The Palaeontology Newsletter

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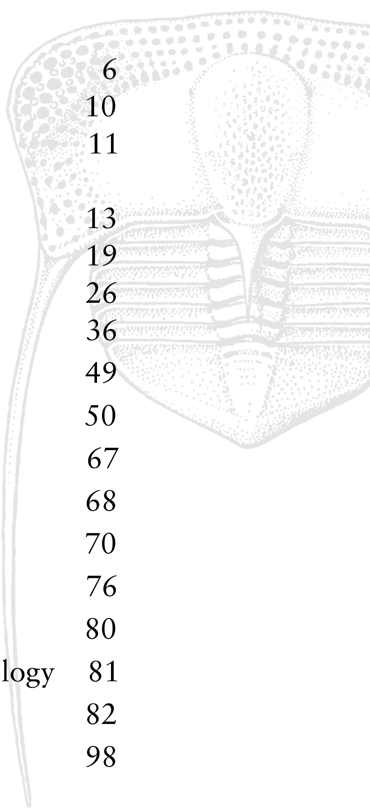
Palaeontology



Reminder: The deadline for copy for Issue no 64 is 19th February 2007.

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Editorial

As many of you will be aware by now, there was a problem with the printed copies of the last issue of the *Newsletter*. The formatting of the images in a number of articles was unacceptably poor, with the images obscuring part of the neighbouring text. This was the result of an error that occurred at the printers. Our Executive Officer, Tim Palmer, sent an email to members in the Summer explaining and apologising for this error, and pointing out that the electronic pdf version on the Association website (**<www.palass.org>**) was unaffected and correctly formatted throughout. I am aware, however, that not everyone has access to email and even those that do may not have received Tim's message. On behalf of the printers, I apologise once again for the formatting error in *Newsletter 62*; we have been assured that it will not happen again!

The Editor in his natural habitat – fieldwork in the Dolomites, Italy, Summer 2006. Photos: Tim Kearsey

On to brighter things! This year sees the 50th Annual Meeting of the Association, which will be held in Sheffield in December. More details are available in the following pages, including abstracts of all the presentations (poster and oral). Hopefully there will be something for everyone! I'm particularly excited about the day-long Macroevolution seminar, which boasts an impressive line up of palaeo-superstars from the UK and abroad. I'm sure it will be a fantastic Annual Meeting and I hope to see you all there!

Richard Twitchett
Newsletter Editor
<**newsletter@palass.org**>

Association Business

AGM 2005

DRAFT AGM MINUTES 2005

Minutes of the Annual General Meeting held on Monday 19th December 2005 in the University Museum of Natural History, University of Oxford.

Apologies for absence: Dr H. A. Armstrong (University of Durham).

1. **Minutes for the 2004 AGM.** The minutes were accepted, proposed by Dr Selden and seconded by Dr Purnell.
2. **Annual Report for 2004.** Agreed, proposed by Prof. Sevastopoulo and seconded by Dr Hilton.
3. **Accounts and Balance Sheet for 2004**. Agreed, proposed by Prof. MacLeod and seconded by Dr Cocks.
4. **Election of Council and vote of thanks to retiring members**
    i. Sir Peter Crane extended a vote of thanks to the retiring members of Council Dr Purnell (Vice-President), Dr Donoghue (retires as Newsletter Editor but stays on Council as a Vice-President), Dr Wellman and Prof. Evans (retire as handling editors), Dr Cusack (Ordinary Member).
    ii. It was noted the following members would come on to Council: Dr Twitchett (Newsletter Editor) and Dr Servais (Ordinary Member). Dr Sutton and Dr Wellman have been co-opted as Ordinary Members.
    iii. Prof. S. E. Evans, Dr J. W. M. Jagt, Dr S. P. Modesto and Dr O. W. M. Rauhut would act as handling editors for the journals but would not be full members of Council.
5. **Association Awards**
    i. Sylvester-Bradley Awards were made to Dr Jennifer England, Dr Howard Falcon-Lang, Mr Randall Irmis, Mr Mark Jones, Mr Tim Kearsey, Ms Claire MacDonald, Mr Daniel Oakley, Mr Robert Raine, Ms Leyla Seyfullah and Dr Bridget Wade.
    ii. The Mary Anning Award was made to Mr Steven Etches and Mr Andrew Yule.
    iii. The Hodson Fund was presented to Dr Philip Donoghue (University of Bristol).
    iv. The award of the Lapworth Medal to Prof. W. G. Chaloner was announced, in recognition of his long and distinguished research career in palaeobotany.

Annual Address

The annual address of the Association was given by Prof. Kennedy (University of Oxford) on ‘William Buckland and the dawning of palaeoecology’.

Paul Smith
Acting Secretary

news

David Batten, Editor-in-Chief of *Palaeontology, Special Papers in Palaeontology* and other publications of the Palaeontological Association, was awarded the Jongmans Medal by the Royal Dutch Geological and Mining Society of the Netherlands at the Seventh European Palaeobotanical and Palynological Conference held in Prague in September.

The award was established in 1994 by the Dutch Foundation of Geology and Palaeontology to honour distinguished earth scientists and to commemorate the life and work of Prof. dr. W. F. Jongmans.

David is the fourth recipient.

SYNTHESYS

SYNTHESYS Project funding is available to provide scientists based in European Member and Associated States to undertake short visits to utilize the infrastructure at one of the 20 partner institutions for the purposes of their research. The 20 partner institutions are organised into 11 national Taxonomic Facilities (TAFs).

The 11 TAF institutions represent an unparalleled resource for taxonomic research, offering:

- Collections amounting to over 337 million natural history specimens, including 3.3 million type specimens.
- Internationally renowned taxonomic and systematic skill base.
- Chemical analysis.
- Molecular and imaging facilities.

SYNTHESYS is able to meet the users' costs for research costs, international travel, local accommodation, and a *per diem* to contribute towards living costs.

Forthcoming deadlines: 16th March 2007
14th September 2007
14th March 2008

For more information visit <**http://www.synthesys.info/**> or contact <**synthesys@nhm.ac.uk**>.

ASSOCIATION MEETINGS

50th Annual Meeting of the Association

Sheffield, UK *18 – 21 December 2006*

IMPORTANT – Registration system error for Palaeontological Association Annual Meeting at Sheffield 2006

We have discovered a bug in our online registration software that affected a small number of people with certain characters (notably apostrophes) in their address. Those affected have *not* completed registration; their credit cards have not been charged, they have not been entered into any of our systems, and they have not been sent a confirmatory email.

Those affected would also have received an on-screen error message, but in some cases this may not have been visible without scrolling.

The problem has now been fixed.

If you received a confirmation e-mail for your conference booking, don't worry, you will be registered on our system. However, if you DID NOT receive a confirmation email for your conference booking, you are probably NOT registered on our system.

If you think you are affected by this issue, please register again at <**palass.org**>. When re-registering, enter a note under 'special requirements' that you are re-registering because of the bug, and we will ensure that the late registration surcharge of £15 is refunded.

Please note that the glitch did not affect abstract submission.

We apologise for this glitch, and look forward to seeing you in Sheffield.

The 50th Annual Meeting of the Palaeontological Association will be held at the University of Sheffield, under the auspices of the Department of Animal & Plant Sciences.

The meeting will begin on Monday 18th December with a special full-day symposium on "Macroevolution" (details below). This will be followed by an evening reception at the Sheffield Botanical Gardens. The technical sessions will consist of two days of talks on Tuesday 19th and Wednesday 20th December in the Auditorium located in the Students' Union on the main campus, together with poster presentations situated adjacent to the lecture theatre. The talks and posters will be open to all aspects of palaeontology. The talks will be scheduled for 15 minutes inclusive of questions and there will not be parallel sessions. Depending on submissions for oral presentations, some talks may have to be re-scheduled as posters. On Thursday 21st December there will be a field excursion collecting Carboniferous plant fossils from a local opencast pit, and incorporating a visit to The National Coal Mining Museum for England, with a trip descending 140 m underground into Caphouse Colliery, one of Britain's oldest working mines.

Venue and travel

Information about the University of Sheffield can be obtained at <**http://www.sheffield.ac.uk/**>. Sheffield is easily reached by road and rail links from London and all other major UK cities. The most convenient airport is Manchester, with a direct rail link to Sheffield (1 hour 15 minutes). Sheffield may be reached from London airports via underground plus overland rail links that take a minimum of 3 hours 30 minutes.

Accommodation

This will be at Tapton student hall of residence, which is situated 10–15 minutes walk (or a short bus ride) from the main University buildings. Details of how to get to the meeting venue on the main University campus and how to get to Tapton student hall of residence are available on the University website at <**http://www.sheffield.ac.uk/travel/**>. There will be a range of accommodation with different facilities and prices.

Registration and Booking

Abstract submission has closed. Registration and booking are available until **Friday 24th November**. Registration, booking and payment (by credit card) is from online forms available on the Palaeontological Association website <**http://palass.org/**>.

Programme:

Monday 18th December	One day symposium on "Macroevolution" (details below).
	Evening reception at Sheffield Botanic Gardens.
Tuesday 19th December	Scientific sessions followed by Annual Address (details below) at the Auditorium in the Students' Union of the University of Sheffield.
	Annual Dinner, the Cutlers' Hall, Sheffield.
Wednesday 20th December	Scientific sessions at the Auditorium in the Students' Union of the University of Sheffield.
	Presentation of awards.
Thursday 21st December	Post-conference field excursion to an open cast coal pit and the National Coal Mining Museum.

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

The Palaeontology Association runs a programme of travel grants to assist student members presenting talks and posters at the Annual Meeting. For the Sheffield 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. 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, by e-mail to <**palass@palass.org**> once the organisers have confirmed that their presentation is accepted, and before 8th December 2006.

Details of symposium

50th Palaeontological Association annual meeting
University of Sheffield
18th–21st December 2006

Special one-day seminar: Macroevolution (18th December 2006)

Macroevolutionary perspective

- Todd Grantham (College of Charleston, USA): *"How does philosophical work on mechanism and emergence bear on the relation between micro- and macro-evolution?"*

Species and Species Interactions

- Mark McPeek (Dartmouth College, USA): *"Phylogenetic patterns resulting from species interactions"*
- Richard Bambach (Harvard University, USA): *"Autecology, ecospace and change in the realized ecospace through the Phanerozoic"*

Tempo and Mode

- Kevin Peterson (Dartmouth College, USA): *"Tempo and the macroecological impact of early animal evolution"*
- Nic Butterfield (University of Cambridge, UK): *"Mode and the macroevolutionary history of metazoans"*

Diversity

- Brent Emerson (University of East Anglia, UK): *"Molecular phylogenetic approaches to understanding the origins and maintenance of community level species diversity"*
- Mike Benton (University of Bristol, UK): *"How did life get to be so diverse?"*

Disparity

- Mike Akam (University of Cambridge, UK): *"Is disparity just skin deep? A developmental perspective"*
- Doug Erwin (Smithsonian Museum of Natural History, USA): *"Why so many gaps? Morphologic disparity in the fossil record"*

Macroevolutionary Synthesis

- David Jablonski (University of Chicago, USA): "*Hierarchy and scale in macroevolution*"

Annual address

We are delighted to announce that this year's annual address of the Palaeontological Association will be given by Professor Art Boucot, and will take place during the Association's Annual Meeting on Tuesday 19th December at the University of Sheffield. Art, a member of the Palaeontological Association since its formation, will present an address on "What can be included in taxonomic descriptions?":

What can be included in taxonomic descriptions?

A. J. Boucot
Department of Zoology, Oregon State University, Corvallis, OR 97331, USA

A case can be made for the expansion of the "routine" taxonomic description. A number of possibilities are readily available for many groups of organisms. Organisms, fossil and extant, are far more than their basic morphology, important as that may be. I am concerned here with the important possibilities inherent in documenting ontogenies in many groups where this has seldom been paid much attention for many higher taxa. Another potentially significant possibility is the documenting of behaviours. I'm thinking here of such things as larval substrate selection behaviour, preferring one substrate over another, as well as spacing in the sense of the spectrum from commonly solitary individuals to those that commonly aggregate together. Physiology is commonly thought to be beyond our grasp, but the relatively conservative substrate selection process is certainly a measure of certain physiological as well as behavioural properties. Evidence of disease, whether it be only teratological as contrasted with knowledge of the actual "cause," can be extracted from the fossil record, particularly if samples are sufficiently large. Information about the diets of past organisms is in short supply. However, visceral region remains provide a fair source for well-preserved vertebrates. For most invertebrates dietary information is mostly absent. Community ecology, contrariwise, is a rich source of potentially useful taxonomic information. For the relatively stenotopic, uncommon to rare genera this is particularly true. The recognition and definition of community types is still in its infancy, despite its great taxonomic potential. Autecology of taxa with close modern relatives is fairly straight forward, but for organisms belonging to extinct higher taxa it is far more speculative, although sound functional morphological analysis is of assistance in some instances. Data on the relative abundances of taxa, high to low, is of great value, particularly since it commonly correlates with the stenotopy to eurytopy spectrum, as well as with the cosmopolitan to provincial spectrum. Counts of the numbers of taxa in each sample are then of great potential value although seldom published in the past. The definition of biogeographic units globally is still another valuable area where the differing degrees of provincialism can provide clues concerning stenotopy and eurytopy. One cannot overemphasize the importance of doing one's best to obtain as large a sample as possible at each locality. Still another potentially valuable data source, particularly for some invertebrate groups, is careful study of shell structure down to at least the family level; its potential at the generic and specific levels is untested at this time. All of the above suggests that many more parameters may be included with profit in taxonomic descriptions.

LYELL MEETING 2007

Early Palaeozoic peri-Gondwana terranes:
New insights from tectonics and biogeography

21 February 2007

The Geological Society, Burlington House,
Piccadilly, London, W1J 0BG

Technical Convenor:

M.G.Bassett
National Museum of Wales

Late Cambrian
490 Ma

The meeting will form part of the 200th anniversary of the Geological Society and the 50th anniversary of the Palaeontological Association. Additional support from the National Museum of Wales will also recognise the 100th anniversary of the Museum.

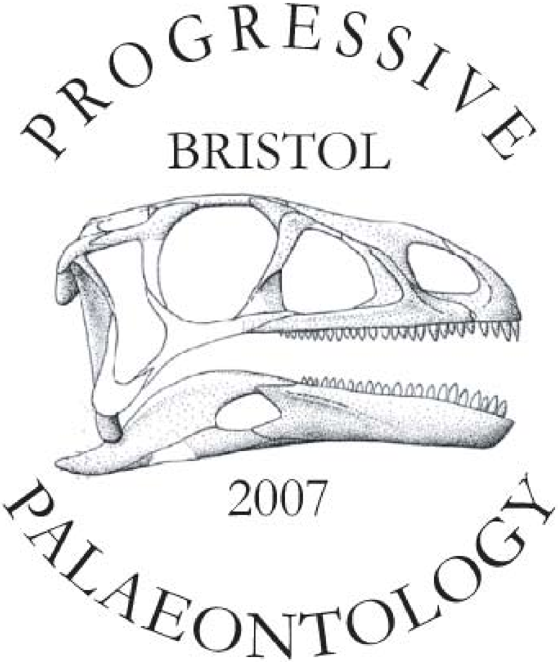
In recent years there has been considerable emphasis in both palaeogeographical/palaeontectonic and palaeobiogeographical studies, with the emphasis on reconstructing ancient Palaeozoic continents. This meeting will focus specifically on the Cambrian to Silurian evolutiom of marginal terranes that form the periphery of Gondwana itself or that broke away from the main Gondwanan supercontinent at various intervals through the early Palaeozoic. Speakers are being invited from various parts of the world to present new insights into aspects of peri-Gondwanan terranes. An outstanding example of recent controversies now challenging what had become an accepted interpretation is the re-examination of the Argentinian Precordillera as a drifted segment from Laurentia.

Apart from examining the physical/tectonic composition of peri-Gonwanan terranes, there will then be regional analysis of Cambrian through Silurian biogeography, covering regions including Armorica/North Africa, Perunica, the Middle East, Kazakh terranes, Avalonia, Cetic oceanic terranes, Argentina/Bolivia and Australia/Antarctica. It is proposed that the proceedings of the meeting will be published as a Special Publication of the Geolgical Society of London and the programme will also represent a contribution towards IGCP Project No. 503 Ordovician Palaeogeography and Palaeoclimate.

For further details please contact Georgina Worrall, Conference Office, Geological Society, Burlington House, Piccadilly, London W1J 0BG. Email: georgina.worrall@geolsoc.org.uk or Tel: +44 (0)20 7434 9944

www.geolsoc.org.uk / www.palass.org

First Announcement



13–14 April

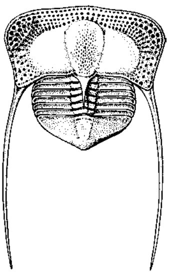
Department of Earth Sciences, University of Bristol

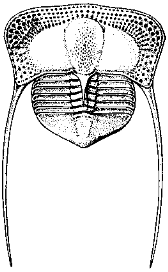
The University of Bristol is pleased to announce that it will host next year's *Progressive Palaeontology*, an annual conference for postgraduate students who wish to present their results at any stage of their research. As in previous years the itinerary will include one day of talks (with social events in the evening) followed by a fieldtrip to a local fossil locality.

Further information, including abstract submission, details of the fieldtrip and social events will be added to the website: <**http://palass.org/**>.

If you have any specific questions then you can contact the organising committee by email: <**progpal2007@palass.org**>.

(Previous attendees of *Progressive Palaeontology*: please note that the meeting has been moved forward from its usual June date.)



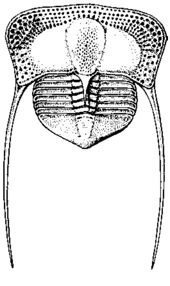


Palaeontology:

CALL FOR SHORT PAPERS!

From January 2005 *Palaeontology* has been published in A4 size with a new layout. In line with this development, space is reserved for rapid publication of short papers on topical issues, exceptional new discoveries and major developments that have important implications for evolution, palaeoclimate, depositional environments and other matters of general interest to palaeontologists. Papers, which should not exceed six printed pages, should be submitted in the normal way, but they will be refereed rapidly and fast tracked, on acceptance, for publication in the next available issue.

Submission of longer review papers is also encouraged, and these too will be given priority for rapid publication. While *Palaeontology* maintains its reputation for scientific quality and presentation, these developments will ensure that the Impact Factor of the journal reflects its status as a leading publication in the field (rising to 1.19 in 2003).



Blowing in the wind

There are those years when a tiny part of nature goes crazy. That plum harvest so abundant the branches break from the sheer weight of fruit. The years when the legendary lemming goes on the lam, and the red tides of toxic plankton. The ladybird Summer that reduces the common greenfly to an endangered species, or the season when massed ranks of daddy-long-legs emerge at dusk, the spirit of Hitchcock taking over their insect souls.

These last few months, in the bizarre ecosystem that is newspaper publishing, it has been the Summer of the free wallchart. Newspapers have vied with other newspapers to produce the biggest, the best, the brightest wallchart. There have been wallcharts of sea fish and freshwater fish, of gentle garden birds and of the big fierce birds that eat gentle garden birds, of amphibians and reptiles, and of whales, and of gemstones, and of the stars of the night sky. We are perilously close, it seems, to the Wallchart Event Horizon, that moment foretold by Douglas Adams[1], when the economy of a nation reaches a threshold when only wallcharts are produced, while agriculture and commerce have collapsed. The wallcharts pile up in boxes in every room of every house (for the walls have long been entirely be-charted), while the starved and ragged inhabitants of that nation roam the streets in search of new and previously undreamed-of wallcharts: a vain enterprise, as every conceivable topic has already been covered three times over.

Well, that threshold may be imminent, but it has not yet been crossed, not quite. So one can simply abandon oneself to the instruction and enjoyment to be found in their content. A few days ago there was – courtesy of the *Grauniad* – the History of Life, a splendidly colourful example of its ilk. Life is represented here mainly by sundry vertebrates, mostly dinosaurical, with a few assorted representatives of the Burgess Shale bestiary and the more Gothic forms of the Echinodermata (the *real* emperors of this planet, the bacteria, mind, don't even get a mention). And that pang when one realises that – oh, scandal and tragedy and thrice woe upon woe! – the graptolites have been omitted altogether. There's no justice in the yellow press.

The timescale is nicely revisionist, and would have Russophiles cheering and the International Commission for Stratigraphy tut-tutting disapprovingly, for the newest geological period of the latest Precambrian is labelled Vendian rather than Ediacaran. The resident Vendobiota, those strange quilt-creatures that ruled the sea floor before the Cambrian exploded with proper creepie-crawlies, are wonderfully depicted. Passive stick-in-the-muds on microbial mats, as dull scientific thought today holds them to be? Pshah! These vendobionts crackle with energy and athleticism: *Spriggina* cleaves through the water like a proto-barracuda, while good old *Charnia*, the original rock star of Charnwood Forest, seems, swaying crazily, to be trying to create the most primordial Elvis impression of all.

Rolling on forward past the dinosaurs, the mammals colourfully bestride the Tertiary Period (cheers for that old-fashioned nomenclature from the more disreputable spectators in the

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[1] Though in his case for shoes. An enigmatic choice, perhaps explicable only by the strange fascination that Imelda Marcos then exerted upon the world.

threepenny stalls). And then on into the Quaternary Period (retained, thank goodness!), starting at 1.8 million years (jeers, now from the paid-up voters for the 2.6-million-year boundary) and then – caramba! – finishing 10,000 years ago (derisive whistles from all, now, and planned letters to the Graun Ed sniffily explaining the difference between the Quaternary Period – still present and ticking – and the Pleistocene Epoch – departed now these past ten millennia). Left field in the Quaternary, and looking pensively across at a sabre-toothed tiger, is an *Australopithecus*, hand outstretched as if already grasping for the furled umbrella of office-bound enslavement, the destiny of the hominid lineage.

All good clean fun. Nonetheless, once one has finished the wholesale puncturing of these barrel-bound fish with the Gatling gun of a rigorous stratigraphic upbringing, deriving merriment quite unjustly at the expense of the harassed and overworked wallchart artists of Fleet Street, there is food for thought here. Just simple interlinked images, perhaps, but nevertheless together they create a context that can be altogether compelling. One of the pictures that, in extreme youth, most kindled my imagination was a marvellously recreated section through the open ocean in an old *Life* (Special Edition for Young Readers) encyclopaedia. This was a marine ecology diorama, in which palest indigo sunlit surface waters, with marlin and flying fish, shaded into deep blue midwaters where squid and sperm whale fought in mortal combat, and thence to a Stygian black abyss inhabited by nightmare fish, huge jaws agape below their phosphorescent lures. There's a sense in which this diorama still forms part of the mental prism through which I try to imagine – always in vain, alas – the long-vanished ocean world of the graptolites.

Some reflection of the train and pattern of life does emerge and – of course – the shadow of Charles Darwin lies deep across these panoplies of interlinked animal and vegetable life. Charles Darwin, of course, cast a giant shadow across both science and society, and in so doing eclipsed, inadvertently, the reputation of a protagonist of my last column, Alexander von Humboldt. Darwin, of course, was trying to understand the relations between living creatures, while Humboldt's ambition stretched further: the last man who knew everything, who literally walked with kings, and whose encouragement to the young Simon Bolivar could literally be said to have shaken kingdoms. A scientist-adventurer, the first person in 60 years to penetrate the jealously guarded Spanish fiefdom of South America, he ascended higher than anyone else in the world, almost reaching the summit of fearsome Chimborazo (then regarded as the highest mountain in the world[2]), and wrote, prodigiously, on his travels[3].

There's no doubting Humboldt's influence on Darwin. His massive *Personal Narrative* was published between 1814 and 1829 – two years before the Beagle set sail – and must have been background reading for the young Cambridge undergraduate. Background, did I say? In *The Voyage of the Beagle*, Humboldt's invisible presence looms large. Sometimes as remembered

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[2] In a sense it is; Everest is higher, but Chimborazo is further from the centre of the earth. A few more nuggets like this, and I might suspect Wikipedia of being a treasury of fascinating but useless information.

[3] As an aside, he stumbled upon the Discworld before Terry Pratchett did, quoting ancient Indian myth[4] where the Earth is borne up by an elephant that in turn is supported by a gigantic tortoise. For good measure, he explains the reason for this arrangement: it is so that *the elephant may not fall*. Ponder Stibbons would tip his hat in admiration, and even Granny Weatherwax might permit herself a wintry smile.

