and dimensions of time, most of us are significantly less well-informed. In this thorough, scholarly, illustrated, and eminently readable book, one encounters not only the legacy of many unfamiliar thinkers, but also a lively commentary on those who are much better known. Professor Richet is a geophysicist, yet he presents his material with all the erudition and competence of a first-rate professional historian, and he builds up a compelling story of the discovery, and quantification, of time.

The thinking of the ancient Greek philosophers (Chapter 1) was free, untrammelled by any prevailing orthodoxy. They were able observers. Their view of time was basically cyclical. Most of them accepted that fossils were the remains of once-living organisms, and that in places, where once was land, now there is sea. Yet as Aristotle believed, these were small changes, by comparison with the vast duration of the universe, and there was no possibility of trying to reconstruct the history of the eternal earth.

In Chapter 2 we see the Greek cyclical view of time replaced by the Mosaic linear concept; the Earth had been created at a particular moment, and all subsequent history was required to fit into this framework. And for well over a thousand years, an orthodoxy prevailed, which gave the age of the Earth at some 6,000 years, from which there was no escaping. This book is not in any way a documentary on the conflict between science and religion, yet the complex history of such issues during the 15th to the late 18th centuries is given appropriate coverage. Whereas such a brave spirit as Giordano Bruno went to the stake as late as 1600 for his heretical views about the infinity of the universe there were others, before and after him, who began to escape from the clutches of confining orthodoxy. Such men as Baruch Spinoza and Richard Simon were of such a kind, but they were very careful of what they actually said.

In Chapter 3 we see further characters, further developments in thought. Galileo, Boyle, Hooke, Newton, and so many others espoused new models of the universe, heliocentrism became no longer seriously doubted. Newton was fascinated by chronology. And the then young Edmund Halley began to study salinity in lakes and wondered whether it could be used as a chronometer. Yet he did not publish his thought for many years, for fear of censure. Just how hard it must have been for these brilliant scientists to argue against the monolithic orthodoxy of the time comes through clearly. Yet so many of them were original thinkers. Then people began to study fossils in earnest (Chapter 4). Were they sports of nature (*lusus naturae*) as many asserted? Were they the remains of dead animals, somehow turned to stone? Nikolaus Steno had dissected a dead shark, and compared its teeth directly with fossil teeth found in rocks. For him, and also for Robert Hooke, who had made microscopical preparations of fossil wood, there was no doubt that they were the remains of formerly living organisms. Might they have been relics of the Great Flood? If so, how are great numbers of fossils found on high mountain tops to be explained? To Leonardo da Vinci, who had studied layering in rocks, there was no question about it. The Great Flood had nothing to do with it. Yet in most circles, Mosaic chronology still prevailed.

Then came the remarkable Georges-Louis Leclerc, Comte de Buffon, a gifted mathematician, naturalist and surely one of the most remarkable scientists of all time (Chapter 5). For 48 years he was the Keeper of the Royal Botanical Garden. And very perceptively he wrote "The past is like distance, our sight diminishes within it, and it, itself, would soon become lost, had not history and chronology placed some lanterns, some torches, at the darkest points". And he himself lit some of these same torches. Whereas his own scale for the age of the earth was no more than 75,000 years he was singularly influential on his successors. By the end of the 18th century had come a new generation of observers (Chapter 6), both of the cosmos and of the Earth itself. These were the scientists of the heroic age of geology (*c.* 1775–1825). Both the immensity of time and the use of fossils in providing a relative chronology were beginning to be understood. And the grip of orthodoxy was weakening. In the early 19th century Pope Pius VII admitted that the 'days' of Genesis were simply indeterminate periods of time. As has been noted, the 'delimiting line was not between religion and science but between the old and modern of each'. By the middle 19th century the Mosaic time scale no longer held sway.

So, we have a relative time scale, but how can it be quantified? Most of the rest of this book is devoted to precisely that question, and although this period in history will be more familiar to many of us, it is fascinatingly illuminated here. In Chapter 7 we read of Fourier, and his obsession with the conduction of heat through a body. He survived the Revolution, and developed his theory of heat, the foundation of all we know on this subject today. But Lord Kelvin used this theory to advocate that the Earth could not possibly be as old as the geologists and palaeontologists would like it to be. Calculating the age of the Earth from the time taken to cool from an originally hot state, not less than 20 million and not more than 400 million years could have elapsed. A likely figure was 100 million years (Chapter 8). It may be tempting to cast Kelvin in the role of the Bad Man. But no, he was a truly great scientist, and a courteous gentleman. In 1869 he had noted that 'British popular geology at the present time is in direct opposition to the principles of natural philosophy', and his stranglehold on the geological time scale lasted for some 50 years, discomfiting the geologists exceedingly. They could not, after all, determine their own timescales with any degree of precision, from geological criteria alone.

But then, starting in 1895 (Chapter 9) we have the discovery of the strange behaviour of uranium salts, emitting radiation of a then unknown kind. Becquerel, and then the Curies, had discovered radioactivity. This remarkable period in the history of science is eloquently dealt with here, as is the impact of the understanding of radioactivity in replenishing the internal fires of the Earth (Chapter 10). By 1904 Rutherford recounted that Kelvin had limited the age of the Earth, 'provided that no new source was discovered'. But although Kelvin died in 1907, unconvinced that radioactivity had any part to play in continually heating the Earth, the stage was set for further developments. Along came Arthur Holmes, living in Britain and surely the father of radioactive dating methods (Chapter 11), as well as Barrell and Chamberlin in America, who applied rare radiometric data to the stratigraphic record, wherever it was possible. The beginning of the Cambrian was pushed back to some 500 million years. This was fine, but the ages of stars – as then available – seemed to be considerably less than the age of the Earth! But this was not to last long, it was sorted out by the astronomers, and it is now agreed that the age of the universe is some 12,000 and the age of the earth some 4,600 million years. In Chapter 12, tribute is paid to the work of magnificent, though perhaps less well-known scientists, Gerling, Houtermans, Patterson and others who developed the use of isotopes to make radiometric dating reliable, precise, and repeatable. Astronomy, physics, geology and palaeontology all have contributed to our present understanding of time, and they all dance to the same tune. A final Epilogue completes this remarkable, erudite book, followed by mathematical complements, sources, suggestions for further reading, and an extensive bibliography.