[4] This is in a passage (Humboldt, 1848, p. 288) where he is musing on the 'most ancient formations of slate and greywacke', that contain 'some remains of seaweeds from the Cambrian or Silurian sea'. I'll bet these seaweeds weren't seaweeds at all but graptolites, discerned by the great man's keen gaze. Humboldt 1: *Grauniad* 0.

phrases from the *Narrative* (in the tropical forests of Bahia, where Darwin (1839, p.33) was:

> "particularly struck by a remark of Humboldt's, who often alludes to 'the thin vapour which, without changing the transparency of the air, renders its tints more harmonious, and softens its effects' ."

Sometimes by comparison:

> "When at the Rio Negro, we heard much of the indefatigable labours of this naturalist. M. Alcide d'Orbigny, during the years 1825 to 1833, traversed several large portions of South America, and has made a collection, and is now publishing the results on a scale of magnificence, which at once places him on the list of American travellers second only to Humboldt" (Darwin,1839, p. 90).

Or sometimes as simple unalloyed praise:

> "As the force of impressions generally depends on preconceived ideas, I may add, that mine were taken from vivid descriptions in the narrative of Humboldt, which far exceed in merit anything else which I have read." (Darwin, 1839, p. 477).

The Voyage of the Beagle may indeed owe much to the example set by Humboldt's journal. Its scale, though, is rather more manageable. One reason why the *Voyage*, and not the *Narrative*, is still widely read today is that it can, in the small print editions, still claim to be a slim paperback. Humboldt's epic weighed in at three volumes when Routledge sacrificed a small forest to its reproduction in 1851: light reading for only the longest of train journeys (Paris to Vladivostok, perhaps).

Another reason is that Darwin's insights may have ranged across a narrower field than Humboldt's, but they bit deeper into the human psyche. So deeply, in fact, that they have become inflamed rather than healed over the last century, in Kansas courtrooms and beyond, as they provided a vision of humanity that is closer to ape than to angel[5].

Our own species-specific sensitivities aside, there's the sheer range and explanatory power of natural selection. We assume that it acted, slowly, on countless generations of bacteria in the Precambrian empire of slime mats, longer than our metazoan one by far. We assume that, yet earlier, it acted on the myriad ever-changing tangles of clay minerals and amino acids in the late Hadean era, as the planet-sterilizing impacts of the Late Heavy Bombardment waned, the inner solar system clearing itself of the most lethal of its leftover planetary rubble. We may speculate (or hope, or fear) that this process is taking/has taken place on worlds many light-years from our own, in whatever cradle of aqueous chemistry or crystal lattice or plasma vortex where life might conceivably emerge.

Can one stretch Darwin's dangerous idea further, into the world of purely physical phenomena? Let's take a walk straight towards the elephant trap of hopelessly misguided analogy. Those of delicate scientific sensibilities may choose – if they have any sense – to depart from the narrative at this point. As to those who rashly stay the course[6]… well, I take no responsibility for any confusions – or possibly contusions? – inflicted upon one of the leading paradigms of our day.

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[5] Thomas Carlyle has many followers, even today, in having 'no patience whatever with these gorilla damnifications of humanity'.

[6] What is about to transgress these pages will, I fear, be akin to a shaggy dog story. The punch line is interminably long in coming, and tantamount to an actionable offence when it finally does arrive.

Some years ago, I was helping run an (inexplicably popular) field course to Tenerife. Now, this is a fine volcanic edifice, higher even than Humboldt's Chimborazo, if one cheats by measuring up from the bottom of the ocean. Taking a little time off from teaching the rudiments of big fierce volcano behaviour, my colleagues and I were on a beach (but where else?) at mid-day. The idyll was tempered by a wind fierce enough to make our lunchtime sandwiches so tautological[7] as to imperil whatever tooth enamel we still possessed. So we looked at the patterns forming in the sand around our feet.

Now, ripples and dunes are things that count among the rudiments of the earth sciences, from school days – those barchans and seifs – on to proper geology (say, by revealing whether strata are the right way up or – locally reversing the polarity of deep time – have been turned upside down). Look closer at a ripple driven by a current of water on a stream bed, and there's the four-dimensional geometry of the sand grains tumbling down its advancing avalanche face, grains scavenged from the destruction of previous avalanche-face-layers on the upcurrent slope of the ripple by the onrushing water. The entire structure advances as one; one, in fact, of a train of equally-spaced ripples. The grains themselves – sometimes buried, sometimes in forward motion – sweep in a stop-go fashion from ripple to ripple. The ripples themselves move steadily on, independent of their component grains, yet related to their motion. It is like observing a living creature.

Now the study of this phenomenon can (and has) become most awfully proper and rigorous, with learned research articles analysing shape and form and grain size and current velocity and deriving com-pli-cat-ed equations from the interplay of these. All kinds of relationships between these parameters have been teased out, and these, for sure, have helped make these sedimentary structures useful clues to the nature of currents of wind and water that functioned in long-departed earthly (and, lately, Martian) environments.

And yet, and yet… what, at heart, *are* ripples? Why do they exist in the shape they do? What is their function – if one can indeed speak of these things in terms of a function? Here things become a little hazy. Terms such as 'self-organizing structures' and 'emergent properties' have been bandied about in recent years (*e.g.* Kocurek & Ewing, 2005). These reach towards terrain occupied by Gaian perspectives of how the Earth functions, but otherwise they haven't helped me much. Selim Yalin, back in 1977 (p. 236), in the midst of a highly mathematical treatment of

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[7] This is only a pun, or play on words, in the narrow sense of the term. Compare the phrase 'punishable offence'.

ripples and dunes, produced a splendidly pithy aside:

> "In other words, the reason for the failure to explain the origin of sand waves does not seem to lie so much in the suggested explanations themselves, but in not being clear as to *what* these explanations were supposed to explain".

A wonderful expression of honest perplexity. That thoughtful interpreter of the Alps (and much else), Ken Hsü, had a go in 1989 (p. 112). Though finding 'no profound theoretical explanation' he quoted the wartime desert engineer and sand-dune theoretician Ralph Bagnold in comparing a river with a motorway. When it needs to slow down, it creates bumps – ripples and dunes – on its bed; when it needs to speed up, it washes them away. Well, that's a thought. But, on that windy Tenerifean beach, it didn't seem to add up, for an atmosphere's worth of moving air doesn't need – surely – the equivalent of microscopic sleeping policemen to slow it down. Instead, looking at those ripples forming, the logic seemed to flip upside down, and an echo of Darwin blew in from the wide Atlantic Ocean.

Wind ripples were forming, sure enough, as the sand whipped past our ankles. But so were surprises. Firstly – something I'd forgotten – wind ripples are not like the current ripples that form underwater. They are low, almost symmetrical, with no avalanche faces. Regular they are, for sure: evenly spaced, in trains. Which brought the second double-take. For the wind that formed them was anything but regular, changing continually from calm standstill into gusts that lasted anything between five and twenty seconds, sometimes evolving into rotatory dust devils.

During gusts, the wind on that beach was whipping up an almost continuous flying carpet of sand, at around ankle height. But as for the wind ripples on the surface… goodness gracious, they *weren't moving*. Closer inspection (at one time three people were lying on their stomachs, like anchovies in a current, intently watching the ripples) revealed that they *were* moving, but only very, very slowly. They were moving slowly because they – or rather their crests – were built up of somewhat coarser grains, while the stuff flying around was the fine-grained material from the troughs.

The coarse crests were in the literature, sure enough; but what wasn't was the sense that these coarse grains were essentially forming barricades to their own movement, assuming a position of maximum stability, enhanced by inter-particle friction within the crests. Linking arms, so to speak, to stay put. When a grain was eventually dislodged, it quickly rolled across the fine grains in the trough, like a football on ball-bearings, to lodge itself among its peers in the next crest. These sedimentary structures weren't operating to facilitate sediment movement, but evolving the best means to prevent it. (The smaller particles, though, just got swept away in the air current, pausing periodically on their breakneck journey in the shallow ripple troughs).

Ripples as structures formed to resist movement? It certainly seemed so, in this case. There are parallels, of course, the most notable being the way that flat pebbles assume an imbricate, upstream-dipping attitude on the bed of a fast-moving river; those dipping downstream immediately get flipped over. Or the way that, for the same reason, shells in such a current settle at their position of maximum stability, which is convex-up. But I hadn't heard of ripples or dunes before being discussed as devices that evolved – or emerged – to maximally resist sediment movement.

Thus, the grains on that beach that remained in the crestline barricades did so by natural selection *sensu lato* – they maintained their position partly by being largest and most appropriately shaped grains, and partly by adopting the most effective position of resisting the shearing effect of the wind. Packed together, they formed a low-angled armoured shield (the ripple lee and crest) facing into the wind.

How close was this really to natural selection? Well, it was entirely natural, and it certainly involved selection from a range of grain sizes and shapes. It caused a flat or irregular sand surface to evolve, quickly, into a pattern of complex, composite, regular structures: that 'self-organizing' aspect. An aspect that has, indeed, been compared (as 'no coincidence') with that of biological systems (Camazine *et al.*, 2003).

An insight of Wordsworthian[8] profundity, therefore? Well, likely not. There are, alas, limits to any analogical relevance in this fable. A surface of windblown sand evolves into ripple-forms, and thence into larger dune shapes, tens or even hundreds of metres high. Are these larger dunes, and, indeed, their cousins on river-beds and sea floors, also transport-resisting devices? Case not proven, and most likely not yet even examined, m'lud. In any case, alas, it seems unlikely that these structures could evolve yet further into even more complex forms: and then on into (eventually) living, metabolizing, sentient dune-creatures[9].

Still, it does emphasize the extent to which selective forces writ large, so to speak, may have shaped the matchless variety of patterns and shapes, both living and non-living, on this and on other worlds. It's a variety that should be further celebrated. How better than by another addition to the wallchart oeuvre? I doubt that the mainstream press would buy the idea of a wallchart on the range and scale of sand dune structures – though such a thing would, of course, increase vastly the pleasure and intellectual profit to be had when watching such cinematic epics as *Lawrence of Arabia* and *The English Patient*.

One might persuade them, though – perhaps after a long lunch break as *de rigueur* during the golden years of Fleet Street – to produce something to show the real variety of life. This would highlight the unjustly disregarded branches of the Tree of Life. Affirmative action, indeed, of the most fundamental type, and just the thing to appeal to a newspaper of unshakeably progressive principles (I take it all back, you see). No dinosaurs or trilobites allowed, while even *Hallucigenia* and its Burgess Shale brethren would be kindly but firmly shown the door.

Instead, there would be euryarchaeotes and deinococci, kinorhynchs and xanthophytes; cryptomonads, sipunculids, pogonophores, sphenophytes, orthonectids, gastrotrichs, echiurids, hepatophytes, phoronids and (well, okay then) perhaps just possibly a token craniate[10]. And, of course, somewhere central and subtly enhanced, representing the hemichordates, would be a graptolite, basking in its fifteen minutes of fame. What a sight that would be: justice – at last! – for the neglected phyla of the earth.

Jan Zalasiewicz

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[8] As so ably encapsulated by James Kenneth Stephen: "One voice is of the deep; and one is of an old half-witted sheep".

[9] A shame, as such silicon-based life-forms would make for marvellously terrifying alien invaders for Captain Kirk of *Star Trek* to valiantly overcome. Formidable opponents, indeed, impervious to laser, taser, phaser or maser. All would seem lost!… until, in the nick of time, our rugged hero would have a flash of inspiration and blow them away with his trusty hair-dryer.

[10] The April 1st edition would naturally include the frumious bandersnatch.

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Demolishing the ivory tower: science as entertainment

A disingenuous definition

Science is the noble pursuit of knowledge, perhaps even “the noblest” of human endeavours (Horgan, 1996: 3). It is part of a long, honourable, and increasingly democratic tradition of attempting to understand the natural world and our place in it. As such, it represents an acme of intellectual struggle rivalled by few other creative endeavours of the mind. This is a version of the standard refrain imbibed by most practising scientists to explain to themselves and to others the why and what of their occupation. It is certainly the rap I present to claim the relevance and value of my work when asked by interested laypeople. However, when we come right down to it, this characterization of science is disingenuous and self-serving. Is science the pursuit of knowledge? Yes, *par excellence*. Is it noble, honourable? Nonsense.

A large proportion of what constitutes scientific research is no nobler than masturbation. The majority of scientists are in science for a very simple reason: they enjoy doing it. Some even seem masochistic as they confess to endure years of drudgery in the lab chiefly as an, often uncertain, means to earn access to what frequently turns out to be the misleading holy grail of security in a permanent position.

There is nothing inherently admirable or noble in doing something that you like. We have a different word for that: hedonism. An activity may have the potential to become noble if it explicitly aims to benefit more than just a single person. Well certainly, scientists may claim, their mental labours contribute much of value to society. In principle, of course, this cannot be denied. But whether this qualifies as noble entirely depends on whether the broader significance is the *raison d'etre* of the activity. As I will argue later, this is very doubtful. To me, pure science is an intensely hedonistic enterprise that merely attempts to masquerade as a noble pursuit to earn the ultimate justification of public approbation. I think we have been hiding behind this mask for so long that we have started to accept it as our own reflection when confronted with a mirror. I certainly did. I think that this deplorable situation is the result of the failure of most scientists to own up to an inconvenient truth that threatens the splendour of science's ivory tower: science is just entertainment.

Science = entertainment

With the exception of medical and applied sciences, such as conservation biology, which have an immediate aim of improving or safeguarding the quality of human life, all science is simply entertainment. Fundamental science is the business of creating knowledge about the world. Producing and consuming that knowledge is simply entertainment. This is obvious when we consider the reason why scientists do what they do. If we are not mere slaves to money, the proximate reason why we do our work is because it entertains us. In this respect practising pure science is no different from other human creative endeavours, including literature, poetry, art, music, and films. The processes of discovery and creation in their different forms are intensely satisfying. Frank Zappa worked up to 16 hours a day alone in the basement of his house composing music because it entertained him. Postdocs all over the world spend long days in the lab because they, most of them anyway, enjoy doing research. Without finding their work entertaining, they could not hope to muster the passion to do it, often for merely a bare minimum in monetary rewards.

So, considered from the proximate perspective of creating science or art, there is no denying that entertainment value is the common currency of our work. What about the ultimate perspective: the consumers? First of all, unless you are a commercial sell-out, explicit concern of your prospective audience is of secondary importance. You can only create something with integrity and freshness if you don't allow your personal vision to be compromised by external demands. Unfortunately, the realities of research funding, and the need to sell your product in order to survive often compromise this creative ideal, both in science and in the arts. The nature of much published mainstream science follows the changing winds of fashion, which, to an important degree, are determined by the funding criteria of granting agents. Similarly, the Top 40 music with which we wallpaper our lives is much less the unconstrained acme of creative intelligence, than a mass product imposed on us by record companies that are continuously in search of the next 'star' needed to satisfy the wishes of the world's 15 year olds. Nevertheless, in an ideal world, in science as in the arts, the product is primarily a reflection of the creator's interests and values.

Second, after they have been created, the products of pure science and the arts are in the public domain. Your judgement of these products is entirely personal; no universal prescribed way to appreciate them exists. As truly democratic and quintessential human constructs, what is entertaining, interesting, and important is entirely in the eye of the beholder. I find it entertaining to know that the gene *engrailed* is expressed during segment formation in the centipede *Strigamia maritima*, just as I find it entertaining to know the music of Frank Zappa. My friend Ariel Chipman, who works on *Strigamia*, probably attaches greater importance to the data about *engrailed* expression, and he may not particularly like Frank Zappa. Both viewpoints are equally defensible. But for both of us, the products of science, whether these are descriptive details about individuals (idiographics), or inference about law-like regularities (nomothetics), simply provide entertainment.

This is not meant to downplay the value of entertainment. To the contrary. As long as our basic needs to survive are secure, entertainment in a diversity of forms is an important determinant of the quality of life. My life would be so much the poorer without science, both popular and professional, but in the end it is just entertainment, just as sport is to other people. Most people are arch hedonists, but they are reluctant to admit it. There is nothing wrong with hedonism, as long as it is not blatantly dishonest. However, pure science masquerading as the noblest of human activities is exactly that. A point could legitimately be made for science as a noble pursuit if it was one of science's explicit aims widely to disseminate the knowledge it produced. Shockingly perhaps, on this criterion, the existing entertainment business seems to be nobler than pure science.

The Gould paradox

As argued above, pure science shares much with other creative human activities, the aim of which is to provide entertainment to enrich our lives. The creative processes involved in doing science and creating art also share a number of commonalities that may attract the same kind of personalities. For example, the cartoonist Gary Larson's fantasy job was to become Stephen Jay Gould's hunchbacked assistant, while Frank Zappa might have become a chemist had not his love for music been so encompassing (Larson, 1999; Zappa, 1989). Interestingly, Bowler (2000) argued that scientists often derive their theoretical orientation as much on the basis of non-rationalized feelings of intuition and instinct as on the basis of an unbiased rational weighing of evidence and logic. This seems firmly to align an important component of scientific thinking with the accepted norms in the creative arts. Yet, the unity of human creative endeavours dissolves into what I consider the most outstanding oddity of science: its remarkably indifferent attitude towards its prospective audience once the product is finished. I call this the Gould paradox.

Surely, this is an unfair allegation? After all, the fruits of our research are published in the appropriate places, where they are available for everyone's delectation. Unfortunately, to the average layperson this professed accessibility of research results is little more than a meaningless pacifier. It's hardly realistic to expect that the average interested layperson will journey to a university library to access a specialist journal in their quest for knowledge. The attitude adopted by many scientists is one of pure elitism, consciously or not. They publish their work for academic peers only. This is of course understandable from the perspective of science as a progressive enterprise, in which new research builds upon previous efforts. This is the only aspect of science that is captured in the citation indices that represent the standards according to which our work is judged. But isn't it supremely selfish, unconscionable even, for scientists to usurp large amounts of public funding without so much as making a serious attempt to disseminate their product to a wide audience? For the public at large the knowledge generated by the majority of pure science is as insignificant as trees falling in the forest with nobody there to witness it. Wouldn't we want, and aren't we at least obliged, to share the excitement of the ride we enjoyed on borrowed money?

Of course we do. We all know that it is important to inform the public about our work. However, by and large, fundamental scientists only pay lip service to public service. Mostly we rely on an able safety net of journalists, science writers and popularizers to communicate our most interesting findings in books, magazines and on TV. Most of us even enjoy consuming some popular science ourselves.

However, all is not well. The David Attenboroughs of this world should be treasured as integral parts of science, facilitating the flow of information to a broad audience. And appreciated they certainly are, but certainly not up to the point of being welcome in the ivory tower. They aren't allowed beyond the moat. Often we have great difficulty hiding our formidable arrogance when we see the work we intimately know exposed in a popular medium. We complain about inaccuracies, simplifications and distortions, conveniently forgetting the many inaccuracies and simplifications that are rolled into the assumptions at the core of much of our own work. We chuckle patronizingly when the flight of the imagination takes a popularizer beyond the strictest limits of scientific fact. I'm sure there is much to object to in the following capsule review of human prehistory by Bill Bryson (2003: 19): "To get from 'protoplasmal primordial atomic globule' … to sentient upright modern human has required you to mutate new traits over and over in a precisely timely manner for an exceedingly long while. So at various periods over the last 3.8 billion years you have abhorred oxygen and then doted on it, grown fins and limbs and jaunty sails, laid eggs, flicked the air with a forked tongue, been sleek, been furry, lived underground, lived in trees, been as big as a deer and as small as a mouse, and a million things more. The tiniest deviation from any of these evolutionary imperatives and you might now be licking algae from cave walls or lolling walrus-like on some stony shore or disgorging air through a blowhole in the top of your head before diving sixty feet for a mouthful of delicious sandworms."

But at least it is enormously entertaining, which is a crucial step in any successful learning process. In return we feel insulted when we are confronted with a patronizing chuckle when we explain to a layperson we are devoting a career to studying the minutiae of the biology of tiny beetles living in mushrooms. If we have something real to whine about, it is our own general unwillingness or ineptitude to engage the public with why our research is interesting, entertaining, important even. We can't blame it on the public or on the popularizers. There are still more than enough laypeople whose enthusiasm about all aspects of the natural world has survived the onslaught of mandatory learning in primary and secondary education. Perhaps we should try to be a bit more proactive in trying to market our own product? It may be a boon to research itself. For example, Stephen Jay Gould was able to support students with money he earned from speaking engagements. Gould did an immense service to science with his popular writings, and many scientists are deeply appreciative for this, as they should be.

But, disturbingly, Gould was also Saganized for his popular science writing. In an infamous incident at the National Academy of Sciences in 1992, the astronomer Carl Sagan was rejected for membership after provisional election. His primary celebrity as an important popularizer of science may well have been at the root of his rejection. Gould suffered in a similar way from being condescendingly depicted by some as a mere popularizer, rather than a serious scientist. Michael Ghiselin, whose work I admire immensely, bluntly put into print that he hoped that the MacArthur grant awarded to Gould would allow him to stop writing popular works and do real science instead (Ghiselin, 2002). And Gould is not unique, as I've repeatedly witnessed colleagues making disparaging remarks about the works of peers that were explicitly intended for a broader audience. Such attitudes are deplorable, ignorant and hypocritical. For a business whose product can be labelled as entertainment without any problem, such an attitude towards marketing is nothing short of mystical.

Evidently, science as entertainment is not a popular notion. However, at its most basic level, entertainment is all it really is. Consumption of the products of the knowledge industry may enhance and enrich your life, depending upon your personal tastes. It is important in exactly the same way as the products of the other great human creative endeavours, such as literature, art and music. Accepting this premise has striking implications for the way in which science could be valued.

SEX: a Scientific Entertainment Index

The citation indices that represent the current standards for judging the merit of our research capture only the extent to which new work is linked to previous work. This is a perfectly valid emphasis in an enterprise dedicated to the process of discovery. However, these indices capture precisely nothing about the value of the finished product as a potential bit of knowledge. In the end, isn't that a crucial measuring stick to have for an enterprise that claims to generate knowledge for knowledge sake? In the absence of consumers outside the halls of science, there is very little justification for fundamental science, apart from facilitating the occasional serendipitous discovery that may help advance applied or medical science in the creation of more palpable benefits for humanity.

In literature, art, and other creative endeavours, the ultimate currency of success or failure is how entertaining the public considers the products. Why should that be any different for pure science? Could it be that some of us don't dare to venture down from the ivory tower simply because we fear that our work will be considered boring? What may be the zenith of excitement for a scientific recluse hidden in the back of a lab or museum may be worth scarcely a glance for anyone else, peer or public. At present, scientific hermits need not worry. As long as the covers of specialist technical journals block the scrutinizing gaze of the public, the fruits of their mental gymnastics will be safe. However, wouldn't it be nice for scientists who are more optimistic about the general value of their work to be able to get an objective idea of public opinion?

Entertainment value is notoriously difficult to quantify. There is no universal, objective index for the worth of a particular piece of science. However, one measure of success that works reasonably well for other entertainment disciplines is the number of sold copies of product. I therefore introduce SEX: the Scientific Entertainment indeX. Restricting this index to scientific papers, in its simplest form it could measure the number of times a paper is downloaded from a journal's homepage. Some journals have already introduced a link to "most viewed articles" on their website. The more a paper is considered to be entertaining, the more often it will be downloaded, and accordingly it becomes more SEXy. This index has the great advantage that it captures in at least some form an appreciation of the papers we will all read and enjoy, but never cite in our own work. For anyone with a healthy appetite for the literature, most of the papers you have enjoyed over the years will not feature directly in your own work. And with very few exceptions, you will probably not have sent the author of each entertaining paper a message to convey your appreciation. This is a missed opportunity for constructive feedback. Discovering your paper is considered SEXy is great positive feedback, while discovering that your paper is not considered SEXy may help you adjust the style or content of future works. This index may of course be refined in various ways, for example to correct for the size of the discipline the paper is reporting on. In this way a paper on the taxonomy of Cretaceous brachiopods can be equally SEXy as a paper on human cancer.*

Such an index may share similarities with, for example, the Faculty of 1000 Biology that is already established on the Internet, with the difference that it is more democratic in allowing everybody, not just a selected elite, to record their appreciation of a scientific paper on the basis of criteria that go beyond the myopia that may be displayed by scientists who have lost all perspective. I'm not suggesting that being SEXy should be the only, or even the most important, criterion on which to judge the success of a scientific contribution. Despite all their faults, current scientific citation indices still have a valuable role to play in helping to determine what research is most seminal in stimulating new work. This is in the proper spirit of science as a way of knowing. However, the importance and interest of fundamental science is not beyond criticism. Knowledge generated by science is not inherently important. Everybody who has ever spent an extended period of time focusing on a small issue knows first-hand that things may come to seem much more important than they really are. I don't think it is rare for scientists to ascribe rather Himalayan proportions to the molehills of their research. I therefore think that it is a good idea to institute an explicit index that allows a democratic assessment of the entertainment value of a bit of research. Raising consciousness about evaluating research on the basis of its entertainment merits among scientists is a first necessary step towards realizing we also have responsibilities to that larger audience: society.

The moral need to acquit accumulated societal debt

Before the modern meaning of 'scientist' came into vogue with its connotations of narrow specialization, men (and women) of science were actively concerned with the general interests

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***Editor's comment:**

If anyone wants to check out the SEXiness of their own (or colleague's!) work, then the following links may be of interest:

ScienceDirect Top 25 Hottest Articles – includes breakdowns by both subject area and individual journal, as well as an archive of recent Top 25 charts: <**http://top25.sciencedirect.com/**>

Faculty of 1000 Biology – includes comments and ratings by individual faculty scientists on individual papers: <**http://www.f1000biology.com/start.asp**>

The Nature Top 10 – does exactly what it says on the tin: the top 10 most downloaded Nature *articles updated monthly:* <**http://www.nature.com/nature/topten/index.html**>

of the public. Thomas H. Huxley is a prime example of a man of science who focused on the minutiae of research, but at the same time organized hugely popular lectures for the general public. At the end of his life he was fighting a losing battle against the redefinition of men of science as mere scientists who had no role to play in public affairs, and whose proper domain was restricted to the lab (White, 2003). The lab is where we stayed. I think we must try to recapture some of the original engagement with the public that dates back to the cradle of professional science. This time not as oracles of moral and social wisdom, but as the suppliers of worthy bits of entertainment. Pure science can no longer turn away from its responsibility to the public. It cannot expect to continue catering solely to its own needs just to create more science for an elite community with scant regard to wider dissemination. I think fundamental science has incurred a large societal debt. Clearly, singing the standard refrain about the noble nature of scientific research published in accessible specialist journals is laughably unsatisfactory as the sole return that taxpayers receive for their money. They deserve more. It is our duty.

The first step on the right way would be to think long and hard about the value of popularizing science, *i.e.* making it accessible to a general audience. We should not tolerate the hypocritical behaviour of colleagues to look down their noses at peers who attempt to bridge the gaping chasm between ivory tower and family living room. We should get down from our high horse and break free from the claustrophobic enclosure of the ivory tower to show what it is that is so entertaining about our work. This will be a necessary first step towards a truly noble contribution of science to society. Even entertainment business can be noble.

Ronald Jenner
Department of Biology and Biochemistry, University of Bath, UK
<rj223@bath.ac.uk>

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Cladistics: Optimisation

In the last two articles of this series we have chosen ways to code characters, constructed a data matrix, analysed the matrix under several options of parsimony analysis (exhaustive, branch & bound, heuristic) and looked at the behaviour of characters on the resulting trees/cladograms. This all came with a bewildering array of details about 'CI', 'HI', 'RI' *etc*. This article delves into what these details mean. They revolve around how the characters are fitted, or optimised, onto trees.

When PAUP* analyses a data matrix it searches for the optimal network that minimises the number of character changes that must be assumed – that is the essence of cladistic analysis. But it is a network and not a tree. To convert one into another requires that we specify a root. A root may be several taxa, one that you specify, or the first taxon in the data matrix (the default option in PAUP*). In pre-computer days folks used to get excited about what was the plesiomorphic or apomorphic state of a particular character. But now, as soon as you choose the outgroup, the plesiomorphic state is set as the state in that taxon (of course, if there are multiple outgroup taxa that differ in the character state assignments then the issues are more complicated – see Maddison *et al.* 1984 for more details). Let us make life simple for now. Optimisation of characters on trees depends on what assumptions of character evolution you wish to enforce. With a binary character (0, 1 states) there is little choice (DELTRAN vs ACCTRAN – see first article). The issues occur with multistate characters that best illustrate how characters are optimised.

For the first way in which a character may be optimised let us assume that we wish the character to change (evolve if you like) in an ordered manner. In the literature this is known as Wagner optimisation because it is the character state behaviour that the botanist H. Wagner assumed when he first devised the 'Wagner algorithm' on which parsimony programs are based. It is also known as additive or ordered for reasons explained below. Figure 1 (overleaf) explains the optimisation procedure. Let us assume that there are six taxa sharing states 0, 1, 2, 4 of a multistate character that has a total of five states (state '3' happens to be missing from the taxa under consideration here). The states of the character possessed by each taxon are given in parentheses. As a result of analysis an unrooted network is produced (Fig. 1A). We choose a root – in this case taxon A that automatically creates the tree topology (Fig. 1B). The nodes on the cladogram/tree are designated by w – z. The process of optimisation reconstructs the states at the nodes that minimises the number of changes that have to be assumed.

We begin by passing down the tree from the terminal taxa, assigning likely states to the nodes. For node (y) subtending taxon C (state 1) and D (state 2) there may be either a '1' or a '2' state. For node (z) subtending taxon E (state 2) and F (state 4) there may be a '2', '3' or '4' state. With a character behaving under Wagner optimisation then to get from state '2' to '4' we must pass through the '3' state (even though it does not happen to be represented in these particular taxa) and in so doing we must add two steps to this change. In other words the character states are *ordered* – hence another name for this optimisation. To express this another way, in order to pass from states 2 – 4 we have to add the state three into consideration; hence the term 'additive'. This is explained in Figure 1D. Now we come down to node (x) that subtends the likely states at nodes (y) and (z). The common element at these latter nodes is state '2'; therefore the simplest explanation is that state '2' exists at this point. Carrying on in the same manner then

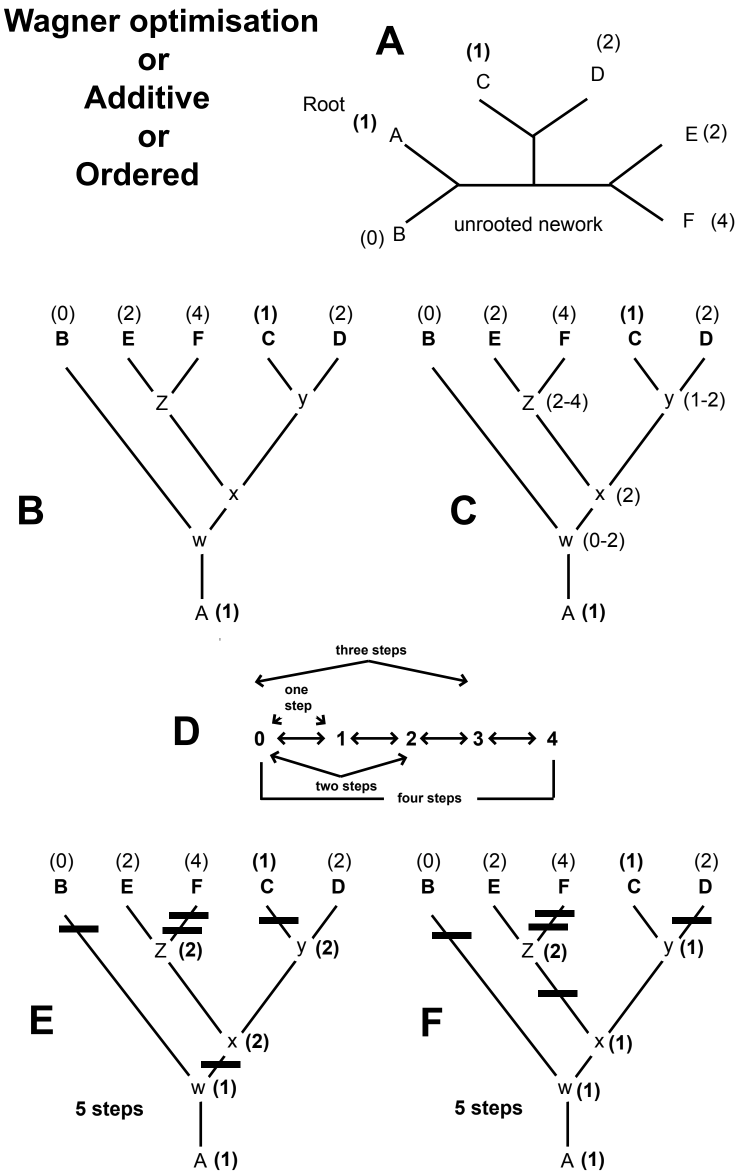


Figure 1. Optimisation of a character assuming ordered transformations

likely states at node (w) are going to be ‘0’, ‘1’ or ‘2’ (0–2). Having done this we are still left with alternatives at nodes (w), (z) and (y). To resolve the states we sweep up the tree choosing the alternatives that minimise the changes. We know the starting point as state ‘1’ since that is seen in the root (taxon A). Therefore passing between taxon A and node (w) to which we assigned ‘0’, ‘1’ or ‘2’ states the most parsimonious solution is to assign a state ‘1’ here. To explain the ‘0’ state in taxon B and the ‘2’ state at node (x), two changes, or steps, are needed. These changes are shown as black horizontal bars in Figure 1E. Try mentally assigning other states to node (w). We know that state ‘2’ exists at node (x). If we assigned a state ‘0’ at node (w) then three changes, or steps, would be necessary to explain the ‘0’ on taxon B and the ‘2’ state at node (x). This is less parsimonious than the first solution and therefore will be rejected. Sweeping further up the tree we do the same exercise and resolve the internal node states as shown in figure 1E, remembering that under this type of optimisation to get from the ‘2’ state to the ‘4’ state we must add two steps, hence the two black bars between node (z) and Taxon F. The total number of steps exhibited by this multistate character on this tree is 5. Figure 1F shows that there is another solution that is also five steps long. When this happens the optimisation is said to be ambiguous (remember those single lines in the character change lists). Cladistics does not choose between these options; you may have your own biological reasons for so doing.

The next commonly used optimisation is Fitch optimisation (after W. Fitch), also known as non-additive or unordered for reasons that are obvious. Here the same network is used as the starting point (Fig. 2A) and the same exercise of assigning likely states to the internal nodes is undertaken (Fig. 2C). This time, however, we can assume that any state can transform into any other at equal cost. Therefore, the node subtending taxa E and F will have a state ‘2’ **or** a state ‘4’, with state ‘3’ not being a possibility. The costs between any of the states are the same (Fig. 2D). Continuing back down the tree and then sweeping up to resolve the alternatives we end up with a solution shown in Figure 2E. Note that there are only four steps shown by this character on this tree when it is assumed that the character is unordered (five steps when it was ordered). Once again there may be more than one solution (ambiguous optimisation). [Please remember that the choice between ordered and unordered is a biological choice and not one simply made because unordered characters usually result in shorter trees! Also, you can order or unorder individual characters (figure 10 in previous article). You cannot set ACCTRAN or DELTRAN for individual characters].

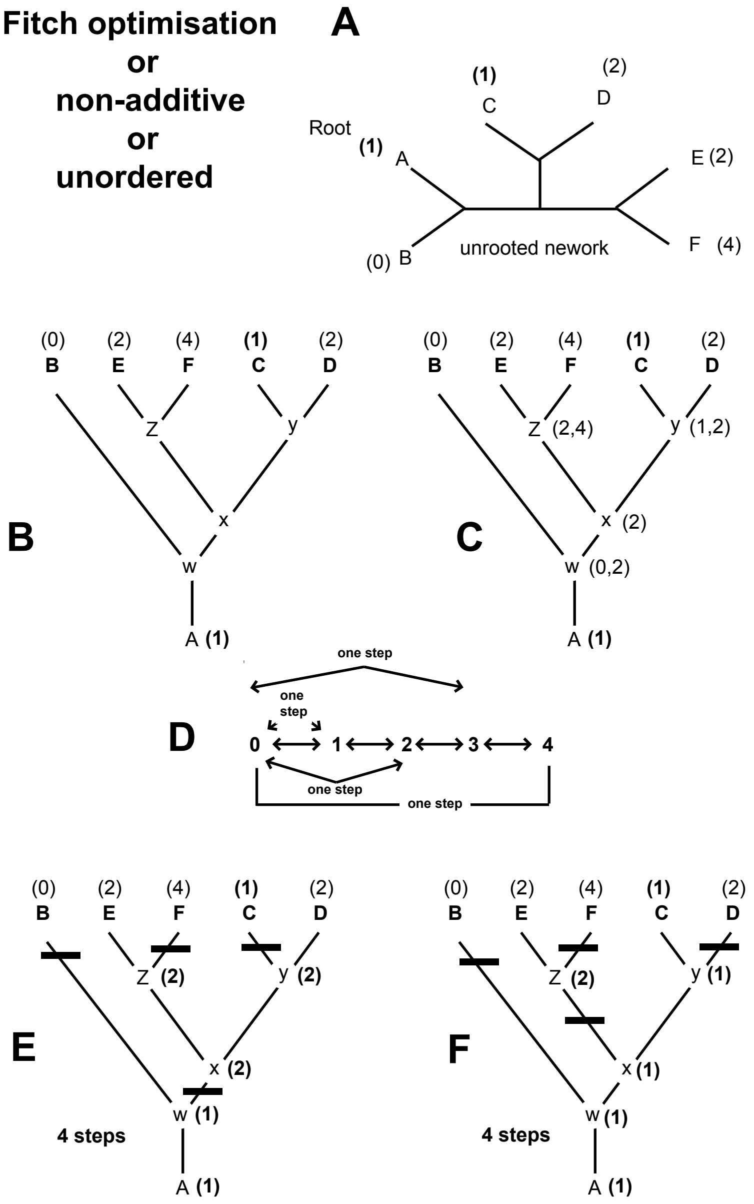


Figure 2. Optimisation of a character assuming unordered transformations

There are two further options that are available for constraining the ‘evolution’ of a character on a tree. Dollo optimisation is used where we may believe that characters cannot be acquired more than once. It is named after the embryologist Anton Dollo (Dollo’s Law) who suggested that once a complex character state has been gained it can never be regained, but that it can be lost on many occasions (an example may be the vertebrate eye). This may be invoked using the ‘Set Character type’ submenu of the ‘DATA’ menu (previous article fig. 10) where you have the option of specifying which way you want the ‘gain’ to be interpreted. In Figure 3 the ‘1’ state is the gain, and because we have to assume that it can only be lost three steps have to be added to the tree in the positions shown, in addition to the basal ‘gain’ step.

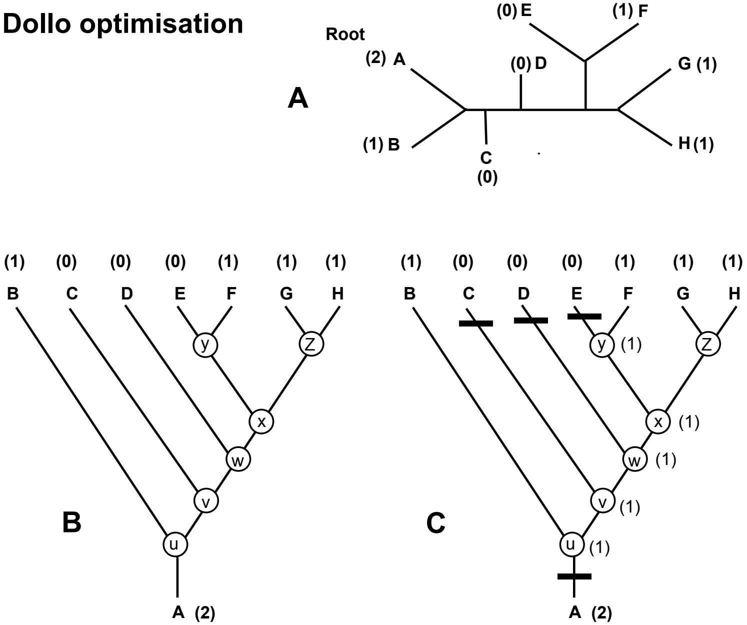
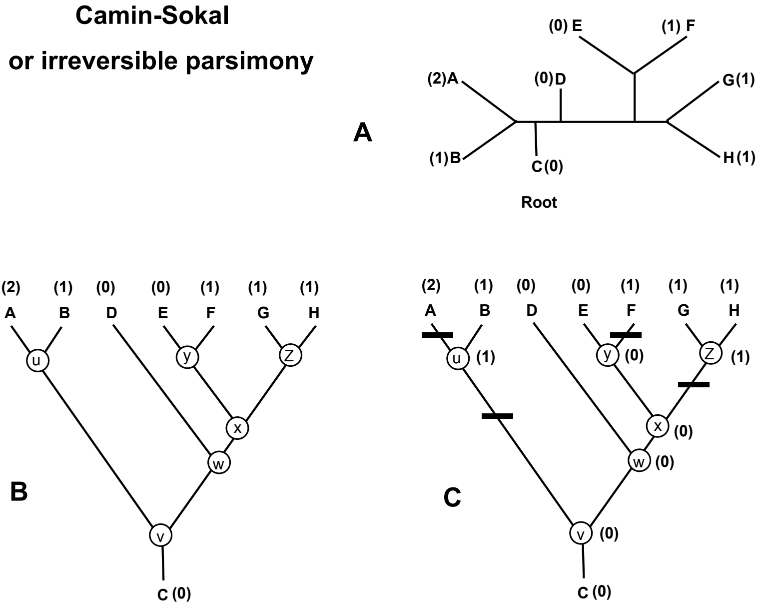


Figure 3. Optimisation of a character assuming Dollo transformation

The opposite of this assumption is called Camin-Sokal parsimony (named after two numerical taxonomists) or irreversible parsimony. This assumes that character states can be gained many times but that, once gained, they can never be lost. I can never think of a good reason for invoking this with morphological data but some biogeographers use it in relation to areas occupied by species.



Camin-Sokal
or irreversible parsimony

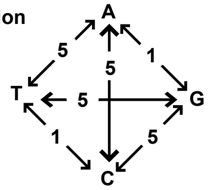
Figure 4. Optimisation of a character assuming irreversible transformation

In the two previous examples given the imposition of Dollo and irreversible is actually no less parsimonious than straightforward unordered optimisation. But usually there are more steps involved. Because of this the more parsimonious trees are likely to be those that favour the minimum assumptions of change under the optimising procedure. But remember the actual result depends on the interaction of many characters, not just the one that you have constrained.

All of the above optimising procedures are carried out in the parsimony algorithm through small matrices called ‘step matrices’. These specify the ‘cost’ of assuming certain character state transformations. In Figure 5 step matrices are given for the four types of optimisation above. For ‘ordered’ characters then the cost of passing from state ‘0’ to ‘2’ (in either direction) is two steps and from state ‘3’ to state ‘0’ it is three steps *etc.* Under the unordered regime than all changes occur with equal cost (one step). Under Dollo then M equals a very large number. Thus if the optimisation favoured two independent changes of ‘0’ to ‘2’ the 2 x 2M steps would be added to the tree and this would almost certainly make the algorithm reject such a tree as decidedly suboptimal. (Note that the reversals *e.g.* ‘3’ state to ‘2’ state add very few steps to the tree). Under the irreversible step matrix the ‘i’ stands for infinity.

	To	**Ordered**				**Unordered**				**Dollo**				**Camin-Sokal**			
		0	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**
F	**0**	-	1	2	3	-	1	1	1	-	M	2M	3M	-	1	2	3
r	**1**	1	-	1	2	1	-	1	1	1	-	M	2M	i	-	1	2
o	**2**	2	1	-	1	1	1	-	1	2	1	-	M	i	i	-	1
m	**3**	3	2	1	-	1	1	1	-	3	2	1	-	i	i	i	-

Transition/Transversion Parsimony



	A	C	G	T
A	-	5	1	5
C	5	-	5	1
G	1	5	-	5
T	5	1	5	-

Figure 5. Generalised parsimony - see text

It is possible to write your own step matrix for any particular multistate character. For instance you may believe that it is four times more likely that state 1 can transform to state 4 than to state 3, *etc.* These are not the easiest things to do, and I do not really know how you would support such actions with morphological data. But the options are there. Remember, the justification is biological, not cladistic. There are perfectly good justifications in molecular data. The laws of chemistry justify that we accept that some changes among the nucleic acids are more likely than others, and molecular systematists regularly use transition/transversion parsimony (Fig. 5 bottom) – in this case imposing a x5 penalty to some changes.

We can now return to the statistics that are poured out when you ask for tree descriptions (see top of fig. 16, previous article). Here you will find the reports of the length of the tree, the consistency index (and a separate line reporting the consistency index excluding the uninformative characters), the homoplasy index and retention index, and something called the rescaled consistency index. All of these statistics relate to the behaviour of **all** characters on the one tree that appears below the statistics paragraph. These are ensemble figures. But they relate back to the statistics of individual characters. The statistics for individual characters can be obtained by checking the ‘*character diagnostics*’ box under the ‘tree description’ menu (previous article, fig. 14).

The character diagnostics reports a number of facts. At the top of Figure 6 (over the page) there are details of the behaviour of two characters, numbered 1 and 2 on the **particular** tree shown immediately below. The character x taxon matrix is shown to the right of the tree. If the tree were a different shape then the statistics for individual characters will probably be different (for nine taxa there are 2,027,025 fully bifurcating possible trees).

Let us have a look at character 1. On the tree character 1 appears twice; once in taxon C and again supporting a group G – I. However, if the tree were a different shape (lower right tree where taxon C is grouped with taxa G – I) then the character may fit only once – it is a perfect synapomorphy and this tree is the best tree for this particular character. Thus, the minimum number of steps the character could make is 1 (this tells you that it is a binary character). On the particular tree in question it actually makes two steps. Therefore the character is not totally consistent with this particular tree. The consistency index (lower case *ci*) tells you by how much it is ‘consistent’ and it is computed by dividing the minimum number of steps the character can make on any of the 2,027,025 trees (= m), divided by the actual number of the steps that it makes on this particular tree (= s). This computes to 0.500 (Fig. 6 bottom). The homoplasy index (lower case hi) is simply 1 – ci. Not many people bother to report this.

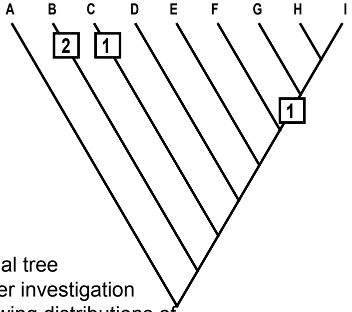
The retention index (lower case *ri*) is a little more subtle. On the particular tree in question the character appears in Taxon C but also as a shared derived character of a group G – I. In other words we could say that, although the character does not fit the tree perfectly, part of the distribution of that character is retained as a shared derived character, potentially enabling us to recognise a group G – I. Part of the character distribution is retained as a potential synapomorphy, hence the term retention index. How much is computed by the formula shown at the bottom of Figure 6. ‘m’ and ‘s’ are the same as for the consistency index calculation. ‘g’ is the maximum or greatest number of steps the character may make on any of the 2,027,025 trees. In other words ‘g’ is the measure of the worst fit. The worst fit actually means the worst of the most parsimonious solutions for all trees (if that makes any sense!). The tree shown at bottom left is such a tree where the character must be assumed to have arisen on four occasions (in practice the ‘g’ value will be the lesser figure of occurrence/non-occurrence in the data matrix). Using the formula given, then the retention index for this character will be 0.666. The rescaled consistency index (lower case *rc*) is ci x ri and is often used to reweight characters (below).

Now look at character 2. This character is only found in Taxon B, therefore it has no grouping ability at all. Yet it fits the tree perfectly and ci = 1 (hi = 0). Because it has no grouping ability the retention index must be 0 (1-1/1-1). Thus the retention index is often more informative that the consistency index.

The values for the consistency index and retention index reported when you ask for tree descriptions are *ensemble* values for *all* characters on a particular tree. Thus the ensemble consistency index for the tree in question (Upper Case *CI*) is calculated as the ratio of the minimum number of steps that all characters can make on any tree to the minimum number of steps all the characters make on the tree/cladogram in question. The ensemble retention index (Upper Case RI) is similarly calculated where G is the greatest number of steps that all characters can exhibit on any cladogram. And RC is simply CI x RI.