It is sad to reflect that in spite of all the labours of so many brilliant scientists, as documented here, the creationist lobby still has a considerable following. Just this day I heard that a fine explicative panel at Siccar Point had been mysteriously, and deliberately, vandalised……

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Tyrannosaurus rex: the Tyrant King

Peter Larson and Kenneth Carpenter (eds) (2008). Indiana University Press, Bloomington and Indianapolis, 435pp. ISBN 978-0-253-35087-9 hardback, includes CD-ROM. $49.95.

Few dinosaurs are as well studied as the Upper Cretaceous tyrannosaurid theropod *Tyrannosaurus rex*. It might be easy to assume that this intense focus has been driven by the fame and glory associated with working on this dinosaur. That might be partly true but, in fact, *T. rex* really is one of the best known dinosaurs, represented by multiple individuals that are often near-complete and well preserved. It has also – in the form of bite marks, coprolites and soft tissue traces (or *alleged* soft tissue traces) – left us more evidence of its behaviour than many other Mesozoic dinosaurs. *T. rex* might really be regarded, then, as a 'model dinosaur', and its familiarity and popularity might instead be argued to be coincidental, the result of its relatively early discovery (it was named in 1905) and of its status as one of the world's largest predatory dinosaurs. In celebration of 100 years of knowledge of the world's most famous dinosaur, the Black Hills Institute of Geological Research (Hill City, South Dakota) held '100 Years of *Tyrannosaurus rex*: A Symposium' in June 2005. Including 21 contributions from 30 authors, this book is the result.

The volume starts with Neal Larson's review of all reported *T. rex* skeletons. This is an interesting catalogue, providing and illustrating a great deal of obscure and even never-before-published information. Here, we receive the first indication that not everyone involved in tyrant dinosaur research agrees on the taxonomy of the population of animals generally referred to as *T. rex*. Referring to the fact that 'there is so much evidence separating *Nanotyrannus* from *T. rex*' (p. 2),

Larson retains *Nanotyrannus* as a distinct taxon (as do some other contributions in the volume). He also notes the even less well known opinion of Stephan Pickering that FMNH PR2081 (aka 'Sue', previously BHI 2033) and a few other specimens represent a distinct species, but Larson disagrees and so does everyone else I think. Unmentioned (and clearly little known) is that yet another alleged *Tyrannosaurus* species, *T. vannus* from Big Bend National Park, was named in an unpublished thesis filed by Douglas Lawson in 1972. There have been mentions here and there in the literature of how this specimen (the holotype is the left maxilla TMM 41436-1) falls outside the range of variation of *T. rex* (most recently, Brochu (2003) said that, if it is not *T. rex*, it represents a close relative) but we are still waiting a definitive reassessment.

When *T. rex* was first described by Henry Osborn in 1905, it was described alongside a second gigantic theropod, the armour-plated *Dynamosaurus imperiosus*. Brent Breithaupt and colleagues provide a brief review of *Dynamosaurus* and other tyrant dinosaur discoveries from the Rocky Mountain West. It is well known that the *Dynamosaurus* type specimen – sold to the British Museum (Natural History) in 1960 – was mounted in the museum's old dinosaur gallery in a rather 'modern' pose: that is, with its body and tail near-horizontal and its tail well up off the ground. Those who have commented on this have usually noted that Barney Newman wanted to depict the animal in a dynamic, modern pose, and said as much in a technical paper (Newman 1970). I was therefore interested to read Alan Charig's comment that the specimen 'was mounted with its body in a far too horizontal position: this was done because it would otherwise have been too tall for the Gallery. Newman, who made the mount, has attempted to rationalise this (1970) by stating that the posture was much more bird-like than is suggested by earlier mounts' (Charig 1972, p. 137).

Mary Schweitzer and colleagues review their recent discoveries on medullary bone in *T. rex*, and Peter Larson looks at variation within the species. While *T. rex* seems to include both gracile and robust individuals, Larson also discusses the idea that *Nanotyrannus* – argued by Carr (1999) to represent a juvenile *T. rex*, contra Bakker *et al*. (1988) – is a distinct taxon. Less familiar is the idea that what is generally known as *T. rex* possibly includes two species, with the 'other one' known provisionally as *Tyrannosaurus "x"*. To my knowledge, the only other outing of this idea in the literature is some very brief discussion in Horner and Lessem's popular book *The Complete T. Rex* where this notion is mentioned as one of Robert Bakker's pet hypotheses (indeed, Larson states here that the *Tyrannosaurus "x"* hypothesis originated with Bakker). While this is very much a minority opinion, the idea that there might have been more than one contemporaneous species in the genus is hardly crazy radical nonsense. Indeed, Maastrichtian western North America was highly unusual in apparently being home to but a single species of large theropod. Ultimately, I found the arguments put forward by Larson unconvincing however: the features suggested to distinguish the two overlap (like number of maxillary or dentary teeth), or are known to be variable in other taxa (like size of the pneumatic foramen in the lacrimal).