Character diagnostics

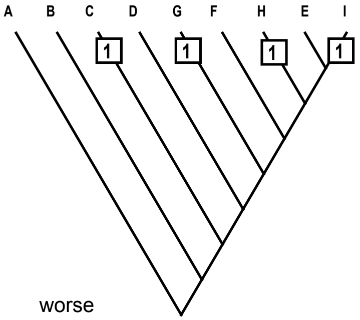
character	minimum steps	tree steps	maximum steps	ci	hi	ri	rc
1	1	2	4	0.500	0.500	0.666	0.333
2	1	1	1	1.000	0.000	0/0	0/0



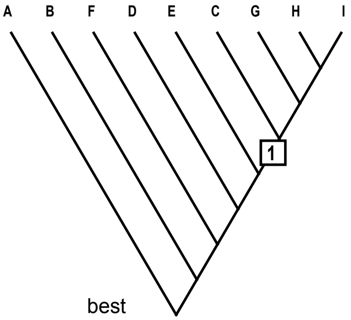
actual tree
under investigation
showing distributions of
characters 1 and 2
s = actual number of steps character makes on this tree

MATRIX

taxa	characters 1	2
A	**0**	**0**
B	**0**	**1**
C	**1**	**0**
D	**0**	**0**
E	**0**	**0**
F	**0**	**0**
G	**1**	**0**
H	**1**	**0**
I	**1**	**0**



worse
possible fit = value 'g'
(greatest number of steps)



best
possible fit = value 'm'
(minimum number of steps)

Character 1

$$\text{consistency index} = \frac{m}{s} = \frac{1}{2} = 0.500$$

$$\text{retention index} = \frac{g - s}{g - m} = \frac{4 - 2}{4 - 1} = 0.666$$

Figure 6. The Consistency and Retention index

You will also notice that the CI is given considering all characters as well as excluding those characters that are uninformative (have no grouping ability) as is character 2 in the example given in Figure 6.

When you report the results of an analysis it is customary to give the ensemble values such as "the resulting tree was 124 steps long, CI = 0.435, RI = 0.723, RC = 0.314".

Of what use may these values be? Some people may choose to use the values to reweight the characters and carry out a further analysis. This is *a posteriori* weighting and can be done under the DATA menu, then '*reweight characters*'. A box will appear asking you by what criterion to reweight (you have the options of using the ci, the ri or the rc – most people choose the last). It will also ask you what baseweight to assign. Let us say that you choose '100'. All those characters that have a value of 1.000 will be weighted by 100, those with a value of 0.666 will be weighted by 66, *etc*. It would be better not to choose the ci as the parameter since, as we have seen above, an autapomorphy may have a ci value of 1.000, yet have no grouping potential. You then carry out another analysis, and continue the procedure until the tree topologies stabilise. Reweighting can reduce the number of equally parsimonious trees *but this is not the primary function of such a procedure*. What is happening is that, at each stage of reweighting, a new data matrix is created such that any character that has a value of 100 will be inserted to the new data matrix 100 times; those of value 66 entered 66 times *etc*. Of course, because there are many more characters in the new matrix then the overall length of the tree will be much greater. This procedure is basically selectively weighting some characters more than others and can be problematic from a philosophical point of view. Instances of where reweighting is done involve cases where, after initial analysis, the CI is low (say below 0.500) but the RI is high (say 0.800). You must also be aware that reweighting may result in tree topologies not found in the initial run.

Reweighting is debatable but it is seen in the literature and its inclusion here is to explain what it means, since it is not immediately obvious. Other parsimony programs also include comparable techniques.

To this point we have now covered the entire analysis. In the next article we will investigate methods of estimating how 'good' the trees and individual nodes actually are.

Peter Forey

REFERENCE

MADDISON, W.P., DONOGHUE, M.J. and MADDISON, D.R. 1984. Outgroup analysis and parsimony. *Systematic Zoology*, **33**: 83–103.

PalaeoMath 101
Data Blocks and Partial Least Squares Analysis

In the last four columns we've looked at problems associated with characterizing and identifying patterns in single datasets. An implicit assumption that runs across all the methods we've discussed so far (bivariate regression, multivariate regression, PCA, Factor Analysis, PCOORD, and correspondence analysis) is that the objects included in the dataset represent independent and randomly selected samples drawn from a population of interest. Using our trilobite dataset as an example, if we are asking questions about this particular assemblage of 20 trilobite genera the results we have obtained to date are perfectly valid. However, it's a big world out there and we'd often like to know how one type of data relates to another type of data. For example, in all but the last of these columns we were concerned with the analysis of simple morphological data. We first considered bivariate data (the linear regression columns), but expanded that to a (still simple) three-variable system when we came to our discussions of the various single-sample multivariate methods. Then, in the last column I wanted to show how another type of data might be handled and so introduced some ecological data in the form of hypothetical frequency counts of these 20 genera in different environments. I'd now like to ask the next most obvious question 'What can we do if we want to explore how the morphological variables relate to the ecological variables for these taxa?'.

As a matter of fact we've already discussed one approach of this situation: 'what to do if we want to relate one variable to a suite of others'. In that case the appropriate approach is multiple regression. Using this method the pattern of linear variation in a dependent variable (*e.g.*, a morphological variable) can be compared to linear patterns of variation in a suite of independent variables (*e.g.*, ecological variables). The purpose of such an analysis would be to (1) assess the overall significance of the various linear relations between the dependent and independent variables and (2) obtain information about the structure of those relations (*e.g.*, which independent variables show the strongest patterns of covariation; which the least). But this method only yields information for one dependent variable at a time. What if we want to assess the significance and structure of co-variation for two different multivariate blocks of variables?

There are two approaches for addressing this data analysis situation: canonical correlation analysis (CCA) and partial least-squares (PLS) analysis. The former has been around for some time while the latter is something of a new kid on the data-analysis block. I've always found it curious that neither has figured prominently in palaeontological analyses to date, though canonical correlation has been used for many years by ecologists, economists, psychometricians, and a host of others, while PLS made its impact felt first in the field of chemometrics. I think part of the problem has been that CCA requires the algebraic manipulation of complex, non-symmetric matrices that are beyond the capabilities of hand calculators and even simple spreadsheet programs. Canonical correlation routines are also somewhat rare in various so-called 'canned' computer packages, though they are straightforward to program in high-level computer languages or using tools such as *Mathematica*, *Maple* or *MatLab*. In this essay, we'll focus on PLS, in part because it's computationally simpler and illustrates many of the same principles as CCA, but mostly because it has several distinct advantages over CCA. Both methods deserve to be used much more widely in palaeontology.

First, let's review our data. You'll remember the trilobite morphological data, three variables measured on a suite of 20 trilobite specimens (Table 1).

Table 1. Trilobite data.

Genus	Body Length (mm)	Glabella Length (mm)	Glabella Width (mm)
Acaste	23.14	3.50	3.77
Balizoma	14.32	3.97	4.08
Calymene	51.69	10.91	10.72
Ceraurus	21.15	4.90	4.69
Cheirurus	31.74	9.33	12.11
Cybantyx	36.81	11.35	10.10
Cybeloides	25.13	6.39	6.81
Dalmanites	32.93	8.46	6.08
Deiphon	21.81	6.92	9.01
Ormathops	13.88	5.03	4.34
Phacopidina	21.43	7.03	6.79
Phacops	27.23	5.30	8.19
Placoparia	38.15	9.40	8.71
Pricyclopyge	40.11	14.98	12.98
Ptychoparia	62.17	12.25	8.71
Rhenops	55.94	19.00	13.10
Sphaerexochus	23.31	3.84	4.60
Toxochasmops	46.12	8.15	11.42
Trimerus	89.43	23.18	21.52
Zacanthoides	47.89	13.56	11.78
Mean	36.22	9.37	8.98
Variance	346.89	27.33	18.27

Those following closely will also recall the hypothetical trilobite occurrence frequency data from a suite of seven facies arrayed along a crude onshore–offshore gradient (Table 2, overleaf).

Table 2. Trilobite frequency data

Genus	Paralic Shale	Shoal Lmstn.	Upper Lmstn.	Mid Lmstn.	Phant. Lmstn.	Org. Siltstn.	Black Shale	Row Total
Acaste	8	5	3	10	4	5	1	36
Balizoma	6	6	5	10	2	3	1	33
Calymene	8	7	7	13	2	2	1	40
Ceraurus	10	1	1	10	10	11	4	47
Cheirurus	10	9	1	14	13	19	2	68
Cybantyx	9	3	1	9	8	10	3	43
Cybeloides	5	4	1	7	6	9	3	35
Dalmanites	6	4	1	7	5	7	2	32
Deiphon	9	7	3	12	4	5	1	41
Ormathops	9	5	1	10	8	10	2	45
Phacopidina	5	3	2	6	3	4	2	25
Phacops	9	7	3	12	5	6	1	43
Placoparia	6	6	2	8	5	7	2	36
Pricyclopyge	3	1	0	3	8	9	8	32
Ptychoparia	10	9	2	14	9	13	2	59
Rhenops	6	1	1	6	5	5	3	27
Sphaerexochus	7	2	2	8	4	5	2	30
Toxochasmops	7	5	4	10	3	3	1	33
Trimerus	2	2	2	3	2	2	4	17
Zacanthoides	4	4	1	5	10	14	5	43
Column Total	139	91	43	177	116	149	50	765

One of the purposes of using the frequency data in our previous discussion of correspondence analysis was to illustrate the superior data handling capabilities of that method. The scaling procedures inherent in correspondence analysis mean essentially any type of data can be submitted to this procedure. Partial least-squares analysis is also a generalized descriptive technique and so makes no particular distributional assumptions about the data. Nevertheless, this seems as good a place as any to point out that all descriptive methods work better if the data exhibit some similarity to a normal distribution. Counts are always suspect from a distributional point of view because they typically follow a Poisson distribution (see Fig. 1A). Since we'll be making use of the correlation relation in our PLS analysis, and since correlations can be badly biased by outliers, I've transformed the ecological data using a variant of Bartlett's (1936) square-root transformation to make them more normal (Fig. 1B). The morphological data were also transformed by taking the $\log_{10}$ of their values, since it is well known that this transformation makes variables more linear and removes any correlation between the variance and the mean (see the 'Data Blocks' worksheet of the PalaeoMath 101 spreadsheet for these transformed matrices).

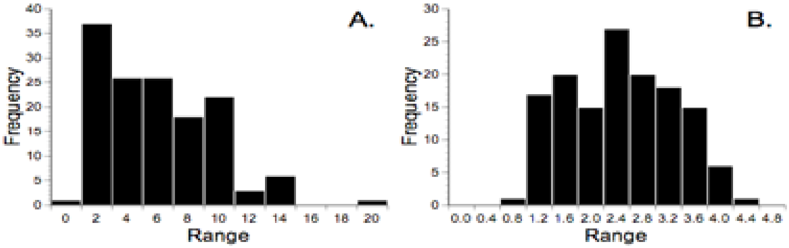


Figure 1. Trilobite frequency count data prior to (A) and after (B) transformation by the equation $y = \sqrt{x + 0.3}$ *, which is a variation of the Bartlett (1936) square-root transformation. Note the similarity of A to a Poisson distribution. Strictly speaking the transformation only made these data more normal (as they still do not conform to a normal distribution) but it did improve the balance of the distribution markedly and reduced the number of outlying values.*

Now that we have our data in appropriate shape it's time to talk about the comparisons we want to make. PLS has many similarities to PCA, one of which is that you can base the analysis on either the covariance or the correlation matrices. For these data the correlation matrix is preferred because the different data groups have different units and characteristically different magnitudes (see the Data Blocks worksheet). As with PCA, you need to consider carefully what basis matrix to use. A covariance matrix is preferred if scaling differences among the variables is something you want the data analysis to take into consideration. For example, if these were two different groups of morphometric variables and one (say the head variables) were characteristically larger than the other (say the tail variables), I might want to include this distinction in the analysis. If I chose to base my PLS analysis on the covariance matrix of raw (though transformed) values, the results would be implicitly weighted toward the larger (= more variable) head variables. On the other hand, if I didn't want these distinctions to affect the results of my analysis I'd want to standardize all my data first so the variances for all variables would be equal, in which case I'd be using a correlation matrix as the basis for my analysis. This standardized covariance, or correlation, matrix for the combined trilobite morphological and ecological variables is shown in Table 3.

Table 3. Composite correlation matrix

Variable	Body Length	Glabella Length	Glabella Width	Paralic Shale	Shoal Lmstn.
Body Length	1.000	0.871	0.840	-0.379	-0.096
Glabella Length	0.871	1.000	0.910	-0.483	-0.214
Glabella Width	0.840	0.910	1.000	-0.427	-0.076
Paral. Shale	-0.379	-0.483	-0.427	1.000	0.501
Shoal Lmstn.	-0.096	-0.214	-0.076	0.501	1.000
Upper Lmstn.	-0.042	-0.293	-0.138	0.232	0.516
Mid Lmstn.	-0.303	-0.465	-0.346	0.014	0.751
Phant. Lmstn.	-0.028	0.108	0.035	0.331	0.013
Organic Siltstn.	-0.070	0.060	-0.013	0.324	0.141
Black Shale	0.326	0.536	0.390	-0.570	-0.680

Variable	Upper Lmstn.	Middle Lmstn.	Phantom Lmstn.	Organic Siltstn.	Black Shale
Body Length	-0.042	-0.303	-0.028	-0.070	0.326
Glab. Length	-0.293	-0.465	0.108	0.060	0.536
Glab. Width	-0.138	-0.346	0.035	-0.013	0.390
Paral. Shale	0.232	0.014	0.331	0.324	-0.570
Shoal Lmstn.	0.516	0.751	0.013	0.141	-0.680
Upper Lmstn.	1.000	0.506	-0.711	-0.667	-0.785
Mid. Lmstn.	0.506	1.000	0.132	0.173	-0.739
Phant. Lmstn.	-0.711	0.132	1.000	0.979	0.472
Organic Siltstn.	-0.667	0.173	0.979	1.000	0.395
Black Shale	-0.785	-0.739	0.472	0.395	1.000

By now you should be familiar with the general form of a correlation matrix (see the *PalaeoMath 101* column in Newsletter 58 for a review). The composite matrices we use for PLS analyses are, however, a bit different. On first inspection they might look like perfectly normal correlation matrices. The diagonal is filled with 1s and the upper and lower parts are mirror images of one another. We could analyze the whole matrix and get a perfectly respectable PCA result. The difference, though, lies in the fact that we know there are two different blocks of data here—the morphometric variable block and the ecological variable block. We also know that we're only interested in examining the inter-relations between these data blocks. This knowledge changes everything. Diagrammatically we can represent this block-level structure of Table 3 as follows.

R_{11}	R_{12}
R_{21}	R_{22}

Here R_{11} refers to the 3x3 data block containing just the three morphological variables, R_{22} refers to the 7x7 block containing just the seven ecological variables. Both R_{12} and R_{21} refer to the block containing the 3x7 (or 7x3) cross-correlation between the morphological and ecological variables with R_{21} being a simple transposition of R_{12} (and vice versa). Two-block PLS analysis foregoes all consideration of blocks R_{11} and R_{22} in favour of focusing on block R_{12}. In effect, our PLS analysis will be an eigenanalysis of only that part of the basis matrix both groups share. Table 4 shows just this section of Table 3.

Table 4. The R_{12} data block of Table 3

	Paralic Shale	Shoal Lmstn.	Upper Lmstn.	Middle Lmstn.	Phantom Lmstn.	Organic Siltstn.	Black Shale
Body Length	-0.379	-0.096	-0.042	-0.303	-0.028	-0.070	0.326
Glab. Length	-0.483	-0.214	-0.293	-0.465	0.108	0.060	0.536
Glab. Width	-0.427	-0.076	-0.138	-0.346	0.035	-0.013	0.390

Note this is a different type of matrix from those we've seen before. It's not square because there are many more columns than rows and it's not symmetric because the two halves of the matrix across the diagonal aren't mirror images of one another. Indeed, there isn't even a diagonal to this matrix! Although this is a common type of matrix, we can't use regular eigenanalysis to decompose it into different modes of variation. That method only works on symmetric, square matrices. Never to fear though; methods have been devised to handle this situation. As a matter of fact, you've already been introduced to the primary method for handling this matrix if you read last issue's column. Singular value decomposition (SVD) rescues us again!

Recall last time we used SVD to perform simultaneous *Q*-mode and *R*-mode analyses of the square, symmetric, χ^2 distance matrix we used as the basis for our example correspondence analysis. That proved a convenient way to represent simultaneous ordinations of objects and variables. Recall also that SVD is an implementation of the Ekhart-Young theorem, which states that for any real matrix X, two matrices, V and U, can be found whose minor products are the identity matrix. This means matrices V and U are composed of vectors arranged at right angles to each other. These matrices are scaled to the original data (X) by matrix W, which is a matrix whose diagonal contains a set of terms called 'singular values' with all off-diagonal elements set to zero. These singular values are the square roots of the eigenvalues of both the V and the U matrices, which are identical for all non-zero singular values. Thus,

$$X = V\,W\,U' \tag{9.1}$$

Each eigenvalue represents an axis through the data cloud aligned with the major directions of variation. Since there are three morphological variables (p) and seven ecological variables (q) there will only be p non-zero singular values (since $p < q$). Matrix V contains the *R*-mode loadings, which are the patterns of weights (covariance basis matrix) or angles (correlation basis matrix) that specify the directional relation between these new axes and the *Q*-mode variables. Matrix U' is the transpose of the *Q*-mode saliences (see below). Here's the bit that concerns us today, however. The Ekhart-Young theorem states that the $X = V\,W\,U'$ relation is true for any matrix of any shape and/or character, not just square, symmetric matrices.

Table 5 shows the singular values and eigenvalues of the R_{12} data block (see Table 3).

Table 5. Singular values and eigenvalues of block R_{12}

	Sing. Val.	Eigenvalue	Variance (%)	Cum. Variance (%)
1	1.310	1.716	97.691	97.691
2	0.194	0.038	2.143	99.834
3	0.054	0.003	0.166	100.000

These were calculated using the PopTools plug-in for Excel (PC version only, see <**http://www.cse.csiro.au/poptools/**>). As you can see, from a geometric point of view, this cross-variable matrix is highly elongate with very small minor axes. But remember, this is only one block of the overall matrix. Since this is a correlation matrix, we know its total variance is the sum of the number of morphological and ecological variables ($p + q = 10$). Thus, this data block—or more correctly, the cross-variable substructure of the overall correlation matrix—accounts for only 17.56 percent of the total variance. Nevertheless, this is the substructure in which we are interested.

Table 6. *R*-mode (*V*) and *Q*-mode (*U*) normalized and scaled eigenvectors

	Eigenvectors (*V*)			Scaled Eigenvectors (*V*)		
	PLS-1	PLS-2	PLS-3	PLS-1	PLS-2	PLS-3
Body Length	0.446	-0.734	-0.512	0.584	-0.142	-0.028
Glab. Length	0.719	0.635	-0.283	0.942	0.123	-0.055
Glab. Width	0.533	-0.241	0.811	0.698	-0.047	0.044

	Eigenvectors (*U*)			Scaled Eigenvectors (*U*)		
	PLS-1	PLS-2	PLS-3	PLS-1	PLS-2	PLS-3
Paral. Shale	-0.571	0.386	-0.296	-0.748	0.075	-0.016
Shoal Lmstn.	-0.185	-0.239	0.872	-0.242	-0.046	0.047
Upper Lmstn.	-0.257	-0.614	-0.280	-0.337	-0.119	-0.015
Mid. Lmstn.	-0.502	0.057	0.092	-0.658	0.011	0.005
Phant. Lmstn.	0.061	0.421	0.200	0.080	0.082	0.011
Organic Siltstn.	-0.001	0.484	0.134	-0.001	0.094	0.007
Black Shale	0.564	0.039	-0.080	0.739	0.008	-0.004

For our example analysis the directional vectors are given in Table 6 in their normalized (left) and scaled (right) forms. The normalized form is the most convenient for interpretation as the squares of the values always add up to 1.00. The scaled form is calculated by multiplying the normalized vector coefficients by the appropriate singular value. This operation restores the differences between the scale of the vectors.

These vectors look superficially like principal components, but there's an important difference. Whereas the coefficients or 'loadings' of principal component eigenvectors represent the angular relation between the principal component axes and the original variables, the coefficients of a PLS analysis represent the angular relations of the variables within one data block with respect to those in the other data block. In a sense they represent the variables that are most useful or salient for predicting patterns in the other data block. For this reason they are referred to as *saliences*.

Turning to an interpretation of these data we first need to ask ourselves how many singular values to interpret. We can approach this using the various qualitative methods discussed in the column on PCA (see the *PalaeoMath 101* column in Newsletter 58) or we can use a more sophisticated, quantitative approach that has been developed recently for use in generalized multivariate analysis (see Morrison 2004, Zelditch *et al.* 2004).

$$\chi^2 = -n \sum_{j=1}^{r} ln\, \lambda_j + n\, r \left(\sum_{j=1}^{r} \lambda_j \Big/ r \right) \tag{9.2}$$

In this equation χ^2 is the χ^2 statistic, n is the number of objects in the sample minus 1, r is the number of eigenvalues being tested and λ_j is the jth singular value. In its typical analytic mode singular values are tested in sequence two at a time (*e.g.*, 1-2, 2-3, 3-4) to determine whether there is a statistically significant amount of variance being explained by the former member of the pair. For this type of test the value of the degrees of freedom is 2. For the comparison between the first and second singular values in the example analysis $\chi^2 = 15.196$, which means the first singular value is highly significant ($\rho = 0.0005$) as you would expect from the high proportion of variance it explains (see Table 5). When we interpret this axis (Table 6) we see all the *R*-mode saliences are positive, suggesting this is an allometric size axis with glabellar length exhibiting the strongest positive allometry. Environmentally, this allometric size vector is correlated most positively with the black shale facies and most negatively with the paralic shale facies, which are the deepest and shallowest environments in our ecological dataset. This is highly suggestive of a possible shallow–deep or onshore–offshore environmental gradient. Further analysis of the patterns of salience coefficients (Fig. 2) shows that, although the relation between size and a depth-shoreline proximity gradient is not strictly consistent, there is more than a hint of this general correlation being a major source of patterning in these data.

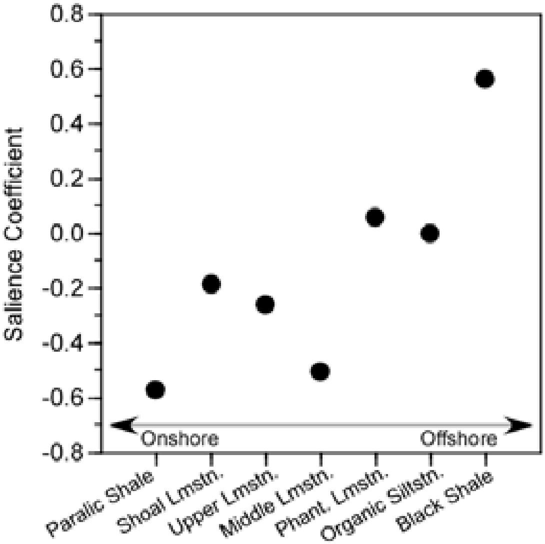


Figure 2. Plot of salience coefficients for the environmental hypothetical variables used in the example analysis. While the trend in these data does not conform strictly to an onshore–offshore gradient, and is not strictly linear, there is a strong suggestion that depth–shoreline proximity is an important source of structure in the R_{12} *block of the correlation matrix. This pattern is associated with strong and uniformly positive salience coefficients for the morphological variables (see Table 6) indicating that this depth–shoreline proximity factor is associated morphologically with an allometric size gradient. See text for discussion.*

The strength of the relation between the morphological and environmental variables can also be assessed through a simple graphical device. Since we have the *R*-mode and *Q*-mode vector for the cross-variable data block we can calculate the *R*-mode and *Q*-mode scores in a manner identical to that for PCA. Table 7 shows these scores while Figure 3 plots them in a simple bivariate ordination space.

Table 7. Scores on PLS-1 (morphology) and PLS-1 (environment) axes

Genus	PLS-1 (morphology)	PLS-1 (environment)
Acaste	-2.313	-1.313
Balizoma	-2.492	-1.239
Calymene	1.136	-2.329
Ceraurus	-1.695	0.252
Cheirurus	0.620	-1.470
Cybantyx	0.812	0.029
Cybeloides	-0.757	1.111
Dalmanites	-0.261	0.475
Deiphon	-0.460	-1.896
Ormathops	-2.131	-0.626
Phacopidina	-0.776	0.728
Phacops	-0.725	-1.874
Placoparia	0.423	-0.009
Pricyclopyge	1.549	4.394
Ptychoparia	1.225	-1.723
Rhenops	2.183	1.295
Sphaerexochus	-1.956	0.043
Toxochasmops	0.712	-1.257
Trimerus	3.442	3.016
Zacanthoides	1.466	2.394

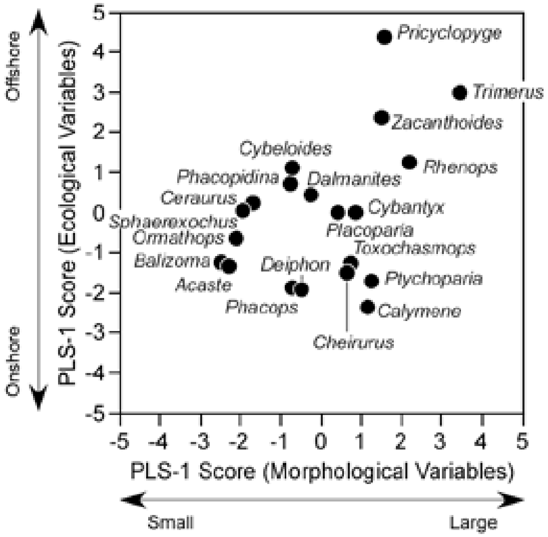


Figure 3. Scatterplot of PLS-1 (morphological variables) and PLS-1 (environmental variables) scores for example PLS analysis. This plot represents 97.69% of the correlation structure within the R_{12} *data block.*

Comparison of the ordination shown in Figure 3 confirms our interpretation of these results based on the *V* and *U* salience matrices. Note large-sized genera (*e.g.*, *Trimerus, Zacanthoides, Pricyclopyge*, see Table 1) plot toward the upper end of PLS-1 (morphological variables) axis and small-sized genera (*e.g.*, *Acaste, Balizoma, Ormathops*) toward the lower end, confirming that this axis expresses a generalized size gradient. Moreover, these two groups of genera also display strikingly different environmental occurrence patterns along the PLS-1 (ecological variables) axis with the larger-sized forms being differentially abundant in deep-water facies (see Table 2) and smaller-sized forms preferring shallow-water facies. The linear correlation between the two PLS-1 scores is 0.445, which is just significant statistically for this sample ($r_{\text{crit., d.f. = 19, } \alpha = 0.05} = 0.433$). Based on these results I wouldn't necessarily conclude that size–environment link represents the whole biological story for these data (*e.g.*, the shallow water fauna is composed of mixed small and intermediated sized genera), but this is the strongest, single, linear signal in these data. More importantly for the purposes of this column, by using two-block PLS we've managed to examine the inter-relations between two datasets we've had to treat either separately or as parts of a larger analysis up to this point, and in doing this we've discovered a new pattern in these data that had been hiding there all along.

Partial least squares analysis represents a very powerful and completely generalized approach to ordination and statistical hypothesis testing. Based on a form of PCA, it extends multiple regression analysis, complements canonical correlation analysis, and allows users to test hypotheses about the inter-relations between blocks of observations made on the same objects. Unlike standard PCA which can use a variety of algorithmic approaches to obtain the eigenvalues and eigenvectors of a square, symmetric basis matrix, PLS employs singular value decomposition to obtain the singular values (square roots of eigenvalues) and eigenvectors of parts of PCA basis matrices which may or may not be square, and which will not be symmetric. Aside from the matrix of singular values, this procedure produces two sets of eigenvectors that express the orientational relations between the variables grouped by data blocks: occupying the rows and columns of the basis matrix block. The number of vectors with nonzero lengths will be equivalent to the number of basis-matrix rows (p) or columns (q), whichever is least. In the example above we employed the correlation matrix as the basis for our PLS analysis because of the nature of the variables. PLS can be performed equally well on either covariance or distance matrices.

Unlike standard multiple regression analysis in which a single dependent variable is regressed against a set of independent variables using a linear least-squares minimization criterion (see the *PalaeoMath 101* column in Newsletter 55 for a review of linear least-squares minimization), PLS regresses two sets of multiple variables against one another using a major axis minimization (see the *PalaeoMath 101* column in Newsletter 57 for a review of linear major axis minimization). Also, the regression coefficients (= slopes) are partial regression coefficients that represent the relation between the trend of the dependent variable and each of the independent variables when the effects of the other independent variables are held constant. Thus, if a pair of variables is highly covariant or correlated, the covariations or correlations of other pairs of variables will be correspondingly reduced since there will not be much residual covariance or correlation structure left after the effects of the first pair are held constant. In contrast, the PLS salience coefficients all represent angular relations with the complete, block-specific, covariance-correlation structure. This makes the interpretation of these coefficients less complex.

Finally, unlike CCA, which recognizes the same block structure as PLS but uses information from all blocks to create a scaled or pooled covariance-correlation basis matrix for SVD decomposition, PLS decomposes only that block which expresses the inter-relations between the variable sets. This means that PLS can focus on only the inter-block aspect of the covariance-correlation substructure irrespective of whether that substructure accounts for a large or small component of the overall covariance-correlation superstructure. Since the coefficients of a CCA, like those of PLS, are used to quantify the inter-relations between blocks of variables, both are referred to as saliences. It is important to note, however, that CCA saliences are equivalent to partial regression coefficients (see above) whereas PLS saliences are analogous to PCA loadings. In effect, CCA represents an attempt to define a set of canonical variables (= linear combinations of variables) for each data block that exhibit overall covariances-correlations that are as large as possible. Indeed, a CCA analysis in which either the set of basis matrix rows or columns contains a single variable is analogous to a major axis-based multiple regression analysis. The goal of PLS differs insofar as it tries to provide a more focused assessment of the inter-block substructure and doesn't allow within-block patterns of covariance-correlation to influence that result.

Partial least squares analysis supports a very large set of investigation types that are often encountered in palaeontological data analysis situations. The example above represents a simple situation in which a set of morphological variables are related to a set of ecological variables, allowing the morphological correlates of ecological distributions (and *vice versa*) to be assessed. A PLS approach could also be used to investigate inter-relations between different blocks of morphological variables, say from the anterior or posterior regions of a species (*e.g.*, Zelditch *et al.* 2004) or between different regions of the same morphological structure. This type of study falls within the general 'morphological integration' research programme that tries to identify regions of correlated morphological variation within organismal *Baupläne* (see Olson and Miller 1958 for a classical treatment of this topic) and is related to the current interest in identifying developmental modules (see Schlosser and Wager 2004). A PLS approach could also be used to examine inter-relations between different types of ecological variables (*e.g.*, organismal-based *vs.* physio-chemical), or to explore the morphological correlates of genetic variation. The possibilities are virtually endless (see Rychlik *et al.* 2006 for a good recent example of PLS analysis being used in a systematic context).

As for the practical matter of how to perform your own PLS analysis, unfortunately the choices here are somewhat more limited than for the other methods we've discussed to date. Of course, the *PalaeoMath 101* spreadsheet contains the complete calculations for the example PLS analysis presented above. These were performed using the PopTools plug-in for the SVD calculations, but all other calculations were made using the standard MS-Excel data analysis tools. As I mentioned above, generalized mathematical packages (*e.g.*, Mathematica, Maple, MatLab) can also be used to program your own routines. Program systems that perform PLS analysis are somewhat rare, reflecting the method's relatively recent introduction. Of these, your best bets at the moment are XL-Stat (<**http://www.xlstat.com/en/home/**>; some limited PLS capability) and NT-SYS (<**http://www.exetersoftware.com/cat/ntsyspc/ ntsyspc.html**>). Since PLS has a longer history of use in chemometrics some stand-alone software is available in program packages that have been developed for that community. Of these, Solo is one of the more complete and better known (see <**http://software.eigenvector.com/toolbox/solo/index.html**>).

Norman MacLeod
Palaeontology Department, The Natural History Museum
<N.MacLeod@nhm.ac.uk>

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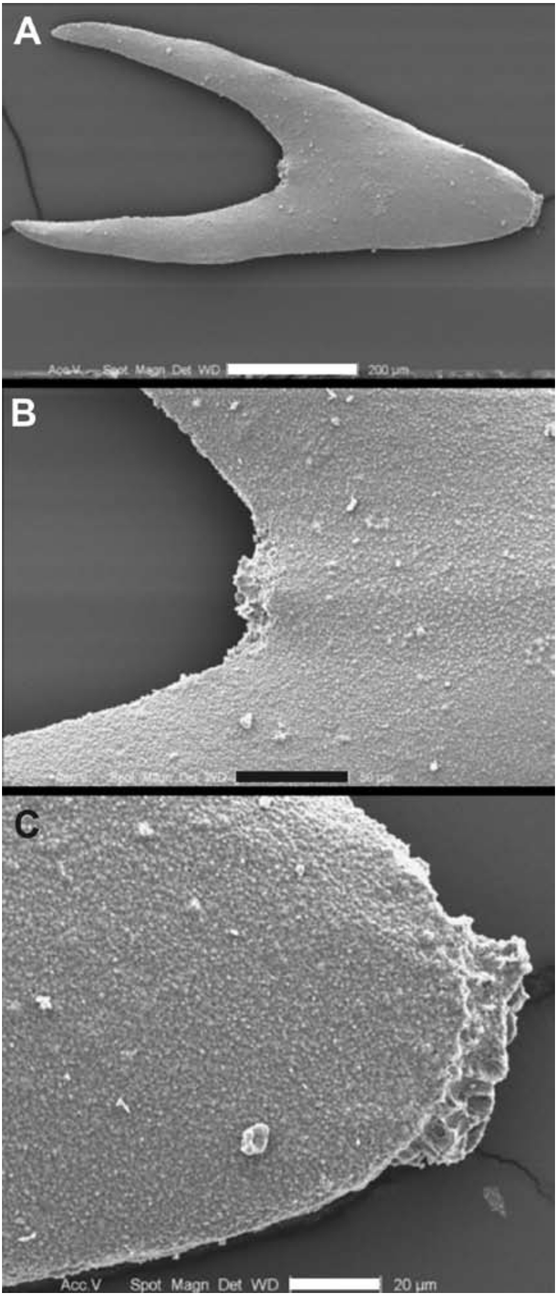
Don't forget the *Palaeo-math 101* web page at:

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

MYSTERY FOSSIL 11



Mystery Fossil number 11 is another microfossil and was discovered by Steffen Kiel (Leeds) in residues from acetic acid digestion of methane seep carbonates from the Miocene Astoria Formation of Washington State, USA. This is one of a number of liberated specimens that Steffen describes as 'fossil pliers', some of which differ from the figured example in having more than two 'arms'.

The 'pliers' are formed of silica, but their original mineralogy could have been something different as associated mollusc shells are also silicified. Image A is the complete specimen; B and C are details of areas between the 'arms' and 'posterior' end respectively that may indicate the 'pliers' are part of a larger structure.

Scale bars:
A = 200 microns;
B = 50 microns;
C = 20 microns.

Cris Little
Department of Earth Sciences,
University of Leeds, UK
<c.little@earth.leeds.ac.uk>

Meeting REPORTS

William Buckland 150th Anniversary Symposium

Oxford *12 August 2006*

Held in the lecture theatre of the Oxford University Museum of Natural History, this was a joint meeting, sponsored by the Museum, the History of Geology Group of the Geological Society, and the Palaeontological Association, to mark the 150th anniversary of the death of William Buckland on 14th August 1856. The meeting was well attended with about 150 delegates, keen to listen to presentations on a wide range of aspects of Buckland's life and work.

Meeting convenor **Jim Kennedy** (Oxford) started the session with a look at Buckland's life. He was born at Axminster in Devon in 1784, the eldest son of Charles Buckland and his first wife Elizabeth. After his early education, first at home, then at schools in Tiverton (Devon), and Winchester (Hampshire), he was taken in by his uncle Charles Buckland, Rector of Warborough, just to the south of Oxford, to complete his education. In 1801 he was admitted to Corpus Christi College, Oxford, where he studied Latin and Greek literature, geometry and theology. He graduated in 1804, and was elected to a fellowship and ordained as a priest in 1808. He became friends with scientists John Kidd and Christopher Pegge, whose lectures he attended, as well as fellow students W.J. Broderip and W.D. Conybeare, all of whose influences changed his life. In 1813 he was appointed to the readership in Mineralogy, and five years later to the newly established post of Readership in Geology, for which he had petitioned the Prince Regent. Georges Cuvier, the great comparative anatomist, visited Oxford in 1818 and Buckland showed him bones from Stonesfield. In 1823 he travelled to the cave at Paviland, South Wales, where he discovered human remains covered in red ochre, subsequently known as the 'red lady of Paviland'. A year later he finally described remains of the great lizard of Stonesfield that he had shown to Cuvier; this was *Megalosaurus*. Dissatisfied with his position at Oxford, he accepted the living at Stoke Charity in Hampshire, and would have left the University, but for being appointed Canon of Christ Church in 1825. In that same year, at the age of 41, he married Mary Morland, aged 28, whom he had known for some years. They went on a year's Grand Tour of Europe for their honeymoon. In 1836 he wrote his *Bridgwater Treatise,* which became a best seller. But his popularity as a teacher was declining. In 1845, he was appointed Dean of Westminster, a position which also included the rectorship at Islip near Oxford. Robert Peel made the appointment and claimed it as "the best I have ever made"; Darwin said Buckland was a buffoon! In 1849 he started to show eccentric behaviour, and was confined to an asylum in Clapham. He never resumed his duties as Dean, but managed to retain the salary and the house at Islip. In 1856 he died in the asylum, and was buried at Islip. Mary died a year later.

Following this opening, **John Brooke** (Oxford) examined Buckland's palaeo-theology. As a theologian, Buckland had a problem in uniting the known human world with the pre-human, and took the decision to become an actor within the scenes he reconstructed. By using extant forms he was able to transfer the language of natural theology to extinct forms, and so refine what was meant by 'progression' in the fossil record. In his inaugural lecture he had to vindicate science, not religion. The Bible was only concerned with the period of human history, and there was no decisive evidence to extend the age of the human race. But Buckland knew that the Earth had undergone a number of revolutions, and the problem was to affirm the unity that would reflect the unity of a divine mind. If the Earth is the product of one piece of work we may expect to find unity and regularity. Buckland strove to integrate extant and extinct forms into a single chain – the Great Chain of Being – which started at the bottom with 'ethereal matter' followed upwards by air, water and pure earth, and thence through all the known geological objects (rocks, crystalline materials), to life forms and the known fossils, known living forms, finally ending with human beings at the top. He had evidence for things such as the great deluge, and there was a tradition of evidence of divine wisdom in earlier works of nature by luminaries such as Boyle and Newton. Buckland also had skills in reconstructing ancient habitats. The fossil species found which gave links to the living, gave him proof of the "unity and universal agency of a common great first cause … where every individual is shown to be an integral part of one grand original design".

Hugh Torrens (Keele University) examined Buckland's transmission of British stratigraphic knowledge. William Buckland is often portrayed as a rather eccentric character – in 1886 he was spoken of as the man who "ate his way through the whole animal creation". But he was a multi-faceted character who in 1814 had issued a broadsheet entitled *'Order of Superposition of Strata or Tabular Arrangement of Rocks',* in which he attempted to list the known strata in their correct order as found. The broadsheet was revised nine times between 1814 and 1818, as new information became available. This new information was not restricted to discoveries made in England, but also included information given to Buckland by Werner in 1816. It also relied to some extent upon the work of Henry Steinhauer (1782–1818), a Moravian church minister based at Haverfordwest. Exactly when in 1814 this chart was first produced is unclear. The surviving copy has no date, but has a watermark of 1811, so could not be earlier than this. But the first series of sheets showed 12 formations, from granite and working upwards to end with peat bogs. It's also noticeable that the name of the Oxford Clay pre-dates William Smith's naming it 'Clunch Clay'. The second series adds the Stonesfield Slate for the first time, which was Buckland's addition from Farey's book of 1811. The third series dates from around 1816, since Etheldred Bennett wrote to Gideon Mantell in that year, telling him that she had "received this version 2 months ago". Version 3 of this series was translated into French and Italian by Breislack in 1818. The fourth version attempted to correlate German and English formations, and Buckland allies the Lias with the Oolite. The fifth version was published by Robert Blackwell and was started by Buckland during his tour of Germany in the company of G.B. Greenough and W.D. Conybeare, during which they met both Goethe and Werner. Version 3 became the most impressive of all. The strata now read downwards, as in nature, and it was used, with permission, by Phillips in his 1818 publication. A version was published in Westgarth Forster's work on the strata between Newcastle and Cross Fell. The charts became more influential than previously realised, and inspired many others. They were produced annually between 1814 and 1820 for Buckland's students.

Martin Rudwick (Cambridge) examined the work of Buckland in the context of Flood, Deluge and the Ice Age. Those who see Buckland as essentially English, or even Oxfordian, do him a disservice. He was more European, and went on several tours, including a whole year for his honeymoon. He was in contact with people on the Continent (and even some in the USA). Cuvier had linked geology to human history and had developed a theory of a catastrophic event in the distant past; there was evidence for an aqueous catastrophe in many places. Buckland adopted the idea of a natural mechanism for this flood event – which might now be called a 'mega-tsunami'. The Edinburgh geologist Hall had already advanced a theory of uplifted oceanic crust, which caused waves to spread outwards, and a retreat of the sea, which then returns with a vengeance. It was applied to an area of western Edinburgh where there are visible striations and deep vallleys (now covered by housing). Buckland plotted the occurrence of gravels containing quartzite pebbles from the West Midlands to Oxford, and on to London, and concluded that it must be the result of a great deluge. He noted that the coastline near Lyme Regis showed a series of deep valleys, which were truncated at the cliff line: these must have been cut by a great flood. But how recent was this event?

For Buckland the Biblical event was "The Flood", but a geological deluge might have occurred much earlier, in pre-human times. Although both were seen as natural events, neither was linkable to Genesis. Most geologists accepted a huge event in the past; the work of Leopold von Buch in tracing erratic boulders from Mont Blanc all the way across the Swiss plain and on to the Jura Mountains was held as evidence, as was the work of Rasomovsky who described erratics from Finland that had been transported all the way to Russia and the Baltic. Others, notably Brongniart (1824 in Sweden), de la Beche (1830 at Lake Como), and Sefstrom (1836 in Sweden) mapped what we would now recognise as eskers, erratics and scratched surfaces respectively, and came to the same conclusion – a pre-human event of some magnitude. To avoid a clash between geological and biblical theory, it was suggested that erratic rocks might have been transported by icebergs, but this failed to explain how they got onto land. The theory of glaciation had been advanced by Esmark, but was ignored. Jean Charpentier (1786–1855) mapped erratics from the Upper Rhine Valley to the Jura Mountains, and proposed the extraordinary theory that climate might once have been different in the past. The only way of having an Ice Age was by assuming the Alps were raised up even higher than at present. Buckland was present at several crucial meetings where the possibility of an ice age was discussed. The eventual change towards ice-age theories was not straightforward, but was logical.

Philip Powell (Oxford) examined the history of *Megalosaurus*, in the light of recent discoveries. *Megalosaurus*, or the 'great fossil lizard of Stonesfield', is one of the best known of all fossils. Delair and Sarjeant (*Proceedings of the Geologists' Association* **113**, 185–197) in a recent paper stated that the bones collected by Buckland were "scattered remnants of a single individual", even though Buckland's paper of 1824 (*Transactions of the Geological Society of London*, Series II, p.190) said that the bones "represent several individuals of different ages and sizes". The Stonesfield Slate lithology occurs at more than one level in the Great Oolite. These beds are thin, never greater than six feet in thickness. They have been used as roofing slates from the 17th century, and were mined from shafts, some up to 60 feet deep. They are fossiliferous, and one of the earliest finds was a dinosaur tooth, illustrated in 1699 by Edward Llhuyd. John Woodward's catalogue of 1728 shows the broken shank of a dinosaur limb bone. A thigh bone, some 29 inches long, with water-worn ends, was acquired by Joshua Platt in 1758, and compared by him with an elephant bone. It is now lost. Other bones were also found. A Dr Watson described a scapula, which had been found in 1784, and presented to the Woodwardian Museum, but this might not be that of a megalosaur.

The now famous 'lower jaw' is known to have been in Oxford in 1797. New evidence, in the form of several letters in the Buckland archive, has shed new light on how the bones came to be in Oxford. The outcome is that *Megalosaurus* is now something of a complex beast to understand.

Simon Knell (Leicester) looked at Buckland and the museum as a 'network hub'. Buckland was very much a museum man, and his collection occupied upper floors of the Old Ashmolean Museum. Instructions on collecting had been given by many authors before Buckland, going back to John Woodward in 1696. However, when Murchison saw the collection he complained that they were untidily kept, to say the least.

Buckland had been a celebrity since his work at Kirkland Cave in 1821, and he was aware of his own status, which he exploited to construct a network of colleagues throughout Europe and beyond. Buckland used fossils to explain the new science of geology, as these made it all the more powerful to his audiences. His museum became a hub, into which flowed specimens and information, and out of which flowed correspondence, theories, and teaching. Buckland exported this idea after his Kirkland discoveries, with the establishment of a museum and later Philosophical Society in York. One of his students, William Vernon, the son of the Archbishop of York, did much to raise funds for purchases, get to know people and reinforce the network.

In 1822, de la Beche visited Conybeare and was shown a lower jaw of a plesiosaur. Conybeare wondered what the whole creature looked like. De la Beche had been finding similar material at Lyme Regis. When Buckland saw it, he was amazed, and perhaps seeing its potential for teaching, said it should be cast in gold! It was too, in Francis Chantry's workshop, though not, alas, in gold. Unfortunately Buckland had hired a Prussian named Mueller to work on the collection, and in the process he dropped the casting and broke it. Nonetheless it stayed in Oxford. Such was the power of actual specimens or even casts for Buckland. He was a sophisticated museum man, and with his reputation, was asked to advise on the quality of specimens being offered for sale to museums and wealthy collectors, as well as their meaning. Not only was he a good museum man, but he also understood the politics necessary to procure specimens or win other favours.

The contribution by **Marianne Sommer** (Zurich) had the intriguing title: 'You say it does not stick to your tongue?', and reviewed the work of Buckland and the problem of antediluvian human remains. Buckland's visions of the animal life of antediluvian Britain came about in the context of natural theology and Mosaic history. The big problem was, where does 'man' fit into this picture? And it wasn't easily avoided. The problem of human antiquity in connection with both a post and antediluvian world troubled Buckland. His own researches led to the discovery of human remains, and he was aware that the evidence for human antiquity being very great was growing. But, he remained adamant in his rejection of the contemporary nature of humans with the extinct mammal faunas of Europe. There were problems in deciding if human remains were 'recent' or of great antiquity, especially in the absence of any stratigraphic dating. Buckland, the showman, is reputed to have shown that the antiquity of some bones could be demonstrated by the fact that they had a tendency to stick to the tongue, which he demonstrated on more than one occasion, without interrupting the flow of his lecture. The use of humour in his lectures was one of his great attributes.

Ralph O'Connor (Aberdeen) chose to look at the literary side of Buckland's work, and in particular his reputation as a great raconteur. For the public, now freed from the problems of a war with Napoleon and able to enjoy wider pursuits, geology was emerging as a history of the deep past which they found interesting. Buckland became the chief storyteller. His work on the Kirkdale hyenas allowed the public to envisage the past but he started by testing his storytelling on more sympathetic audiences than the public. This was not just caution – geology was seen as anti-church. The public could read about the theories, but for most people books were too expensive, and geology was an unknown concept for them. Buckland was fairly uninhibited when presenting geology out loud – to students or the public – where he could be clear who he was talking to as well as know their social class. Speaking also gave more scope for improvisation. He was known to have mixed humour and seriousness when talking, in order to avoid a serious discussion, and the mixture made it more memorable for his audience. This style made a big impression, though Charles Darwin found the 'buffoonery' in bad taste. Today it is not easy to get a feel for what his lectures were like, partly because history only records the humorous anecdotes. Buckland was seen by some to have a heroic status and to be able to travel back in time. Buckland's ability as a populariser of geology was sealed with the publication of his book *Bridgwater Treatise* in 1824 which contained imaginative plates of creatures which helped to capture the public's imagination.

Philip Taquet (Paris) looked at the professional relationship between Buckland and the great French comparative anatomist George Cuvier. Cuvier was born in 1769 in Montbeliard, in the Jura Mountains. After studying in Germany he took a job with a noble French family, in a château near Caen in Normandy, which still stands. He set out to be the new Aristotle, and decided to make an inventory of all known animals. At the time the French Revolution was raging, but he was protected from the worst of its violence. His exquisite drawings of birds especially were recognised, and in 1795 he was invited to Paris by Geoffroy Saint-Hilaire at the newly reformed Muséum National d'Histoire Naturelle, where, after a period as an assistant, where his first job was to make an inventory of artefacts saved from the revolutionaries, he became a full professor of anatomy. His strategy was to collect skeletons of creatures for comparative anatomical studies, which he was able to house in a building with seven rooms, each one devoted to a different class of animal (*e.g.* birds, mammals, fish *etc*). Within a few years, he had 16,000 skeletons. When Napoleon came to power, Cuvier continued his work, but times were hard under the Emperor. As his fame spread he was appointed to different honorary posts including one as foreign correspondent to the Royal Society. In 1818 he visited London for the first time, in his capacity as Inspector of the University of France, for which he received a sum of 6,000Fr to visit British Universities, with his wife as an assistant. In addition to visiting universities, he met William Herschel and saw his telescope, as well as meeting George IV. During this visit he went to Oxford and met William Buckland, and saw the bones from the Stonesfield Slate, as well as the skeletons of two woolly rhinoceros. He established a cordial relationship with Buckland, exchanging many letters documents, fossils, casts, and most importantly, ideas. Buckland sent at least 25 letters and drawings to Cuvier between 1822 and 1830, and these still survive. Buckland also sent exquisite drawings, made by Mary Morland, his wife-to-be, between 1822 and 1823. Both Cuvier and Buckland benefited from the talents of Joseph Pentland, an Irish naturalist, who made beautiful casts of specimens for exchange. Buckland and Cuvier's mutual admiration for each other is shown by the homage paid in various works. Cuvier died in 1832, in Paris.