Proposing an 'integral morphodynamic solution' to tyrant dinosaur body shape and proportions, Martin Lockley and colleagues dismiss the idea that adaptation provides the explanation for the striking skull and forelimb proportions. They argue instead that 'morphodynamic compensation' explains how the diminutive forelimbs of these theropods were an accidental consequence of genetic investment in the proportionally gigantic skull. This is easily the strangest and most problematic contribution to the book, and even within the volume itself, other authors (Lipkin and Carpenter) note that these conclusions are untestable and speculative. Lockley and colleagues have recently used similar arguments to explain the presence of short tails in pterodactyloid pterosaurs. Their arguments need to be properly evaluated by someone active in the field of evo-devo, but I find it hard to take them seriously. The dismissal of adaptation as an explanation for a given bauplan is strange given that this is one of the most fundamental concepts in evolutionary theory.

Christine Lipkin and Kenneth Carpenter look anew at forelimb function in *T. rex*. In keeping with some previous work on the subject, the authors conclude – based on evidence from pathologies, reconstructed musculature and mathematical modelling – that the short arms of *T. rex* were very powerful and perhaps played a role in predation. In view of Brochu's (2003) critique they revisit the too-avian reconstruction previously published by Carpenter and Smith (2001). However, given that these dinosaurs had banana-shaped teeth over 15 cm long and could literally bite animals in half with an astronomically high bite-force, I find it hard to accept that short didactyl arms, even very well-muscled and robust didactyl arms, were all that useful in predating upon multi-ton herbivores, but this is not to say that the arms were useless. As Lipkin and Carpenter argue, the pathologies present in *T. rex* forelimb and pectoral bones indicate that they were indeed subjecting their arms to extensive forces.

Digital modelling of a *T. rex* skeleton is used by Kent Stevens and colleagues to reconstruct possible sitting and resting poses in the animal. Relatively little technical work exists in which authors have tried to depict the resting and sitting postures of dinosaurs, and understandably there is little opportunity to test ideas on this subject. Lambe (1917) depicted a possible resting posture in *Gorgosaurus* and several artists have followed suit, but these reconstructions were nothing more than artistic endeavours. The beauty of the computer-generated work that Stevens and colleagues present is that it allows the digital manipulation of accurately proportioned models that incorporate data on ranges of motion, gravity and loading. So we get our first *scientifically rigorous* look at what a squatting and resting tyrannosaur might look like. Newman's (1970) idea that tyrant dinosaurs might have used their strong arms to help steady themselves when rising from a recumbent posture is testable, but while it might work it appears more awkward than does the possibility that the release of the energy stored in the Achilles tendons allowed the animal to stand without resorting to this. An accompanying presentation included on the CD-ROM that comes with the book illustrates the ranges of motion permitted by the model, and excellent animations show what it is capable of.

Phil Manning provides an overview of new ideas on footprint dynamics and how to study them and, in his second contribution in the book, Peter Larson provides an atlas of *T. rex* skull bones. The accompanying photos (on the CD-ROM) are excellent and useful (if you work on theropods), but are marred by the total absence of scale bars. Hans Larsson looks briefly at palatal kinesis, with the evidence for this hinting at the possibility that the kinesis so typical of birds may have originated deep within Tetanurae. Given comments made about such animals as allosauroids and coelophysoids elsewhere in the literature, there are certainly indications that cranial kinesis was present throughout the evolutionary history of the theropods.

Ralph Molnar's article complements his previous papers on cranial morphology and mechanics in *T. rex* (Molnar 1991, 2000). These articles are all well-written, well illustrated and pretty convincing, and the new paper included here provides a detailed discussion of the inferred cranial musculature of *T. rex*. One interesting area of conflict that arises from Molnar's reconstruction concerns the soft-tissue anatomy of the antorbital fossa in *T. rex*, and by inference that of all theropods and perhaps of all archosaurs with large antorbital fossae. Based on the surface texture of the bone within the antorbital fossa, Molnar reconstructs *T. rex* with an immense pterygoideus anterior that fills the cavity and anchors to the ventral, anterior *and* dorsal margins of the fossa. This is the 'conventional' reconstruction for theropods. However, it's flatly at odds with Witmer's proposal that the whole of the antorbital fossa was occupied by a gigantic antorbital sinus (see Witmer 1997, fig. 6): Witmer still, of course, depicted the pterygoideus anterior musculature as anchoring in the antorbital fossa, but as being far smaller and far more ventrally restricted. Molnar is well aware of this conflict and suggests that histological examination of the fossa margins might resolve this problem. He also suggests that different archosaurs might have differed in the extent of the pterygoideus anterior. One might predict that an animal such as *T. rex*, specialised for power-biting and well known for possessing hypertrophied cranial musculature, might represent an extreme example at the 'muscular' end of the scale.

Molnar's article will also be of use to those interested in reconstructing the life appearances of dinosaurs, given that it is one of very few works that shows exactly where the tympanum belongs. Artists apparently lacking in guidance have often positioned the ear on the side of the neck, posterior to the depressor mandibulae, or even within the laterotemporal fenestra, but it should in fact be located anterior to depressor mandibulae and just ventral to the posteroventral part of the squamosal. One unfortunate problem does afflict this paper, and that is its formatting: several of the figures are far removed from the associated text of the article and have been placed adjacent to the references.

Bruce Rothschild and Ralph Molnar look at pathologies, of which a great many are known from tyrant dinosaurs. This is a useful survey, but questions might be raised as to whether the aetiologies they propose are the most likely ones. They suggest, for example, that healing fractures observed in gastralia present evidence that tyrants could survive and recover from accidental falls. Well, maybe, but falling flat on your belly is not the only way in which you might receive broken gastralia (interactions with prey and conspecifics are just as likely).