Claudia Schweizer (Vienna) took as her subject the relationships between Buckland, Brogniart, Sternberg, and Ernst Friedrich Schlotheim (1764–1832). For them 1804 was a landmark year, for it was then that Schlotheim published a seminal work on fossil plants. In this work he noted the fossil imprints of plants in coal formations and compared their morphologies with those of extant species. The first plants to appear were tree-like ferns similar to those from the coal transition rocks, while primordial plants were more similar to modern equivalents. This led to the view that temperatures may have fallen since primordial times. Palaeobotany advanced in 1820 when Schlotheim published a further work which deepened the knowledge of fossil plants, and raised the idea of a continuous history of life, thus replacing the then widely-held diluvian theories. This was also about the time that Buckland started taking an interest in fossil plants. Kaspar Sternberg (1761–1838), who had initially studied theology in Rome before moving on to botany and fossil plants, also published his findings in 1820. He continued a correspondence with Schlotheim up to 1832, and this gave an insight into ideas for a change in climate based on similarities between plant fossils and extant forms. Adolphe Brogniart was born in Paris in 1801, the son of Alexandre Brogniart, already known for his botanical classification. In 1824 he visited Schlotheim and exchanged ideas. In 1827 he was studying medicine in Paris, but by 1833 held a professorship in botany and plant physiology. He followed Sternberg and Schlotheim's basic ideas in his major publication. Buckland visited Sternberg in 1822, and started corresponding with him, but never met Schlotheim. Schlotheim, Sternberg, and Brogniart all followed the same idea of several successive vegetational periods, and a climate shift in Europe, which led to morphological similarities between fossil plants and extant ones. Buckland saw it differently. He accepted that the theory of the Earth was ordained by a plan of God. He saw the process as one of a biblical deluge, which was compatible with christian knowledge.

The final speaker was **Patrick Boylan** (Leicester) who examined Buckland's association with the Oxford Readership, the Geological Society and the British Association for the Advancement of Science, and the institutionalising of English geology. The idea of travelling to Europe to study geology in place, as part of a Grand Tour, was one which was devolving downwards towards the middle classes. At least 40,000 English people were estimated to be travelling or living on the Continent in 1785, just before the French Revolution. Not only did it offer education, but the cost of living in Rome, for instance, was only about a fifth of that of London. Other nationalities also partook, including Goethe who went on a two-year Grand Tour in 1785. It reinforced a complex web of introductions, contacts, study at universities, private tutoring, and correspondence. But in 1789 it all changed, as revolution spread throughout France. While this marooned Buckland and his contemporaries on island Britain, it did have a beneficial effect, as Grand Tours were undertaken to look at English geology. Buckland also became well aware of just how different things were on the Continent, with funding for geology being made available from official sources. In Bologna there was substantial funding from the Church, and academicians in Paris received State salaries, while the Swedish Academy of Sciences gave scholars a reward for every almanac sold. Buckland and others felt that the State in England could help, and geology especially needed to be brought in from the margins. After Wellington's victory at Waterloo, Buckland was once again able to travel freely, and did so almost every year. This only reinforced his feeling that the State should take a greater part in funding. Despite Buckland's own position in the mostly privately funded Oxford University being precarious, he began, in 1818, to try and persuade patrons and friends of the Prince Regent, that there should be a publicly funded Chair of Geology. With the support, especially, of Lord Grenville, a former Prime Minister and a man involved in anti-slavery legislation, the Government made available £200 for a Readership in Geology. Buckland was eventually elected to the post (which he held along with the Readership in Mineralogy, to which he had been appointed in 1813). Buckland was pleased to get the post, but the funding was miserly, and was not the start of general funding of geology, as he had hoped. Buckland was aware of the funding and royal patronage of the Royal Society, and he wanted similar support for the Geological Society. In 1824, during his first Presidency of the Geological Society, he started out on a high-risk strategy of raising the matter with influential people. The response was positive, and in 1825 the Society was awarded a Royal Charter. Buckland remained dissatisfied, and worked to bring geology before a wider audience. He was familiar with the annual meetings for scientists in Leipzig, and became an enthusiastic supporter of the British Association for the Advancement of Science, and their annual meetings, held at venues throughout the United Kingdom. The first meeting was in 1831, but the first full meeting of the "Parliament of Science" was in 1832 at Oxford. Buckland served as President.

It was left to convenor Jim Kennedy to thank all those who had given talks, the audience for attending, and the projectionist for faultless work, before delegates were allowed to take a glass or two of wine and to wander among the dinosaurs.

Following the meeting, the speakers and others retreated to Islip, where Roderick Gordon, a grandson several times removed, laid a wreath on the grave of the Dean and his wife Mary, toured the Old Rectory, the Bucklands' home from 1845 to 1856, and dined on less exotic cuisine than that for which Buckland's table was renowned.

Peter Tandy
History of Geology Group Newsletter Editor, The Geological Society, Burlington House, Picadilly, London W1J OGB, UK

Tinkering: The Microevolution of Development

Novartis Foundation *14 July 2006*

This one-day meeting was the culmination of a longer closed meeting that brought together a diverse group of international researchers to discuss how developmental pathways and processes might be responsible for evolutionary change. Considerable attention was also given to the topic of genotype to phenotype mapping, and the perennial question of evolutionary 'constraints'. The proceedings of the closed meeting are to be published "warts and all" in April 2007. Details can be found on the Wiley website <**http://www.wileyeurope.com/**>.

The setting of the meeting was in itself rather interesting. The Novartis Foundation runs a large number of meetings throughout the year. The building in which the meeting was held on Portland Place can be booked for small workshops and meetings, and also operates as a small hotel. While not the cheapest place to stay in London, it does have two rather unique features. Use of the accommodation is limited to scientifically and medically qualified persons only, and it is possible to have your breakfast in the library of the Foundation, so you can catch up on the latest journals. So if you have ever fancied yourself as a gentlewoman/gentleman scientist, you can indulge that fantasy for a few hours before getting back to grant writing. Anyone interested in the facilities Novartis can offer can find out more at <**http://www.novartisfound.org.uk/**>.

Gregory Bock welcomed us all to the meeting, and explained that the talks we were about to hear had all been given in the closed sessions earlier in the week, and he was interested to see what changes had been made for the public versions after the discussions in closed session.

In the opening address **Brian Hall** immediately indicated that he thought the subtitle of the meeting should be changed to cover macroevolution and natural selection as well as microevolution. He reminded the audience that Jacques Monod coined the current use of 'tinkering' in 1977 to express the idea that the non-optimal solutions that organisms arrive at via evolutionary processes, are different to engineered or designed solutions. He observed that there is no such thing as a taxon-specific gene, and emphasised the molecular level as the site of tinkering. The 'physiological genetics' of Goldschmidt, which emphasizes genes that are involved in determining rates and process control in developmental systems, was an area that Brian thought warranted more research effort.

Ken Weiss: *Escaping from Flatland to tame the beast of complexity, or complexity made simple*. Ken used the metaphor of Abbot's Flatland, in which beings who inhabit a two-dimensional plane encounter the third dimension. The book explores the question of how three-dimensional objects would appear to such beings. This primed the audience for his introduction to how evolutionary developmental maps – which have a time element – would look to us who live in only three dimensions, and experience time as discrete slices.

To illustrate the difficulties associated he showed a figure of a fully worked out developmental pathway, which he likened to a circuit diagram. The figure was bewildering in its number of links and detail. Ken indicated that he though the way to simplify such maps was to recognize four dimensions to understand evolutionary processes. These were evolutionary, ecological and developmental axes all related to a time axis. This was a bold way to try and unite the main disciplines that contribute to our understanding of phenotypic diversity, as well as a new way to visualize the interactions among these forces acting on organisms.

David Stern: *Developmental Genetics of Evolution*. David presented another way of looking at populations and species, which essentially viewed the characters defining them as a lineage of mutations. To understand the role of development we should be seeking important phenotypic events along these lineages which should reflect the predictable effects of the appearance of advantageous mutations. He explained that the difficulty of testing the importance of certain mutations was that the methods (strong promoters) used to assess the role of mutations in the laboratory can hide the down regulation of expression in the wild populations, which can allow them to retain certain mutations that are apparently deleterious. On these grounds he stressed the importance of identifying natural experiments that have occurred in the field as a means of identifying key mutations in the developmental network that favour or 'privilege' certain mutations in ways that are not obvious under laboratory protocols. David thought that the best way to reconcile the idea of the developmental network with many pathways through it was to use the concept of pathworks, which captured the notion of fixed lines through the nodes of developmental networks that led to the same phenotypic outcomes.

Adam Wilkins: *Genetic networks as transmitting and amplifying devices in evolutionary 'tinkering'.* Adam opened with the observation that rapid evolutionary change is not predicted by Neodarwinian theory, but it does happen. He argued that to comprehend the evolution of morphology we must understand the evolution of gene networks. To understand morphological evolution, the quantification of individual gene properties is insufficient. Genes have to be understood within the context of the networks of their interactions, which are not deducible from individual gene properties.

Adam made the case for directing research effort into scenarios about how networks arise, and examining the comparative biology of gene networks. Rather than using brute force approaches of sequencing whole genomes, the emphasis should be upon biologically interesting differences in relevant parts of gene networks. As examples Adam discussed the evolution of gene networks in sea urchins and sockeye salmon as examples of systems that had potential for further investigation.

The potential difficulties in developing a programme of research into the comparative biology of gene networks closed the talk. The practical difficulties of gathering data and running the experiments were a major obstacle. The bewildering 'circuit diagrams' of developmental networks present their own difficulties in representation of these data gathered from experiments. Finally, conceptual problems remain in defining the spatio-temporal boundaries of developmental networks, which prevents the definition of clear-cut modules and the stabilizing effects of feedback loops in developmental networks.

Paul Brakefield: *Making and Tinkering with Butterfly Eyespots.* Paul's work on the evolvability of traits is his way of answering the question "Why does diversity occur?" His conceptual model moved from the origin of novelties in genetic networks, through to the elaboration of these novelties and 'tinkering" with them via natural selection. The final outcome of these three steps was evolutionary radiation expressed at the phenotypic level in morphological traits.

The model system that Paul works with is the development of eyespots on butterfly wings. By studying the developmental morphospace of these eyespots he has been able to manipulate the developmental pathways for size, colour and position to distinguish between those parts of morphospace that are possible but unrealized, and those parts which are genuinely unreachable due to strong covariation of traits which acts to constrain traits to a small area of morphospace.

To investigate how these developmental pathways interact with natural selection to shape morphospace occupancy, Paul stressed the need to draw together field and laboratory studies, and carry out more work on integrative evolutionary biology.

Michael Coates: *Using patterns of fin and limb phylogeny to test developmental–evolutionary scenarios.* Mike presented a strong case for the use of fossils in the understanding of the assembly of the basic ground-plan of the tetrapod limb. He noted the problems with considering only the range of morphology found in extant taxa, and the limitations of molecular data derived from extant taxa, both in deriving phylogenies and in representing the range of variation in limb morphologies. By using only extant taxa in such investigations, we end up privileging the status of five digits as the primitive state. The fossils that fall into the stem groups are important sources of data that need to be incorporated.

Mike demonstrated the potential insights to be gained in regarding the fore- and hindlimbs from the same organisms as 'taxa' within phylogenetic analyses due to the serial homology of these modules. This allows differentiation between the first fins, which were dermal features, and the endoskeletal radials that later developed. The cladogram indicated that there had been a phylogenetic bottleneck followed by repeated radiations into semi-aquatic ecospace. The phylogeny has allowed the evolutionary rates across the tree to be calculated and two major events to be identified: the traditional fish-to-tetrapod transition, and the beginning of the radiation of crown-group tetrapods.

Jukka Jernvall: *Developmental or ecological interactions in explaining biological diversity.* This talk examined a major question in evolutionary biology: relative roles of intrinsic and/or extrinsic forces in the origin of biodiversity. Jukka split the factors involved into molecular and ecological aspects. His major research interest is into whether evolution does follow the path of least resistance.

Jukka's work makes innovative use of Geographic Information Systems (GIS) to quantify mammal tooth morphology, and map the areas in which various morphogens are acting within a tooth. Jukka's group has developed reaction–diffusion models of morphogens to study the transition from mouse to vole teeth. Voles have retained an ancestral zig-zag patterning, but have increased the number of cusps. The morphogen models have allowed them to identify the lack of homology at the molecular level responsible for generating features regarded as morphological homologies. Another aspect of the research was the development of the "Morphobrowser", a system for digital phenotype storage, which allows data mining of digital representations to find new ways for searching among tooth shapes on the basis of user-defined search routines. The group's website (<**http://www.biocenter.helsinki.fi/bi/evodevo/**>) is worth a look, and Morphobrowser is now online.

The GIS models allowed them to further investigate complexity of teeth with a quantitative method. They found that plant eaters had the most complex dentition that involved the development of multiple slopes, as opposed to carnivores, which have less complex tooth evolution patterns.

Dan Lieberman: *Tinkering in human evolution.* Dan's talk started with some historical background to the development of the study of evolutionary developmental biology. He noted the frustration of workers who had developed many of the theoretical aspects during the 1970s, but had to wait until the 1990s. A particular problem has been the lack of information on non-model organisms, although the drop in costs has made research into a wider range of non-model organisms possible. However, for researchers working on human evolution, the ethical restrictions on developmental work have made it necessary to develop other means of investigating major evolutionary transitions.

The bias of evolutionary models has been towards simple explanations involving large transitions. Dan observed that such shifts are possible but unlikely, and suggested we should turn to the fossil record to understand major transitions better, because such major transitions are likely to have been selected against. By using patterns of covariance among parts of the body, a range of developmental models can be developed.

Dan used the example of the development of the human face using Euclidean distance matrix techniques to distinguish between specimens of Anatomically Modern Homo sapiens (AMHS) and those assigned to “archaic” Homos sapiens. Unlike standard morphometric studies the focus was on growth, not shape *per se*. So the change in the shape of growth sites that had been identified in previous studies provided the morphometric data. The partial correlations among these data revealed that variation in growth site shape was structured among the widths of the sites, and allowed Dan to define AMHS on the basis of facial retraction and the globularity of the skull. The use of the growth sites data has also allowed Dan to demonstrate that the changes occur early in ontogeny.

Jim Cheverund: *The Relationship of Development to Evolution: Reconsidering the Atchley-Hall Model*. Jim discussed the shift from the early research on genotype to phenotype mapping which regarded the relationship between the two as a ‘black box’. Developmental biology has discovered much about the processes going on within the ‘black box’, replacing the statistical correlation with developmental causation.

Jim laid out a case as to why development matters in the generation of variation. Development has a major role in structuring variation by biasing which genotypes are selected for by acting on features that interact together during development (modular pleiotropic units). These modular pleiotropic units are the targets of natural selection through the action of module-specific genes on functionally and developmentally linked phenotypic traits. Jim presented a case study of the effects of individual gene loci upon the length of long bones by applying the Atchley-Hall model to study the pathways linking variation in long bone length during development to variation in long bone length in the adult phenotype.

The meeting provided an excellent summary of the important questions in evo-devo at the moment, and perhaps as importantly the techniques being used to tackle them. The emphasis on uniting different strands of research, such as morphology and ecology, with developmental data was really encouraging, and the ideas presented at the meeting could make a real difference to our understanding of evolutionary processes in both extant and fossil taxa.

Al McGowan
Newsletter Reporter

IGCP 503: Ordovician Palaeogeography and Palaeoclimate, 3rd annual meeting

Glasgow *30 August – 1 September 2006*

The third annual meeting of IGCP project 503 saw 70 participants from 17 countries gather at the University of Glasgow to describe, discuss and debate the latest research on Ordovician palaeogeography and palaeoclimate. The theme of this year’s meeting was changing patterns in palaeogeography and palaeobiogeography, though a multitude of other topics had their moment in the limelight. Before we get down to the nitty gritty, warm thanks must be extended to **Alan Owen**, the conference organiser, for compiling and managing such a stimulating, progressive and, above all, enjoyable meeting.

The three days of presentations were preceded by a fieldtrip to Dob’s Linn, the global stratotype for the Ordovician–Silurian boundary, and Hartfell Score, a contender for the GSSP of the base of the middle stage of the Upper Ordovician, led by Euan Clarkson (University of Edinburgh), Keith Ingham and Chris Burton (University of Glasgow) and Thijs Vandenbroucke (University of Ghent). Once everyone had made it to Glasgow (minibus malfunctions permitting), an evening drinks reception was held in the auspicious surroundings of the University of Glasgow's own Hunterian Museum. Those delayed even further (*e.g.* by the tardiness of trains) had to make do with drinking in local hostelries, before convening at 9:15 the following morning to be welcomed, first by Alan Owen and then by the University's Vice-Principal for Science and Engineering, Prof. Robin Leake. Completing the introductions on behalf of the IGCP 503 project and committee, **Thomas Servais** (Lille) apologized for a lack of dancing girls but said they were simply too expensive for the meeting budget.

The very first talk was also the first keynote lecture, as **Matt Saltzman** (Ohio State) set the scene with a presentation on the biogeochemical evolution of the Ordovician and Silurian oceans, a theme that was to raise its head subtly throughout the three days. With illustration from his popularly cited Nevada $\delta^{13}C$ curve, Matt highlighted the Ordovician hydrospheric and climatic processes that are required to elucidate the mechanisms that controlled Ordovician biodiversification. He emphasized also the need to use modern analogues to understand the contributions of interlinking subcycles, such as the weathering cycle and Sr isotope record, and thus to comprehend fully the contribution of positive (carbon cycle) and negative (silicate weathering) feedback mechanisms. The significance of the Taconic Orogeny was debated hotly.

Following on from Matt's high-impact lecture, the first session was dedicated to palaeogeography and palaeobiogeography. **Trond Torsvik** (Geological Survey of Norway) got the ball rolling by revealing new evidence and models for the progressive rotation of the Siberian Terrane during the gradual accretion of the many peri-Siberian terranes during the Palaeozoic. Trond also demonstrated, using brachiopod and trilobite data collected by Robin Cocks, that during the Ordovician the Siberian Terrane was an isolated landmass situated at approximately the Equator. By contrast, Ordovician China was three separate entities, as **Li Jun** (Nanjing) illustrated in his talk on the palaeoecology of acritarchs. He suggested there might have been a radiation of primary producers in the Early–Middle Ordovician.

Looking resplendent in his wedding jacket and speaking with trademark enthusiasm, **Jan Rasmussen** (Geological Museum, Copenhagen) explained facies controls on the conodont index taxon *Oepikodus evae*. In the East Greenland Caledonides, *O. evae* is missing and the biozone is represented instead by Laurentian facies-controlled faunas indicative of similar marine conditions. Aside from the palaeobiogeographic results indicating that the East Greenland shelf was in fact further east than recognized previously, Jan's presentation highlighted a particular problem in biostratigraphy, namely that index taxa can be strongly facies-dependent and diachronous. And from the Laurentian taxa of Greenland we switched to fossils with Baltican affinities from Northern Iran, as **Mansoureh Ghobadi Pour** (Gorgan University) introduced the biogeographical affinities of some Early to Middle Ordovician faunas. By the Middle Ordovician a lower diversity fauna more representative of Gondwana had been established, with a high-latitude ostracod fauna suggesting a biogeographical link between Baltica and Gondwana.

Being in Glasgow, it was perhaps appropriate that **Enrique Villas** (Zaragoza) should present a talk on brachiopods with Celtic affinities from Peru, though he sensibly employed a royal blue background to appease any Rangers fans present. A low diversity brachiopod fauna from the Lower Ordovician of the Andean Basin is the 'most northerly in South America' and suggests that the Peruvian margin of Gondwana was within spitting distance of Avalonia prior to the opening of the Rheic ocean and its rapid drift to the north. And before we were allowed to sate our lunchtime appetites with delicious pizza slices, sandwiches and cream buns, all delegates were briskly whisked off for a conference photograph.

The Hunterian Museum and main University buildings provided a Hogwarts-esque backdrop (strange how so many palaeontology conference venues now seem to get described as being reminiscent of the famous 'University of Magic').

Palaeobiogeography was again on the menu for the third session as we heard more tales of the itinerant *Oepikodus evae*, this time in the company of **Svend Stouge** (University of Copenhagen). This low to mid-latitude confined, deep water dwelling organism (*O. evae*, not Svend) was constrained to Iapetus, its presence associated with the mid-Ordovician '*evae*' transgression, but its facies dependency and diachroneity possibly undermine its value as a zone fossil. The biodiversification curves produced by IGCP 410 were used to great effect for the Chitinozoa by **Aicha Achab** (INRS-ETE, Quebec) who described the group's diversity through the Ordovician in terms of temperature, ocean circulation patterns and plate tectonics, emphasizing particularly the fall in endemism during the docking of Avalonia with Baltica and the contemporaneous tectonic events along the Laurentian margin.

Jan Ove Ebbestad (Uppsala) looked at the changing biogeographical affinities of gastropods and monoplacophorans from Girvan, showing that the earlier groups are strongly Laurentian affinity, but as the Iapetus Ocean closed a greater influx of non-Laurentian taxa began to appear. Of particular note are peri-Gondwanan species that may reflect the global warming of the Boda Event. Bringing the session to a close, **Bertrand Lefebvre** (Bourgogne) unravelled 100 million years of stylophoran echinoderms, from the Middle Cambrian to the Late Silurian. The pattern of their dispersal and disparity is similar to that of other marine invertebrates, with a rapid increase in disparity during the Cambrian and Early Ordovician, a major diversification in the Early to Middle Ordovician, and a relatively steady change in both towards the end of the Ordovician.

Session 4 was held in conjunction with IGCP 497: *The Rheic Ocean: its origins, evolution and correlatives*. **Jacques Verniers** (Ghent) kicked things off with his study of the rifting of micro-continents away from Northern Gondwana. Detailed palaeomagnetic studies need to be done, but Avalonia was probably the first to break free, with evidence suggesting that the Anglo-Brabant Massif might have been a separate micro-micro-continent. **Jürgen von Raumer** (Fribourg) went in search of oceanic plates to try and unravel the development of Prototethys, Palaeotethys and the Rheic Ocean. A strip of microcontinental terranes separated the Prototethys and Palaeotethys, but the Variscan Orogeny has erased much of the sedimentological and palaeontological evidence. The methods used to define terranes were examined by **Thomas Servais**, who showed that some fossils are good palaeogeographic indicators whilst others certainly are not. Additionally, Thomas pointed out that terranes defined by palaeomagnetic data are more readily accepted than terranes defined by fossils (*i.e.* numbers are deemed to be ‘better’ than bugs), despite the doubtful validity of some palaeomagnetic terranes, such as Armorica.

A civic reception in the resplendent Glasgow City Chambers allowed delegates the chance to finish the first day with further discussion of the good, the bad and the ugly terranes. However, free booze and canapés ensured the topics of conversation soon lowered as people migrated, like mixed-layer dwellers in the ocean, to the pubs, restaurants and dives of Glasgow city on a Wednesday evening.

In the unsettled climate of Scotland, the unsettled climate of the Ordovician was up for scrutiny during the first session of the second day. The dynamics of the end-Ordovician glaciation will probably never be settled upon to total satisfaction, but a new agenda for modelling the late Ordovician climate was introduced by **Howard Armstrong** (Durham University) in his keynote lecture. Howard argued that the Hirnantian event was not a unique Phanerozoic glacial event but that it shared many characteristics with the Plio–Pleistocene glaciations. The Ordovician glaciation was the result of the interaction of gateway closure and a responsive ocean–atmosphere system whereby a shifting Inter Tropical Convergence Zone produced a ‘snow gun’ which was coupled with CO_2 drawdown in response to the shifting climate belts. Evidence from runoff proxies, coupled with whole-rock and individual plankton $\delta^{13}C$ values from anoxic events, argued further for a troubled Late Ordovician climate system, as detailed by **Tom Challands** (Durham University) who recognised sub Ma-scale climate belt shifts as being responsible for basin productivity change at mid-latitudes during pre-glacial warming. It was also good to see Jan Rasmussen’s wedding jacket get its second airing of the conference. Using non-variant $\delta^{18}O$ values derived from conodont apatite samples, **Oli Lehnert** (University of Erlangen) argued for a stable climate in the tropics and subtropics in the Lower to Mid Ordovician, before coupled atmosphere–ocean global climate models produced by **Mika Kashiwagi** (University of Alberta) suggested there may have been strong monsoon flows over equatorial Laurentia and Gondwana during the Ordovician greenhouse climate, with ENSO-like events over the Panthalassic and Palaeo–Tethys oceans.