Greg Paul's paper on 'the totally extreme lifestyles and amazing habits of the gigantic mega-awesome tyrannosaurid superhyperpredators of the Late Cretaceous of North America and Asia' (or something like that) essentially consists of a series of informed speculations that, while appearing reasonable based on what we know, will be annoying to some given his habit of making unsupported assertions. He provides an extended critique on tyrant dinosaur hindlimb anatomy, limb posture and running speed, and he continues to disagree strongly with those who argue that *T. rex* was limited to elephant-like speeds. New work indicates that tyrannosaurs grew quickly and died young (as did, as a generalisation, all dinosaurs it seems), a discovery that leads Paul to imagine that tyrant dinosaurs were 'chronically living closer to the edge of danger and death'. In other words, that they lived reckless, dangerous lives where caution was thrown to the wind: more like salmon than elephants, notes Paul. The comparative work presented here on the skulls of the different tyrants is useful.

John Happ describes an exciting *Triceratops* specimen that many will already be familiar with because of its appearance on television documentaries: it would appear that a large predator with a very powerful bite grabbed hold of one of the animal's brow horns and bit it off, and also damaged the side of the frill with a bite. The *Triceratops* survived, but appears to have suffered from osteomyelitis following the attack. By reconstructing the angle of attack employed by the predator, Happ shows how the *Triceratops* and its attacker (*T. rex* is the only candidate) engaged in face-to-face conflict. The unknown factor is how common interactions of this sort were. Paul notes in his paper that this was quite likely an attack gone wrong, as attacking an elephant-sized horned herbivore from the front and biting its horns is probably not a good idea.

In a long-awaited contribution, Thomas Holtz provides a formal, critical answer to John Horner's proposal that *T. rex* was an obligate scavenger, unable to kill live prey and destined for a life of wandering the Cretaceous landscape ever in the quest of decomposing carcasses. It's difficult to be sure whether Horner really believes his own hypothesis: one gets the impression that he likes promoting it because it earns him lectures and TV appearances, and surely he knows that it's not really a defensible point of view. Horner's claim that *T. rex* had 'beady little eyes' (and hence poor eyesight) is shown to be incorrect, and Holtz also tackles claims that hindlimb proportions and tooth morphology support a scavenging lifestyle when the data show that they don't. Holtz reviews the evidence for predatory behaviour in giant tyrant dinosaurs, concluding (like Paul) that they were most likely canid- or hyaenid-like 'jaw-based' predators, able to resist significant twisting and skull loading when grabbing prey, and also able to withstand occasional contact with bone.

The volume ends with a look at the role of *T. rex* in popular culture, by Don Glut. From the art of Charles Knight to the Zallinger mural and its role in sci-fi stories and movies, *T. rex* has been a constant presence, and one invariably portrayed quite inaccurately. This continued until recently (the BBC's *T. rex* in *Walking With Dinosaurs* is one of the least accurate modern renditions of this animal), but has finally begun to change. Brief contributions by other authors are also included elsewhere in the book and look at such topics as the age of *T. rex*-bearing beds, and at the discovery and taphonomy of specific individuals.

Tyrannosaurus rex: the Tyrant King contains some very interesting contributions, and everyone involved in tyrant dinosaur, or Cretaceous theropod, research will want at least some of the papers that are included; Molnar's and Holtz's chapters in particular are sound contributions to the literature, and it is good to see the studies by Happ and Stevens *et al*. in print. But the book also incorporates some unusual and problematic articles that, one cannot help but assume, might have appeared here because they could not be published elsewhere. A phylogenetic perspective on the book's subject is notably absent, and – given the controversial and very interesting claims about the validity of *Nanotyrannus* and additional *Tyrannosaurus* species – it's unfortunate that nobody submitted a paper that provided a rigorous, empirical analysis of *T. rex* systematics. This is partly because another special meeting on tyrannosaurs was held at the Burpee Museum of Natural History just a few months after the Hill City meeting, and for whatever reason this is the one where the phylogenetic papers were presented. I also found the lack of abstracts from the contributions unhelpful (particularly in writing this review, when access to brief summaries would have been very helpful!) and, as is unfortunately par for the course for IUP volumes, the editing is not too hot and typos are easy to find.

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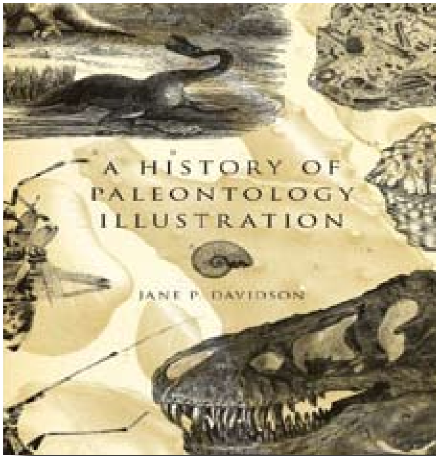
A History of Paleontology Illustration

Jane P. Davidson (2008). Indiana University Press, Bloomington, 240 pp, ISBN 978-0-253-35175-3 (cloth), $39.95.

In the modern electronic media the general perception of prehistory is of a time and place of danger and carnage – giant predators and prey all set in tropical lands and seascapes in multi-coloured splendour. Whether in movies, documentaries or any number of books and in today's interactive museums, these lively interpretations all begin with the fossil record. In a recent 'bones and stones' workshop that I conducted I encouraged parents and children to draw from life – a various selection of animal skulls, fossils and natural objects. The room became quiet as everyone was absorbed in their observations of patterns and structure. As Jane Davidson, the author of 'The History of Paleontology Illustration,' remarks in her preface, "even in the age of digital cameras and cellphones with cameras … students are still being instructed to draw their lab specimens".



This book covers five centuries of science-related illustration, and the early chapters relate the obsession with collecting and recording fossils and other curiosities. Early illustration in an age of artistic realism converged with the dawn of modern scientific thinking, and data from specimens were recorded in formal paintings and, sometimes, slightly whimsical engravings. Throughout the book an episodic structure of subheadings are dotted throughout the chapters and describe the characters producing and commissioning artwork. The author gives the reader a comprehensive description of the different techniques of printed reproduction – for example, early woodcuts, copperplate engraving and etching, and later, highly detailed lithography and photo-engraving. All these processes are introduced and explained in sequence, and in many cases she credits the technicians producing the plates as well as the original artist.

Apart from the drawings of fossil specimens, the book encompasses restorations of animals and plants in their environments, sculpture, museum murals and paintings, and in the last chapters, the introduction of photography as a tool to record site digs and articulated skeletons, notably Henry Osborn's pair of tail dragging, but very vitally posed, skeletal *Tyrannosaurus rex* arguing over yet more bones.

20th century imagery is described in the last chapter, and the highly influential Charles Knight paintings and models dominate as well as the beautiful sculptures of Irwin Christman, the museum artist at the American Museum of Natural History.

As a volume on illustration a book must rely on its examples, and we have a generously scattered selection of figures all in relative position to the text with concise captioning and dates which is very helpful to the reader. A number of stories and images will be familiar to many readers, but the author gives fresh insight and perspectives to these accounts, for example, the enigmatic trackways of *Chirotherium*, Hitchcock's trackways and footprints. Additional to the often repeated story of Waterhouse Hawkins' tableau of sculpted dinosaurs and "fossil reptiles" for the Crystal Palace and the ill-fated Central Park project, the author has drawn on Hawkins' personal ephemera from his Scrapbook Album which is now in the The Academy of Natural Sciences of Philadelphia. Familiar as some of the illustrations are, the detail and clarity of the text, as well as this new material, gives a thorough insight into the quality of these works.

This book is a medium-sized hardback priced at $39.95, and the one thing that lets it down is the quality of reproduction. In my copy the quality of line and tone is a little soft and overall the illustrations have a somewhat grey appearance to them – and in a few examples the quality of xerox as a source. The rather small selection of eight colour plates could have been enhanced by including a wider range of influential artists. Good examples could have been Rudolph Zallinger's or Jay Matternes' murals, or everybody's favourite Zdenek Burian's impressionistic paintings, and perhaps a classic example of a Douglas Henderson environment whose influence can be seen in the work of many illustrators working today.

This is a well written and researched book which can be read chronologically or as a source of reference. It cries out for a larger format and higher production values, but it can be recommended to anyone interested in the history of palaeontology and scientific image makers who created work of such quality.

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The Evolution of Artiodactyls

Donald R. Prothero and Scott E. Foss (eds) (2007). The Johns Hopkins University Press, Baltimore. 367pp. ISBN978-0-8018-8735-2 (hardback) $120.00.

Artiodactyla is one of the most successful and cosmopolitan order of living mammals. Extant artiodactyls are native to all continents except Antarctica and Australia and, for most of the Cenozoic, extinct artiodactyls were nearly as broadly distributed. Artiodactyl abundance and diversity has also been high for much of the Cenozoic. Given their prominence in modern and fossil mammalian communities, a detailed understanding of artiodactyl evolution is critical to an understanding of the broader patterns of Cenozoic mammalian evolution. *The Evolution of Artiodactyls*, a new volume edited by Donald Prothero and Scott Foss, is a welcome review of this critical group of mammals.

In recent years, artiodactyl systematics has been thrown into disarray by the increasing prominence of molecular data. Most famously, molecular evidence published over the past decade and a half strongly supports the nesting of whales *within* a traditionally defined Artiodactyla, as the sister taxon to extant hippopotamids. While this discovery, and subsequent attempts to grapple with its implications for whale origins and artiodactyl evolution, has been quite visible in the palaeontological and systematic literature, other, equally unexpected aspects of molecular phylogenetic studies have thrown artiodactyl phylogeny into further confusion. Morphology-based studies of living and extinct artiodactyls have favoured a basal dichotomy between skeletally and dentally pig-like taxa (pigs, peccaries, and hippos) on the one hand and more antelope-like taxa (camels and ruminants) on the other. Molecular studies, by contrast, indicate that neither of these groups is monophyletic. Rather, camels appear to be basal to all other living taxa, while hippos (and whales) and ruminants are identified as sister taxa, leaving pigs and peccaries in the middle.

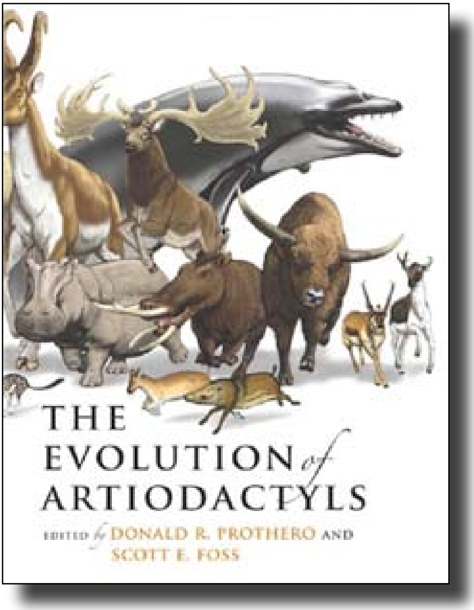
The first two chapters after the introduction focus on this critical conflict in artiodactyl phylogeny. Marcot presents a supermatrix analysis of extant artiodactyl interrelationships, focusing on three areas of particular contention: relationships at the subordinal level, interfamilial relationships within Ruminantia, and bovid phylogeny. He also presents a thoughtful discussion of the failings of both morphological and molecular data. The former is prone to being misled by convergence, particularly the iterative evolution of pig and antelope-like morphologies on partially isolated continents. Molecular analyses of Artiodactyla, on the other hand, have difficulty disentangling several very rapid radiations that appear to have taken place in artiodactyl history. In fact, Marcot explicitly emphasizes the role that the fossil record will have to play in resolving the basal radiations of pecorans (advanced ruminants) and bovids, both of which have defied confident resolution by molecular phylogenetics.