We then stepped back into the Cambrian for a moment, as **Arne Nielsen** (Geological Museum, Copenhagen) examined the Hawke Bay event of the Lower and Middle Cambrian, and its effects on sequence stratigraphy, sea-level changes and palaeogeography in Scandinavia. The flat topography of the area meant that sea-level changes had particularly profound effects on environments and fauna. Staying in Balto-Scandia but returning to the Ordovician, **Tonu Meidla** (Tartu) calculated sedimentation rates in Estonian sequences, demonstrating that changes in sedimentation correlate with carbonate productivity in the Mid–Late Ordovician, but not in the terrigenous Lower Ordovician. Sea-level responses to climate change in the late Ordovician are currently a subject of much study and, from a Hirnantian section on Anticosti Island, **André Desrochers** (University of Ottawa) recognized four glacioeustatic cycles expressed in equatorial carbonate ramp deposits that correspond with the two established Hirnantian carbon isotope excursions. Ending the morning's talks, and with his second appearance of the day, **Oli Lehnert** used conodont $\delta^{18}O$ to record a further glacial episode, the Lau Event, in the terminal Silurian greenhouse climate. Based on brachiopod $\delta^{18}O$ data, Oli suggested the ambient seawater temperature dropped from 40°C to 23°C. After that we were all ready for some lunch and a stroll around Loch Lomond in the afternoon sunshine. Led by Alan Owen and Keith Ingham, participants were lucky enough to inspect some alluvial 'flans' (Owen) of the Upper Old Red Sandstone, whilst those of us not listening properly (Herringshaw) somehow misheard Keith's description of the 'profoundly North American' fossils as 'profoundly erotic'.

As evening follows afternoon, so drinking followed the end of the day's geological activities, with the conference dinner in the Grosvenor Hotel. Naturally it was an extremely civilised affair* and, as the night drew on and the mixing of alcoholic beverages became more pronounced, so the toasts and speeches became more interesting. They began with a general 'thanks to all and one' from Thomas Servais, followed by a toast to "the best project in the world!" (Dimitri Kaljo), Mike Bassett's account of the demise of the Silures and Ordovices tribes and, to top it all off, a Scandinavian nursery rhyme[1] courtesy of the Anglo-Scandian Mixed Voice Choir (conductor Jan Rasmussen).

Despite all that merriment, the first session of the final day attracted a good attendance to see **Alex Nützel** (University of Erlangen) present his keynote lecture on the major contribution the first appearance and dispersion of small planktotrophic gastropod larval shells may have had towards the Ordovician Biodiversification event. Could the two be causally linked? The Ordovician Phytoplankton Database, compiled by **Gary Mullins** (University of Leicester) and a long list of partners in crime (visit <**http://www.le.ac.uk/geology/glm2/phytopal.html**>) is now reaching maturity and is at a stage whereby the enormous quantities of data it contains can start to be analysed. Gary presented some of the first results of an analysis of the phytoplankton diversity changes throughout the Ordovician, demonstrating a phytoplankton acme in the Dariwillian before a dwindling towards the end of the Ordovician. Of especial interest from the point of view of a coupled biosphere–atmosphere model, the diversity curve coincides with periods of low CO_2 and high O_2, postulated to be a causal link between phytoplankton biogeochemical processes and RuBisCo, a crucial carbon fixation enzyme. At the O-S boundary **Marco Vecoli** (University of Lille) demonstrated that acritarchs are a promising group for biozonation for high-latitude Gondwana where origination rate was high alongside an increased extinction rate. As such, acritarchs do not appear to have suffered severely during the Hirnantian mass extinction. As ecospace was made available at the beginning of the Silurian, the very first calcareous nannoplankton appeared, from

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[1] *"Ole dole doff,*
Kinkliane koff,
Kofliane binkebane,
Ole dole doff"
Anon

Gotland, Sweden, as presented by **Axel Munnecke** (University of Erlangen). Axel and co-workers suggest that these early calcareous forms are not comparable to modern pelagic calcareous plankton, being restricted to shallow water carbonate platforms which were a major CO_2 buffering mechanism in the Palaeozoic.

Session 8 had graptolites and brachiopods coming out of its ears, as **Chen Xu** (Nanjing) identified three periods of graptolite radiation during the Ordovician, **Peter Sheehan** (Milwaukee Public Museum) showed how sea-level changes controlled brachiopod zoogeography in Laurentia, **Christian Rasmussen** (Geological Museum, Copenhagen) correlated increased water depth with brachiopod bioevents in the Middle Ordovician, and **Dave Harper** (Geological Museum, Copenhagen) charted the rise and fall of the orthide brachiopods.

A special session of the International Subcommission on Ordovician Stratigraphy (ISOS) was held after lunch, announcing the introduction of three additional stage names for the Ordovician: the Floian Stage (second stage of the Ordovician System), the Sandbian Stage (fifth stage) and the Katian Stage (sixth stage). These have been published formally by Bergström *et al*. (2006) in *Lethaia*, **39**, pp. 287–288.

Palaeoecology and biodiversity change were discussed in the ninth session, beginning with **Graham Young**'s (Manitoba Museum) unveiling of a unique late Ordovician shallow marine Lagerstätte from the interior of Laurentia (Manitoba Canada), and followed by the description of morphology changes in Mid–Upper Ordovician trilobites from Armorica by **Aurélien Delabroye** (University of Lille). Gastropods from erratic boulders around the rim of a Baltoscandian impact crater caught the attention of **Åsa Frisk** (Uppsala University) and **Zivile Zigaite** (Vilnius University) recognized facies-restricted thelodont assemblages from the Wenlock, Ludlow and Přidoli that are noted to respond to basin sediment input. Zivile is beginning to correlate these assemblages with oxygen isotope data to compare thelodont facies distribution with changing climate. **Joe Botting** (Mitcham, Surrey) warned against making simple causal links between any one abiotic phenomenon and increases in biodiversity, both on local and global scales, though he was able to make links between the establishment of a shallow water ecosystem and an increase in local diversity. This change was probably the consequence of offshore taxa migrating into a 'prepared' environment, established by a pioneering substrate-modifying sponge fauna, although plenty of other factors were undoubtedly involved.

The final four presentations concerned issues of stratigraphical correlation. **Cemal Göncüoglu** (METU, Ankara) has contributed to the Lower Silurian graptolite biozonation of the Eastern Taurides by recognising the *acuminatus* Biozone and the *vesiculosus* to *guerichi* Biozones in three successive Lower Silurian black shale units. **Dimitri Kaljo** (Tallinn University) then suggested that, for Baltica and Laurentia, the splitting and regrouping of the continents was the major controlling factor on global carbon isotopic excursion events. Unfortunately, the GSSP section for the Hirnantian in Wangjiawan, China does not favourably lend itself to establishing a carbon isotope profile, the section being intensively weathered. **Fan Junxuan** (Nanjing Inst. Geology and Palaeontology) described the $\delta^{13}C$ profile of a surrogate section just 180m from the GSSP that provides the best alternative section from which to examine the Katian–Hirnantian carbon isotope profile. Here, as at Dob's Linn, the characteristic first positive $\delta^{13}C$ kick begins just below the boundary. Stable carbon isotope chemostratigraphy has been demonstrated as a powerful tool for correlating the Hirnantian the world over, but on a much broader scale there are doubts over some of the techniques employed, at least in terms of the plausibility of results. This was discussed in the meeting's final presentation by **Bradley Cramer** (Ohio State University), who used high-resolution sequence stratigraphy from the Silurian as an example. Bradley exhorted palaeontologists to collaborate wherever possible with geochemists and palaeomagnetists to ensure the most scientifically reasonable conclusions are reached.


(photo by Axel Munnecke)

And so ended the oral presentation programme, although the fun wasn't quite over. Those who did not have to get back to the office promptly were lucky enough to spend the next three days exploring the Ordovician and Silurian delights of the Girvan District and the North Esk Silurian Inlier under the auspices of Harper, Clarkson, Ingham, Owen and Burton. But, prior to this, being in Scotland, it was only appropriate to combine two of its greatest exports and have a whisky tasting combined with a lecture on the Loch Ness Monster. Despite my best efforts, I really couldn't convince myself that there were banana or seaweed flavours in any of the malts I tried, but I was convinced that some of the sightings of the Loch Ness Monster may actually have been circus animals. The description of a 1919 sighting – "Body like a camel, head like a camel" – was especially entertaining. And that really was that. Next year's annual meeting will be in Nanjing, far, far away from the Iapetus margin, and will address Early Palaeozoic events and stratigraphy. If you've never come up with a good excuse to visit China, maybe now's your chance.


Alan Owen (photo by Thomas Servais)

Tom Challands
Durham University
<t.j.challands@durham.ac.uk>

Liam Herringshaw
University of Aberdeen
<l.herringshaw@abdn.ac.uk>


(photo by Helje Pärnaste)

* Those who may harbour doubts as to the civilised nature of the proceedings are directed to the following link which provides photographic evidence <**http://sarv.gi.ee/igcp503/gallery/index.php?cat=17**>

Marine Institute
UNIVERSITY OF PLYMOUTH

New MSc/MRes opportunities

University of Plymouth
School of Earth, Ocean and Environmental Sciences

The University of Plymouth School of Earth, Ocean and Environmental Sciences is introducing a new one-year MSc/MRes degree course in Marine Geosciences. The course has been approved by a University panel and is awaiting final ratification.

The course will commence in September 2007.

This new course will complement our existing MSc/MRes courses in Global Environmental Change and Micropalaeontology.

Understanding the evolution and interactions of the marine biosphere and geosphere is critical to predicting and managing the effects of present climatic and environmental change. As a key member of the new Plymouth Marine Institute, the School of Earth, Ocean and Environmental Sciences is at the forefront of this interdisciplinary research. The new and established graduate courses listed above benefit from the knowledge and experience of leading researchers in the fields of Palaeoclimatology, Palaeoceanography, Palaeontology, Biogeochemistry, Marine Biosciences and Geodynamics.

We welcome applications from graduate students with backgrounds in any branch of the Physical or Life Sciences.

For further information please see
<**http://www.research.plymouth.ac.uk/marine/**>

or contact Postgraduate Admissions at <**Science@plymouth.ac.uk**>

If you have any questions about the academic content of the course, feel free to contact Dr Gregory Price: <**gprice@plymouth.ac.uk**>, tel +44 (0)1752 233119.

Soapbox

Instructions for who? Or destruction to authors?

I was sat editing. I always seem to be sat editing. As usual, I was picking up inconsistencies and errors of format, using more red ink than any reviewer. I was gambolling through the reference list, that graveyard of the good intentions of so many authors, when I was pulled up by one particular entry. In the 'Instructions to Authors' of my journal, I include eleven references to publications of various sorts as a guide to prospective authors. Some of the examples are standard references, whereas others are books, papers and theses that demonstrate particular types of organisation. The important point is that these should be in the correct format for the journal; accept no substitute. As one example, consider the following:

> International Commission on Zoological Nomenclature. 1999. *International Code of Zoological Nomenclature (4th edition)*. International Trust for Zoological Nomenclature, London: xxix+306 pp.

The impersonal authorship of this reference is as it is recommended on p. VI of the *Code*, where you will find listed the names of the editorial board; botanists aren't so shy (Greuter *et al*. 2000). However, the above reference appeared in the offending paper in a somewhat more imaginative form:

> ICZN (International Commission on Zoological Nomenclature). 2000. *International code for zoological nomenclature*. The International Trust for Zoological Nomenclature, 1999, London. 306 pp.

I will ignore the obvious question, that if an author makes such a bad job of formatting the reference for International Commission on Zoological Nomenclature (1999), can I trust them to apply it? The author of the article is a fine systematist and the paper received positive external peer review. Rather, I quote this grotesque example as an illustration of what every editor will recognise as a too common occurrence in scientific research papers. It is reminiscent of those puzzles that you find in children's magazines, the sort that is captioned 'Can you spot eight differences between these two pictures?', although eight is a low estimate in this example.

Geological research papers are written by highly intelligent people who travel the world in search of their specimens, use complex equipment to collect, process and analyse them, and can then explain their results by diverse processes of analogy, extrapolation and original thought. Then, with a desire to inform their interested colleagues, not to mention self promotion and supplying a transfusion of new blood for their c.v., they sit down to write up their results for publication. I believe that this may be the most daunting aspect of the scientific process for a significant few at the very least, but probably more.

Writing a research paper for a journal is always going to be a compromise between what the author wants to say and how they want to say it, and what a journal's format lets them say and how. There are, quite literally, thousands and thousands of scientific research journals (Testa 2004), although for palaeontologists the list probably only constitutes hundreds, at most. Any of these journals worth their salt will provide an 'Instructions to Authors' page(s), but how much notice do authors take of them?

It is at this point that I remember the Airfix kit of H.M.S. *Ark Royal*, that fine aircraft carrier that was sunk by a U-boat in the Mediterranean. The kit was a Christmas present, probably before I was ten, and obviously too complicated for a small lad to make. Into the breach stepped my Dad, an ex-Navy man, with a fine sense of proportion in construction, but also a certain cavalier attitude to following the sheet of instructions provided with the kit. I was very proud of the finished model, which was undoubtedly *Ark Royal*, but what were all these pieces left over in the box?

The analogy between my *Ark Royal* and what many authors submit for publication is strong. The 'Instructions to Authors' are there, not because the editor needed to write something to fill up space inside the back cover, web site or wherever, but because they are an important guide for potential contributors. Too many authors of scientific papers consider that "… an editor can always correct your spelling and fix your grammar …" (Flagg 2002, p. 69), not to mention reformat your references, but it really is your job, not his or hers. I have nine red pens on my desk as I write. You have been warned.

Stephen K. Donovan
Department of Geology, Nationaal Natuurhistorisch Museum, Postbus 9517, 2300 RA Leiden, The Netherlands
<donovan@naturalis.nnm.nl>

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>>*Future* Meetings of Other Bodies

Please find below a list of known meetings from other bodies. Help us to help you! *Send announcements of forthcoming meetings to:* Meetings co-ordinator (<**meetings@palass.org**>). The Palaeontological Association Future Meetings website is updated regularly; it is at <**http://www.palass.org/modules.php?name=palaeo&sec=meetings&page=55**>.

5th International Bioerosion Workshop

Erlangen, Germany *29 October – 3 November 2006*

The aim of the bioerosion workshop series is to provide an interdisciplinary platform bringing together ichnologists dealing with bioerosion processes from the Proterozoic to the Recent and biologists studying various aspects of the hard substrate degrading mode of life.

The workshop comprises talks, poster sessions and field trips. In addition, all participants are strongly encouraged to bring along samples, outcrop images, SEM images, reprints *etc.* for lively discussions.

For further information please visit <**http://www.pal.uni-erlangen.de/index.php?id=79**>.

International Conference on Changing Scenarios in Palaeobotany and Allied Subjects

Lucknow, India *15–17 November 2006*

An International Conference on “Changing Scenario in Palaeobotany and Allied Subjects” is planned during 15–17 November 2006 to mark the occasion of the Diamond Jubilee year of the Birbal Sahni Institute of Palaeobotany.

The Conference aims to stimulate and disseminate new information/ideas in palaeobotanical research. The emphasis would be given to the applied aspects of palaeobotany, palynology and related subjects. The scientific deliberations to be held during the conference will be useful in identifying future trends in palaeobotanical and palynological research.

This Conference will deal with the following major themes:

- Origin and evolution of early life
- Biodiversity through time
- Gondwana floristics and biostratigraphy
- Patterns of Angiosperm origin and early evolution
- Quaternary Palaeoclimate and Palaeobotanical proxies
- Palynology and fossil fuel exploration
- Archaeobotany and Anthropogenic activities
- Mass extinctions, time boundaries and the fossil record
- Applications of modern tools/techniques in palaeobotanical research
- Geochronometry

The proceedings of the conference will be published in the regular volume of the journal *The Palaeobotanist* after proper refereeing.

Field Trips: A Pre-Conference field trip to Garhwal & Himachal Himalaya showing Neoproterozoic successions of Krol-Tal during 5–13 November 2006 and a post Conference field trip of 3–5 days covering Gondwana and Tertiary localities of Central India from 18th November 2006 are proposed. The organization of field trips will depend upon the availability of participants.

Venue: Birbal Sahni Institute of Palaeobotany. It is about 9 km from Lucknow Railway Station and about 18 km from the Airport. The city is well connected with New Delhi, the Capital of India, by air, rail and road. Please contact the organizers for further details

Registration Conference (15–17 November 2006)
Indian Participants Rs. 5000/-
Foreign Participants US$ 500/-
Accompanying Member (Indian) Rs.1000/-
(Foreign) US$ 300/-

Pre- and Post Conference Field-Trips Indian Participants Rs. 10,000/- (each trip)
Foreign Participants US$ 1000/- (each trip)

Registered delegates will be provided all conference material including abstract volume, breakfast, tea between the sessions, lunch and dinner *etc.* during the conference period.

Accommodation: Delegates will be accommodated in Hotels and Guest Houses located in the city on payment basis. Details of rental charges will be provided later.

Contact information: The Director, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India; Tel: 0091-522-2740008/2740011/2740399/2740413; Fax: 0091-522-2740098/2740485; Website: <**http://www.bsip.res.in/**>; Email: <**director@bsip.res.in**>, <**djconfsect@yahoo.co.in**>.

Primitive Life, Ancient Radiations International Symposium

Dijon, France *7 – 8 December 2006*

As part of the 21st RST meeting, a special international symposium is organised on the theme 'Primitive Life, Ancient radiations'. The goal of this symposium is to present fresh and contradictory ideas on the major biological events that marked the first four billion years of the Earth's history: the appearance of life, the first microbial communities, the first eucaryotic cells, multicellularity, Vendian faunas, Cambro-Ordovician radiations. This symposium will bring together the following disciplines: palaeontology, microbiology, palaeoecology, genetics, molecular phylogeny, geochemistry and biomineralization.

For more information, please see the meeting's website: <**http://www.u-bourgogne.fr/RST-DIJON**> or contact the meeting organizers: Bertrand LEFEBVRE (<Bertrand.lefebvre@u-bourgogne.fr>) or Frédéric MARIN (<Frederic.marin@u-bourgogne.fr>). By post: UMR CNRS 5561 'Biogéosciences', Université de Bourgogne 6, Boulevard Gabriel 21000 DIJON, France.

First Mediterranean Herpetological Congress (CMH1)

Marrakech, Morocco *16 – 20 April 2007*

This meeting is also devoted to palaeontologists interested in palaeobiodiversity and evolution of Amphibians and Reptiles, and the dynamics of palaeo-environments in the Mediterranean-type regions. Our principal aim is to promote the conservation of present and past herpetofauna as an integral part of the natural heritage of the Mediterranean-type regions.

For more information, please see the first circular on the meeting's website at <**http://www.ucam.ac.ma/cmh1**>, or contact the meeting organizer, Prof. N. E. Jalil (e-mail <**cmh1@ucam.ac.ma**>).

23rd Argentine Meeting of Vertebrate Paleontology

Trelew, Patagonia *21 – 24 May 2007*

The Museo Paleontológico Egidio Feruglio (MEF) will host the 23rd Argentine Meeting of Vertebrate Paleontology. These meetings are held annually and gather the vertebrate palaeontology community of Argentina and neighbouring countries. Abstracts focused on all aspects of vertebrate palaeontology research are welcome, including systematics, palaeoecology, taphonomy, and biogeography.

This meeting will be held in the city of Trelew (Eastern Patagonia) between 21st May and 24th May 2007. A post-meeting trip will be organized to visit some of the most important Tertiary outcrops located along the Chubut River Valley.

We cordially invite you to submit abstracts for either oral or poster presentations, which must be received by 2nd March 2007.

For more information, please consult the meeting's website: <**http://www.japv23.org.ar/**> or contact the meeting organizers: <**info@japv23.org.ar**>.

The Global Triassic

Albuquerque, New Mexico, USA *23 – 25 May 2007*

This international symposium will be devoted to all aspects of the Triassic System, with particular focus on the Triassic timescale and Triassic biotic events. It will be an official meeting of the IUGS Subcommission on Triassic Stratigraphy, and a final meeting of IGCP 467 on *Triassic Time and Correlation*. The meeting will be three days of talks and posters at the New Mexico Museum of Natural History in Albuquerque. Planning for pre-meeting and post-meeting field trips is underway, and the trips will be announced in the second circular. They will afford an opportunity to visit several classic marine sections including Fossil Hill (A–L), South Canyon (L–C), and New York Canyon (T–J), as well as classic nonmarine Triassic sections in New Mexico–Arizona. For further information please contact Spencer G. Lucas, New Mexico Museum of Natural History, 1801 Mountain Road N.W., Albuquerque, NM 87104, tel: 505-841-2873, fax: 505-841-2808, e-mail <**spencer.lucas@state.nm.us**>.

First International Palaeobiogeography Symposium

Paris, France *10 – 13 August 2007*

The research unit 'Paléobiodiversité et Paléoenvironnements' (UMR 5143) cordially invites you to attend the 1st International Symposium on Palaeobiogeography. The Symposium will be held at the Université Pierre et Marie Curie (Paris 6). The Symposium will be held in collaboration with the IGCP project 503 meeting. Full details are available on the meeting website at <**http://sgfr.free.fr/rencontrer/seances/s07-07paleobiogeo.html**>.

The Symposium is officially sponsored by:

- CNRS (Centre National de la Recherche Scientifique),
- UPMC (Université Pierre et Marie Curie, Paris 6),
- MNHN (Muséum national d'Histoire naturelle, Paris),
- PF (Association Paléontologique Française),
- APLF (Association des Palynologues de Langue Française),
- SGF (Société géologique de France),
- IGCP project 503 (International Geological Correlation Programme),
- SFS (Société Française de Systématique).

The topics of the Symposium are intended as research priorities in the area of palaeobiogeography *i.e.* the contribution of fossil data to the reconstruction of the Phanerozoic biogeographic history and the use of fossils to propose palaeogeographic reconstructions.

While the biogeographic signature of Pangaea break-up is still evident in the Modern World biosphere, the Palaeozoic one is still debated. Fossils offer important constraints in palaeogeographic reconstructions, particularly to those of Palaeozoic. The Modern World Biogeography is the result of a long history characterized by vicariant events and also phases of biotic interchanges that need to be discussed and analysed. The research for areas of endemism and area monophyly is relevant to the whole Phanerozoic and increasingly needs the use and the development of analytical tools: this gives scope for a topic dedicated to the analytical methods.

Proposed Topical categories and Special Sessions

1 - Palaeozoic Palaeobiogeography
2 - Biogeographical Constraints in Palaeozoic palaeo-reconstructions.
3 - Mesozoic Palaeobiogeography and the break-up of Pangaea
4 - Shaping Modern Biogeography
5 - Biotic interchanges
6 - Analytical methods in biogeography

Publication of Conference Papers: We expect to publish the proceedings as special issues in international peer-reviewed journals.

Registration Fees	Before 30th January 2007:	After 30th January 2007:
	• Full Registration €150	• Full Registration €190
	• Student Registration €100	• Student Registration €100

The registration fee will include Symposium programme and abstract, an icebreaker party and coffee breaks. Delegates are expected to provide their own lunches.

An additional late registration fee of €50 will be incurred for registrations made after 30th June 2007. Please note that all refunds (including non-attendance) will incur a 25% charge. Information regarding payment procedures will be outlined in the next circular.

Accommodation

Participants are expected to arrange their own accommodation during their stay. Paris offers a large range of hotels, guest houses and student accommodation. We do, however, urge participants to book early (at least six months in advance) as accommodation in Paris is very difficult to find at short notice during the Summer period.

We recommend that participants search the web for accommodation or book through a travel agency. For those that wish to book student accommodation please check out the websites <**http://www.cisp.asso.fr/**> and <**http://www.fiap.asso.fr/**>.

More information regarding accommodation and how to get to Paris will be available in the next circular.

The Official languages of the symposium will be French and English.