As a counterpoint to Marcot's emphasis on molecular phylogenetics, Geisler, Theodor, Uhen and Foss present a new phylogenetic analysis that emphasizes morphological data. The authors integrate two previously published large morphological data sets into a combined analysis that also includes molecular and stratigraphic data. Due to the presence of molecular data, results are consistent with molecular hypotheses. The authors note a continuing lack of morphological synapomorphies for some strongly supported molecular clades (*e.g.*, the grouping of whales, hippos, and ruminants in Cetruminantia) and provide some general discussion of the relationships of extinct artiodactyl families. Unfortunately, these topics are treated too briefly in favour of a more extended discussion of the immediate terrestrial outgroups to Cetacea. There is little guidance on the reliability of the reconstructed positions of many taxa. In particular, extinct selenodont taxa are dispersed between the camelid and ruminant stems, but there is little discussion of the nature of the character support for these aspects of the topology.

After the introductory chapters, almost all remaining chapters focus on individual families or, in a few instances, groups of families. Most chapters follow a basic format focusing on a generic review of members of the family or families under consideration, with generic diagnoses, lists of valid species, and distributional information. Often, this is accompanied by some relevant discussion of unresolved issues concerning the delineation, specific content, or distribution of the genus under discussion. The taxonomic section is typically accompanied by a range chart and, frequently, by a phylogeny. In addition to the basic generic review, most chapters also include a review of the origins and palaeoecology of the family or families under discussion. This general format should be familiar to readers of similarly-themed volumes, particularly Hartwig's (2002) recent treatment of primates. The overall quality is high, with all chapters being well-written and up to date in their review of the literature.

The editors should be commended for assembling a truly international group of contributors for these chapters, a factor that is certainly helpful in addressing such a cosmopolitan radiation. Almost all chapters addressing widely distributed groups do a thorough, balanced job of reviewing taxa from all continents. The lone exception is Harris and Liu's treatment of Suoidea, which devotes very little attention to North American tayassuids, although Old World taxa purportedly assignable to this family are thoroughly discussed. However, the near exclusion of tayassuids appears to be a reflection of the fact that almost no work has been done on the family since a previous review by Wright (1998).

With one or two exceptions, chapters are consistently well-illustrated. The first two family-level chapters are particularly noteworthy in this regard. Theodor, Erfurt and Métais's review of the earliest artiodactyl and Erfurt and Métais's treatment of endemic European forms both cover several diverse families (five and seven, respectively) and include reprinted original illustrations of the dental morphology of almost all relevant genera, and many species, making them particularly



invaluable resources for anyone needing to identify specimens. Beyond the basic format described above, the editors have wisely permitted the authors considerable flexibility. Individual chapters break from the basic format to focus on issues particularly relevant to specific families, including alpha taxonomic revisions, phylogenetic analyses of intrafamilial relationships, and character analyses.

Three chapters present new phylogenetic analyses of groups that have received limited attention using modern phylogenetic methods. Lihoreau and Ducrocq's review of Anthracotheriidae greatly expands on the senior author's previous work on anthracothere phylogeny with a new analysis that incorporates most well-known anthracothere genera. Métais and Vislobokova's chapter on basal ruminant families also presents a new analysis, performed at the family level. Finally, Solounias presents an admittedly preliminary phylogenetic analysis of Giraffidae and closely allied families. Both of the first mentioned analyses are somewhat marred by a failure to include likely descendants of the taxa under consideration. Thus, Lihoreau and Ducrocq exclude hippopotamids from their analysis, while Métais and Vislobokova restrict their sample to basal ruminants or traguloids, excluding higher ruminant families (pecorans) that have a likely traguloid origin. The analysis in the traguloid chapter also suffers somewhat from its reliance on family-level terminal taxa, with the genera and/or species used to score each family left unspecified.

While most chapters are largely content to review existing literature on the taxonomy of the family or families under study, a few present substantial revisions to generic and specific taxonomy of the groups in question. Foss addresses the confused taxonomy of Entelodontidae, attempting to clearly delimit genera, naming one new genus, and tackling two thorny questions of generic nomenclature. Stevens and Stevens address the even more confused systematics of Merycoidodontidae, where a legacy of taxonomic oversplitting has proved to be an impediment to using this abundant, diverse group of American endemic artiodactyls in either biostratigraphic or macroevolutionary studies. While the reviews are welcome, both chapters are clearly summaries of much longer, as yet unpublished revisions of the families in question; an understandable, but somewhat regrettable, necessity given the overall format of the book. In particular, neither chapter provides comprehensive lists of generic and specific synonyms, allocates most previously published specimens to particular taxa, or presents sufficient metric data to fully characterize genera or species. Two other chapters, by Prothero on Moschidae and Prothero and Liter on Palaeomerycidae, present similarly incomplete taxonomic revisions of groups with a convoluted taxonomy, particularly the latter family. In both cases, however, more thorough revisions are cited as in press.

Two chapters, both by Solounias, are focused on discussions of phylogenetically significant aspects of the morphology of Giraffidae and Bovidae. In the giraffid chapter, character analysis is presented in the context of the preliminary phylogenetic analysis of living and extinct giraffids mentioned above, while the bovid chapter is content with a brief review of the family's systematics and fossil record (Solounias's treatment of bovids is one of the few chapters that does not include a generic review of fossil taxa). Both chapters present a wealth of character data that should be of assistance to future workers attempting to unravel these substantial radiations, while addressing issues such as homology, character independence and functional considerations that are critical to evaluating the reliability of morphological characters.

Another departure from the basic format of the book is Groves' review of Cervidae, which focuses on the delineation and interrelationships of extant taxa, with only limited discussion of fossil taxa. Despite the lack of a focus on fossils, the chapter provides a fascinating look at the state of modern neontological taxonomy. In particular, the number of living species, and even genera, with likely hybrid origins is quite surprising and should serve as a useful reminder that dichotomous cladograms are frequently an oversimplification of the complexity of evolution. It should also come as some comfort to readers that, at least in this instance, morphological and molecular data appear to be largely in agreement.

A final chapter that departs from the overall format of the book is Honey's contribution on Camelidae. Rather than providing a review of the family as a whole, he focuses on a very specific issue: distinguishing taxonomic differences from sexual dimorphism in a clade of Miocene camels. The editors note in a footnote that the unusual focus of the chapter is due to a lack of major developments in camelid systematics since a previous thorough review by Honey *et al.* (1998). While the justification seems reasonable, the decision to title the contribution "Camelidae" to keep it in line with the other chapters was a poor one, as it provides no indication of the true content of the chapter.

After the family-level chapters, the final contribution, excepting a brief summary chapter, by Janis takes a broader view, focusing on major evolutionary patterns in artiodactyl history. Janis provides an extended discussion of several events, including the sequential displacement of perissodactyls by artiodactyls in the late Eocene, the rise of ruminants and modern suiforms in the Oligocene and Miocene, and the dominance of bovids in the later Neogene and Pleistocene, as well as one non-event, the failure of ruminants to evolve truly large-bodied representatives. In addressing all of these topics, Janis draws from a wealth of knowledge of artiodactyl morphology, physiology and fossil record, as well as such diverse topics as plant physiology and climate history, to provide a fascinating look beyond mere patterns of diversity to look at the underlying mechanisms driving the success and sometimes failure of Artiodactyla and its subclades.

Overall, *The Evolution of Artiodactyls* is an impressive collection of papers that should prove useful to both artiodactyl specialists and, given the ubiquity of the order, all students of Cenozoic mammals. Hopefully, it can serve as a model for future volumes focusing on similarly cosmopolitan taxa.

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Nautiloids before and during the origin of ammonoids in a Siluro–Devonian section in the Tafilalt, Anti-Atlas, Morocco

Special Papers in Palaeontology 79. 110 pp, 16 pls, ISBN 978-1-4051-8770-1, £48 (members £24).

Björn Kröger

Abstract: The non-ammonoid cephalopod fauna of the Siluro–Devonian section of Filon Douze, in the southern Tafilalt, Morocco is described. The section spans a sedimentary succession of predominantly argillites with intercalated cephalopod limestones of Ludlow–Eifelian age with a thickness of *c.* 450 m. More than 2,000 cephalopods were collected bed by bed and comprise 52 genera (17 new) and 86 species (39 new). Only one discosorid occurs, the new taxon *Pseudendoplectoceras lahcani*. The oncocerids are highly endemic, since out of nine recorded genera five are new: *Cerovoceras*, *Mutoblakeoceras*, *Orthorizoceras*, *Tafilaltoceras* and *Ventrobalashovia*. Only one of 13 oncocerid species is known from elsewhere and nine are new: *Bohemojovellania adrae*, *B. obliquum*, *Brevicoceras magnum*, *Cerovoceras brevidomus*, *C. fatimi*, *Jovellania cheirae*, *Mutoblakeoceras inconstans*, *Tafilaltoceras adgoi* and *Ventrobalashovia zhuravlevae*. Three actinocerids occur, two of which, *Metarmenoceras fatimae* and *Deiroceras hollardi*, are new. Within the Pseudorthoceratida the new taxa *Cancellspyroceras*, *Geidoloceras ouaoufilalense*, *Subdoloceras atrouzense*, *S. tafilaltense*, and *S. engeseri*, *Subormoceras erfoudense* and *S. rissaniense* are erected. The pseudorthoceratid species *Neocycloceras termierorum*, *Spyroceras cyrtopatronus*, *S. latepatronus* and *Sulcoceras longipulchrum* are also erected. New genera and species of the Orthocerida are *Adiagoceras taouzense*, *Angeisonoceras reteornatum*, *Chebbioceras erfoudense*, *Infundibuloceras brevimira*, *I. longicameratum*, *I. mohamadi*, *Pseudospyroceras reticulatum*, *Theoceras felondouzense* and *Tibichoanoceras tibichoanum*. Additionally, the orthoceratid species *Hemicosmorthoceras aichae*, *Orthocycloceras tafilaltense*, *Plagiostomoceras lategruenwaldti*, *P. reticulatum*, *Sichuanoceras zizense* and *Temperoceras aequinudum*, and the bactritoid species *Devonobactrites emsiense*, are erected, and 22 species are transferred to different genera. The stratigraphical section is described in detail and the depth of deposition of key horizons is estimated. Cephalopods occur mainly in three different facies types: (1) massive limestones, silty shales and marls with a bivalve–orthocerid association, reflecting (par-)autochthonous conditions in a distal environment below storm wave base; (2) proximal tempestites with a bivalve–orthocerid association, reflecting (par-)autochthonous conditions in a distal environment above storm wave base; and (3) marls and nodular limestones containing orthocones and a diverse benthos reflecting a well-oxygenated environment below storm wave base. The bivalve–orthocerid association is exclusively pre-Pragian. The bivalve–orthocerid storm beds abruptly disappear at the top of the Lochkovian. The Pragian, Emsian and Eifelian sediments invariably contain cephalopods together with a highly diverse benthos. A significant increase in cephalopod richness and taxonomic distinctness occurs in the uppermost Lochkovian tempestites. The Lochkovian/Pragian boundary also marks a profound change in the morphological composition of the cephalopod association. In the uppermost Lochkovian several cephalopod taxa, which were adapted to the low energy needs that dominated during the late Silurian and earliest Devonian, have their last occurrence. In post-Lochkovian strata cephalopod morphotypes that were adapted to energy-intensive buoyancy regulation dominate. Finally, in late Pragian and Zlíchovian deposits, bactritoids *sensu stricto*, ammonoids, coiled nautiloids and several pseudorthocerids have their first occurrence. These groups dominated in the late Palaeozoic. Therefore, the changes at the Lochkovian/Pragian boundary resulting in better conditions for life on the seafloor can be interpreted as a precondition that led to the landmark evolutionary innovations in the Zlíchovian.

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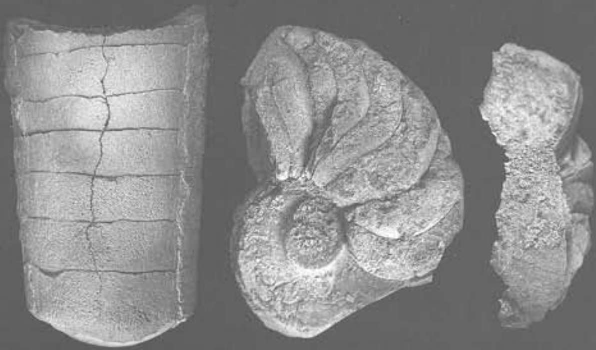
Nautiloids before and during the origin of ammonoids in a Siluro-Devonian section in the Tafilalt, Anti-Atlas, Morocco

by BJÖRN KRÖGER



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The Early Jurassic pterosaur *Dorygnathus banthensis* (Theodori, 1830) and The Early Jurassic pterosaur *Campylognathoides* Strand, 1928

Special Papers in Palaeontology 80. **107 pp, 10 pls, ISBN 978-1-4051-9224-8, £48 (members £24).**

Kevin Padian

Abstract: Over 30 skeletons and dozens of isolated bones of the Liassic pterosaur *Dorygnathus* have been recovered from the Early Jurassic (Toarcian) of Baden-Württemberg and Lower Saxony in Germany, and from Nancy, France. All but one specimen have been assigned to the species *D. banthensis*; the exception was assigned to a larger species, *D. 'mistelgauensis'*, which new discoveries suggest is simply a large individual of *D. banthensis*. The form of the lower jaw and premaxillary teeth are diagnostic for the genus, as are several other features. Here I review the history of the understanding of *Dorygnathus*, describe the known specimens in public repositories, and characterize the general morphology and systematic position of the genus. *Dorygnathus* is distinguished by its extremely large anterior teeth (four premaxillary and three or four anterior dentary teeth), which are proportionally larger than in any other pterosaur. Its deep maxilla gives the skull a high, straight, gradual slope, and its long, deepened, upwardly curved mandibular symphysis is diagnostic for the taxon. Other features such as the proportions of the wing elements, the form of the pelvis, and the shape and proportions of the toes are equally characteristic. *Dorygnathus* is most closely related to *Rhamphorhynchus* and the Pterodactyloidea, and represents this lineage in the Early Jurassic of Europe.

Abstract: The Early Jurassic (Liassic) pterosaur *Campylognathoides*, from the Schwarzjura ε II of southern Germany, is known from three specimens of its type species, *C. zitteli*, nine of a smaller species, *C. liasicus*, and some partial material from the Kota Formation of India referred to a third species, *'C. indicus'*, of dubious validity. Most of the German specimens have never been described. At least one specimen previously referred to *Campylognathoides* now appears to belong to *Dorygnathus banthensis*, a second and better known contemporaneous pterosaur. *Campylognathoides* is diagnosed by its steeply sloping snout; rod-like jugal; triangular antorbital fenestra confined to the lower half of the skull; ventral border of the orbit reaching nearly to the level of the tooth row; 9–10 small maxillary teeth; large, broad quadrangular sternum flared at posterior ends, with short cristospine; forelimb element length ratios wph 2 > wph 1 > wph 3 > wph 4 > r/u > h > mc; large medial carpal; very short, blunt pteroid; and a short fifth toe. *C. zitteli* is proportionally larger than *C. liasicus* and has 17 or 19 instead of 12 mandibular teeth. These and other historically accepted specific differences may reflect size rather than phylogeny, a question that could be resolved by the discovery of specimens of intermediate size. The closest relative of *Campylognathoides* appears to be *Eudimorphodon*, from Late Triassic deposits in Italy; this pterosaur lineage seems to be an early divergent branch from the main line leading to the Pterodactyloidea.

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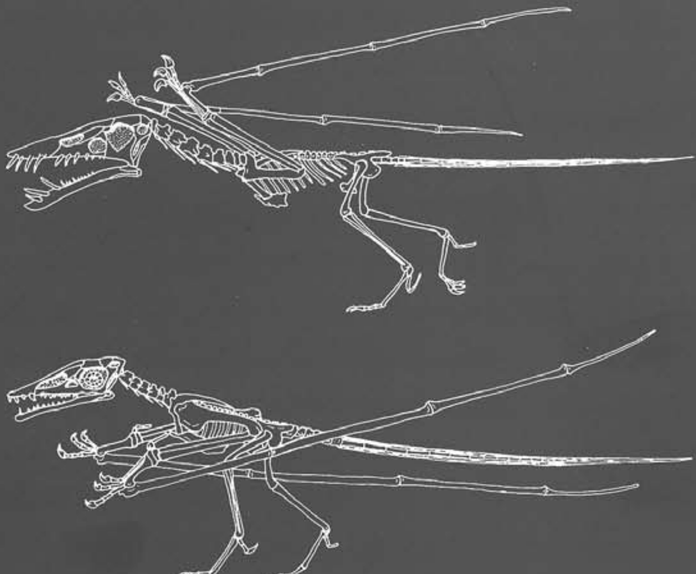
The Early Jurassic pterosaur *Dorygnathus banthensis* (Theodori, 1830) and The Early Jurassic pterosaur *Campylognathoides* Strand, 1928

by KEVIN PADIAN



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