Conference Secretary

Monique Troy
Université Pierre et Marie Curie - Paris VI
4, place Jussieu – case 117
F-75252 Paris Cedex 05, France
Tel: +33 1 44 27 47 86
Fax: +33 1 44 27 38 31
E-mail: <**palstrat@ccr.jussieu.fr**>

40th Anniversary Symposium on Early Vertebrates/Lower Vertebrates

Uppsala, Sweden *13 – 16 August 2007*

In August 2007, Uppsala University will be hosting the Symposium on Early vertebrates/Lower Vertebrates, the latest in a series of meetings initiated in Stockholm in 1967 by the Fourth Nobel symposium, “Current Problems of Lower Vertebrate Phylogeny”. The meetings are not linked to any society, but have been hosted by institutions in different countries on a running 3–4 year rotation. In 2004, the symposium was held in Gramado, Brazil; previous symposia have included Paris 1995, Miguasha (Québec) 1991 and Beijing 1987.

The Symposia on Early Vertebrates/Lower Vertebrates are the only recurring international meetings targeted specifically at the Palaeozoic vertebrate research community. As such, they draw a broad international field of very high profile speakers, including most of the acknowledged leaders in early vertebrate research. The meetings are friendly and informal, making them outstanding venues for young researchers to meet the established figures in their fields.

Poster and platform presentations are accepted on an open competitive basis (there is usually room for all the posters); there are normally no invited speakers. Topics of presentations usually range from the earliest chordates, through Palaeozoic agnathans and fishes, up to the origin and early radiation of tetrapods. Platform presenters are invited, but not required, to contribute papers to a symposium volume.

2007 is not only the 40th anniversary of the first Symposium, but also the 300th anniversary of the birth of Linnaeus – Professor of Botany at Uppsala University and one of the most influential biologists of all time. In this jubilee year, we are delighted to invite you to Uppsala, to attend what we hope will be an outstanding meeting on the early evolution and palaeontology of the Vertebrata.

Pre-registration deadline: 30th November 2006

Abstract submission deadline: 28th February 2007

Registration deadline: 25th April 2007

Symposium e-mail address: <**EarlyVertebrates2007@ebc.uu.se**>.

Symposium website: <**http://www.fu.uu.se/eo/earlyvertebrates2007/**>.

WOGOGOB 2007
Rättvik in Siljan, Sweden *17 – 20 August 2007*

Next year, the 9th WOGOGOB meeting will take place at Rättvik in Siljan. This marks the 20th anniversary of WOGOGOB – an acronym for WOrking Group on Ordovician Geology Of Baltoscandia. We invite presentations on all aspects of Ordovician geology and palaeontology of Baltoscandia. Two days for technical sessions are scheduled (18–19 August), and abstracts and field guides will be published in a volume of the Swedish Geological Survey Bulletin. A one-day pre-conference day excursion (17th August) in the Siljan area, and a two-day post-conference excursion (19-–20 August) to Jämtland will be offered. The meeting is held in collaboration with IGCP project 503, Ordovician Palaeogeography and Palaeoclimate.

For first circular and preliminary registration please visit our website <**http://www.palaeontology.geo.uu.se/Mainpages/WOGOGOB/Layout.htm**>.

International Federation of Palynological Societies
Bonn, Germany *August 2008*

The next International Palynological Congress will be in August 2008, in Bonn (Germany). For further details please refer to: <**http://www.geo.arizona.edu/palynology//ifps.html**>.

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

Geodiversity: an opportunity to promote public involvement in palaeontology

The Earth Summit in Rio de Janeiro held in 1992 was responsible for raising public awareness about a range of environmental concerns and concepts. One of the most notable outcomes of the Earth Summit was the entry of the term 'biodiversity' into wide public use. A direct result of attempts to quantify biodiversity down to the level of individual local sites was the development of Biodiversity Action Plans (BAPs) in many countries. This article will focus on the situation in the UK and I would be interested to hear from readers in other countries how these issues are developing where they live and/or work.

Wherever you live in the UK, you can now find out about local actions taken to quantify and conserve biodiversity. These plans can be found on the UK Biodiversity plan website at <**http://www.ukbap.org.uk/**>. UK BAPs have been developed for three main areas: species action plans, habitat action plans and local action plans. Species action plans focus on individual species. Habitat action plans look at broad habitats and focus on conservation of whole ecosystems. The smallest scale plans are local BAPs, which deal with individual sites. These local BAPs are often the main point of contact between the wider local community and governmental and scientific bodies.

The role of geological factors in underpinning the diversity of ecosystems has become much better understood in the past 20 years, partly because of the increased emphasis on understanding geological and geomorphological factors in landscape ecology, and partly because of the focus of some habitat BAPs on certain habitats clearly defined by their geological attributes. For example, limestone pavements are recognized as a non-renewable category of habitat relating to the glacial scouring of limestone areas. The flora and fauna that exist on these pavements are often unique, and are classic examples of 'continental' islands. Surveys were carried out by English Nature (now Natural England) to establish the extent of these habitats. An inspection of the habitat BAPs relating to these sites (<**http://www.ukbap.org.uk/UKPlans.aspx?ID=26#1**>) reveals no groups with a primarily geological focus among the partnerships for these sites. Geologists, or people with geological knowledge, may exist within these partner groups, but the lack of clear involvement may result in a public perception that geologists are not interested in these issues and/or have no contribution to make.

The late 1990s saw the development of the concept of geodiversity as another category of earth system diversity. Wikipedia defines geodiversity as follows:

> **Geodiversity** or **geological diversity** is the diversity of minerals, rocks (whether 'solid' or 'drift'), fossils, soils, land forms and geological processes that constitute the topography, landscape and the underlying structure of the Earth.

This term can be applied to any particular region, county or country. The degree of geodiversity depends upon the range of geological and palaeontological features relative to the region or area discussed. A relatively higher (richer) geodiversity occurs in areas that are characterized by the presence of many different geological structures, especially if these belong to differing geological eras (such as occur in the British Isles). A relatively lower diversity occurs in areas that are characterized by large tracts of similar geological structures, for example the Earth's deserts.

Local Geodiversity Action Plans (LGAPs) have begun to be developed to perform a similar role to BAPs. Partners with primarily geological expertise or interests are represented on all of the LGAPs featured on the Natural England LGAP site (<**http://www.english-nature.org.uk/special/geological/lgap/lgap5.htm**>). The development of the UK Regionally Important Geological and Geomorphological Sites Association (UK RIGGS) has been a major factor in helping to channel local knowledge and expertise into LGAPs. Cheshire was the first area in the UK to develop a GAP in 2003, which seems to have been the result of active involvement from University College Chester. GAPs are emerging for some sites in Wales, Scotland and Northern Ireland, but most are still in the development stage.

The concept of geodiversity seems to have been slower to penetrate the Earth Sciences research community than biodiversity was in the 1990s. A search on Google Scholar found 424,000 matches for ‘biodiversity’ and 371 for ‘geodiversity’. Despite the optimistic title of one article ‘Non-geologists now dig Geodiversity’, I think this search result reveals how poor a relation geodiversity is to biodiversity. Much of the published literature appears to have been published in non-peer reviewed contexts. This is not to say that the publications are not important and valuable sources of knowledge, but given the demands placed on university and museum researchers to publish in peer-reviewed journals, they are less likely to invest time in pursing work on geodiversity if the perception is that there will be a limited return for their efforts.

I think palaeontologists are perhaps the group of earth scientists best placed to engage in the promotion of geodiversity because of their training and interests. Many will have at least some undergraduate training in geology. However, the shift in the research emphasis in palaeontology towards questions of biodiversity and palaeoecological questions makes palaeontologists the group best able to collaborate with biologists and ecologists, especially in the emerging field of joint BAPs and GAPs, because they are familiar with biological concepts and concerns and speak a common language.

Palaeontology has an active role in understanding biodiversity change, as the fossil record is the past record of biodiversity. At a research level the discipline has developed the techniques for analyzing large-scale evolutionary patterns, and much of the language surrounding the ‘sixth’ mass extinction has been borrowed directly from palaeontologists. We also have the advantage that the ‘charismatic megafauna’ of the geological sciences (dinosaurs) falls within our discipline. Some areas, such as the Jurassic Coast World Heritage Site and the Isle of Wight, are natural targets for public outreach in the field, but there are many other places where it could occur, and trying to become involved in Local GAPs, particularly as joint GAPs and BAPs start to become more common, may be the best way for palaeontologists to do so.

A related area in which geology and palaeontology compare poorly to our colleagues involved in biodiversity studies is the on-line provision of information to the public via geographic systems. The UK National Biodiversity Network (<**http://www.nbn.org.uk/**>) is another part of the wider effort to quantify and conserve biodiversity. The NBN Gateway provides a means of accessing a diverse range of biological records information about the taxa recorded within UK National Grid 10km squares (*e.g.* TL 45, within which Cambridge lies). The sources of the species data range from governmental/statutory bodies such as the Environment Agency to local conservation bodies and natural history societies that have also contributed their data sets to the NBN, on the understanding that they retain ownership of their data. Many of the datasets are down to 100m resolution. Those datasets that are regarded as sensitive (*e.g.* rare plant sites) are not available to the general public. The NBN, along with websites run by the Wildlife Trusts and many councils, provide people with a strong sense of the biodiversity on their doorstep.

The compilation of these datasets makes excellent use of the long-standing tradition of natural history in the UK that stretches back for hundreds of years. By relating the recording system to spatial areas, this allows the NBN recording efforts to take advantage of the tendency of many naturalists to have a 'local patch', a site or sites close to where they live or work that they often visit and know well. Vast recording networks and datasets have been built on the basis of these people who are happy to give their time and share their data.

Local geological societies, and people with intimate knowledge of particular geological formations or areas, are the obvious corollary of the local naturalist, and in some cases there is considerable overlap. Such local societies often have members who have detailed information on the condition of the outcrop and access issues. By either making it possible to enter such data into the NBN as additional habitat information, or at least making it compatible with NBN data through using the UK National Grid, we could tap into local knowledge about geological and palaeontological sites. Concerns about the quality of the data could be addressed in a number of ways, and certainly do not seem to present an obstacle to biological recording. Making this knowledge base available in tandem with biodiversity data through the NBN would greatly improve the amount of available information on geodiversity. By having geological data within the NBN, joint studies of biodiversity and geodiversity would also become far easier.

Other possible sources of data are the large online projects such as the Paleobiology Database Project (<**http://www.pbdb.org/**>) that have both geological and palaeontological information tied to spatial data, and published literature could provide a major initial boost to getting information online. Websites that deal specifically with fossil sites, such as (<**http://www.ukfossils.co.uk/main.htm**>), and sites run by schools and universities to support palaeontological field courses, could all contribute to the promotion of the palaeontological aspect of geodiversity.

Geological and palaeontological data tied to the UK National Grid, the basis of the maps that many people are familiar with, could represent a major resource for public engagement, and for encouraging the public to go out and 'geologize'. Restricting public access to certain datasets, as is common with biodiversity data, would be a practical means of avoiding problems of sensitive sites being plundered. Recent incidents such as the theft of dinosaur footprints from Bendrick Rock in Wales (<**http://news.bbc.co.uk/2/hi/uk_news/wales/south_east/5299016.stm**>) make it clear that determined individuals will remove material from sites, and more importantly there are individuals willing to buy such material at prices that make it worth the risk. Making the people who live in the vicinity of important sites aware of what they contain – which belongs to all of us – might encourage reporting of unusual activities on such sites. Community engagement has been used to great effect in the re-introduction of sea eagles on the Isle of Mull. Broadening the remit and training of specialist police officers who deal with wildlife crimes could also be a worthwhile measure in increasing the protection of key sites, and was certainly important in the recovery of the dinosaur footprints from Wales.

The establishment of Geoparks, which play both conservation and public engagement roles, is another spin-off from geodiversity. The Abberley and Malvern Hills European Geopark is an example of a highly integrated park that highlights the relationship between geodiversity and biodiversity, archaeology and cultural heritage (<**http://www.geopark.org.uk/**>), and the number of geoparks is growing worldwide. Large-scale geotourism has the potential to be a major employer in areas with high geodiversity. On these grounds it was rather concerning that a preliminary search on UK geodiversity courses could find only one course that was being taught in a geography department. The huge growth in BAPs and the related field of environmental impact assessments has done wonders for the job prospects of ecologists and field biologists. A fair proportion of students still do geology degrees because they enjoy being outdoors. We should be trying to help them find new career paths after they leave university through promoting the concept of geodiversity.

The recognition of the concept of geodiversity represents an opportunity for the geological sciences to raise their profile, and raise awareness of the importance of abiotic parts of ecosystems. The local nature of GAPs and BAPs also offers a new avenue for public outreach by geologists, and palaeontology's fortuitous position at the interface of geology and biology is an opportunity that we should take. The range of potential interactions with different groups has been outlined in this article. However, I think that involvement in LGAPs has two great attractions: getting out in the field with people interested in geology and palaeontology, and following one of the main maxims of environmental action: 'Think global, act local.'

Al McGowan
Newsletter Reporter

FURTHER READING

GRAY, M. (2004). *Geodiversity: valuing and conserving abiotic nature.* John Wiley, Chichester.

STEVENS, C., GORDON, J. E., GREEN, C. P. and MACKLIN, M. G. (eds) (1994). *Conserving our landscape.* English Nature, Peterborough.

WILSON, C. (ed) (1994). *Earth heritage conservation.* Geological Society, London & Open University, Milton Keynes.

Discounts available to Palaeontological Association Members

Geobiology

£25 reduction on a personal subscription. Contact *Blackwells* Journal subscription department for further details.

Paleobiology

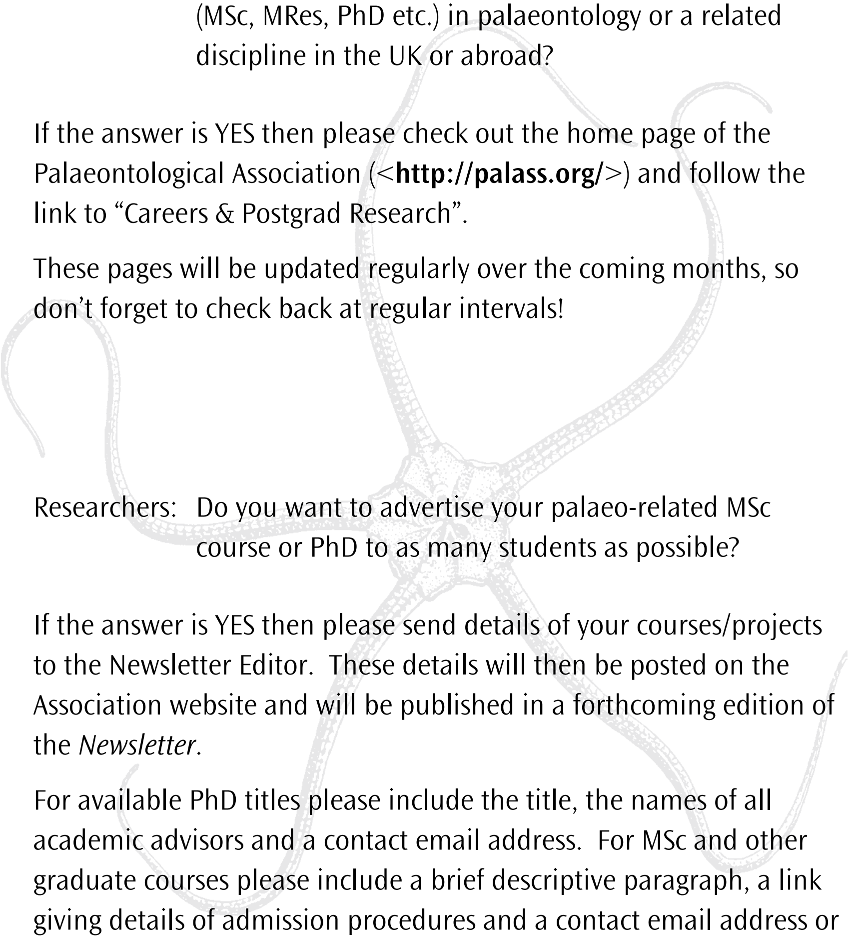
2005 subscription: $45 to ordinary members, $25 to student members, plus an additional $10 for an online subscription. Payment to the Paleontological Society's Subscription Office in the normal way (*not* to the Palaeontological Association). Download the form (in PDF format) from <**http://www.paleosoc.org/member.pdf>**

Please mark the form "PalAss Member" and provide evidence of membership in the form of a confirmatory email from the Executive Officer, or the mailing label from a current issue of *Palaeontology*, which bears the PA member's name and membership status. It is possible to subscribe and renew on-line from January 2005.

Palaeontological Association Publications

Don't forget that all PalAss members are eligible for a 50% discount on back issues of the *Special Papers in Palaeontology* monograph series. Discounts are also available on PalAss field guides and issues of the *Fold-out fossils* series. See the Association website for details of available titles, discounts, and ordering.

Graduate Opportunities in Palaeontology!



Students: Do you want to study for a postgraduate qualification (MSc, MRes, PhD etc.) in palaeontology or a related discipline in the UK or abroad?

If the answer is YES then please check out the home page of the Palaeontological Association (<**http://palass.org/**>) and follow the link to “Careers & Postgrad Research”.

These pages will be updated regularly over the coming months, so don’t forget to check back at regular intervals!

Researchers: Do you want to advertise your palaeo-related MSc course or PhD to as many students as possible?

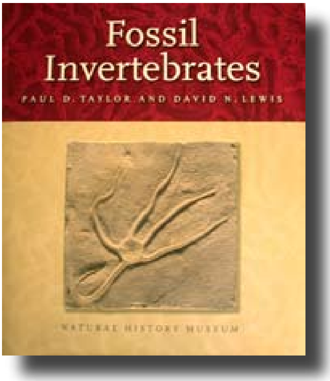
If the answer is YES then please send details of your courses/projects to the Newsletter Editor. These details will then be posted on the Association website and will be published in a forthcoming edition of the *Newsletter*.

For available PhD titles please include the title, the names of all academic advisors and a contact email address. For MSc and other graduate courses please include a brief descriptive paragraph, a link giving details of admission procedures and a contact email address or telephone number.

Book Reviews

Fossil Invertebrates

Taylor, P. D and Lewis, D. N. (2005). Natural History Museum, London.
ISBN 0-565-09183-2 (hardback), £25.00.



I like museums. I especially like museums that contain lots of Stuff. Growing up in Bournemouth, I did not have access to many museums, and even I found the British Typewriter Museum a bit too niche. Despite this, there was always the Red House Museum in Christchurch, one of the best museums of Stuff that I have come across. Tertiary shells vie for space with Edwardian toys, archaeological artefacts from Hengistbury Head and stuffed wading birds. London, in contrast, has huge numbers of museums and galleries, but relatively few of them are true Stuff museums. There are some fantastic small museums (I am particularly fond of the Petrie Museum of Egyptian Archaeology, hidden in a back room of the University College science library), but with increasing size and profile, museums are pretty much forced to show less and less examples of more and more impressive exhibits. This obviously makes for larger and more dramatic displays, but results in Stuff being hidden away in storage.

The Natural History Museum is a perfect example of a Stuff-free museum. This is at least in part due to the building itself being so dramatic, and only by having lots of open space can this be seen to its best. It is only when you get into the storage areas that Stuff becomes obvious. Even before you get at the drawers, there are large mounted slabs of fish, eurypterids and reptiles leaning in corners, and partly unpacked boxes of specimens on shelves. Opening the drawers reveals the real treasures of the museum. Some of the specimens are oddly familiar even though you have never seen them before, having already come across them in publications, maybe as photographs in an issue of *Palaeontology* only a few months old, or as drawings in a 19th century monograph. And then there are the rest of the specimens, sometimes accompanied by detailed data and with modern identification, and sometimes in a rather unloved state labelled as just an obsolete genus. It is therefore to be expected that any book produced within the Natural History Museum, and hence with access to all of this palaeontological Stuff, would have illustrations of some of the best fossils available.

I must state that at the moment I feel like a bit of a charlatan reviewing a book on invertebrate fossils, as I have just put a sample of fossiliferous rock in a bath of acetic acid to extract any bones and teeth it contains, but in doing so destroying any shelly invertebrates. The overall appearance of the book immediately suggests it is more of a coffee table book than anything else, with a large format and a shiny cover. Despite this, I thought there was a bit of a wasted opportunity with this, as the cover is not full colour, and so is less eye catching than it could be. The interior of the book is far less intensively illustrated as the overall appearance would suggest, but the quality of the photographs is uniformly excellent. I was, however, a bit disappointed by the way the photographs were laid out. Through most of the book, the pictures are black and white, and in many cases cropped from the background so they could be slotted into the text. Colour photographs of both fossils and living representatives of fossil groups, although of exceptional quality, are all bound together in the middle of the book, away from the text they relate to. I am sure that this saves money on production, but it rather spoils the book for me.

As with the photographs, the structure of the book is far from what would be expected from the glossy outside. Although very well and clearly written, the overall layout leaves me a bit confused as to the intended audience. There is a very nice introductory section on the context of fossils, followed by a small number of chapters each dealing with several different, often unrelated, fossil groups. Chapter headings give no real idea of the detail within them, with chapters such as 'living in colonies' (bryozoans, corals, sponges and graptolites) and 'shells galore' (molluscs and brachiopods) more suggestive of a book for children than one where the functions of the different zooids of bryozoans are explained. Within these sections, the fossil groups are explained in a far more sophisticated way than suggested by the chapter titles, with each fossil group illustrated by a small number of representative genera. The small numbers of genera mentioned and the detail in which they are described make the overall aims of the book rather unclear. There are too few examples for an identification guide, too much emphasis on certain genera to give a good overall impression of any group, and too much text for this to be of more general interest.

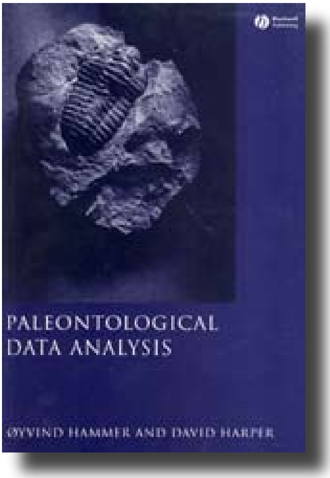
I think that this lack of focus towards a particular audience is a pity, as the text is very well laid out and easy to read, and the specimens very well chosen to illustrate the genera described. In addition, the book is good value for a well illustrated hardback book of this size. I am sure that it will end up in the book cases of a large number of the people reading this (and indeed probably would whatever I wrote about it), but as for a larger readership, I am not sure – but I wish the authors all the best in proving me wrong!

Charlie Underwood
School of Earth Sciences, Birkbeck College, UK
<c.underwood@bbk.ac.uk>

Paleontological Data Analysis

Øyvind Hammer and David Harper (2005, not 2006 as the copyright states).
Blackwell Publishing, Oxford. ISBN 1-405-11544-0 (paperback), £39.99.

In the last two decades quantitative methods have become increasingly important in palaeontology, but knowing which method to use and how to implement it can be confusing, especially as much of the appropriate literature is scattered across a plethora of publications which are often hidden away in other departmental libraries (*e.g.* biomechanics in Engineering, stochastic modelling in Mathematics, ecology in Biological Sciences). Often these methods may not be applicable to the peculiarities of palaeontological data and may be hard to 'translate' into our particular research areas. Until now, no single text was available as an overall guide to quantitative palaeontology. This is why *Paleontological Data Analysis* has quickly become popular, frequently spotted in the hands of my colleagues and popping up as a reference in recently read manuscripts.



Many readers are familiar with the authors' software package PAST (PAleontological STatistics), which as its name suggests, is a program designed specifically to analyse palaeontological data. PAST is a diverse program, capable of univariate and multivariate data analyses that can be applied to a range of topics including morphometrics, ecology, phylogenetics and biostratigraphy. This book is as equally well-rounded as the PAST software. The authors state, "We have identified a need for a simple, practically oriented catalogue of frequently used methods for data analysis". Hammer and Harper wrote this book to fill the gap and as such it is an excellent starting point for an introduction to quantitative methods in palaeontology.

The writing style is easy to understand and relaxed. A little humour and interesting trivia are scattered around the book. Did you know that the Student's t test was invented by an employee of the Guinness brewing company? Understanding is aided by equally clear, uncluttered, diagrams, conveying all the necessary information. The material is laid out in a logical order and presented in a consistent format. Each section clearly states the purpose of the test, what data is required, and describes how to implement the test. The accompanying examples are case studies in which the statistical tests are applied to real data. The case studies are a refreshing mix of invertebrate and vertebrate organisms ranging from classic trilobite examples to brachiopods, ammonites, fishes, mammals and even *Tyrannosaurus* for the dinosaur enthusiasts. Chapters 2 and 4 illustrate case studies with photographs and reconstructions of the organisms used in the example, providing a nice context for the test; other chapters would benefit from the addition of such images.

The first chapter provides the reader with common sense advice about the great power that quantitative techniques can provide to scientists, with stern warnings about the unintentional misuse of such techniques. The next chapter, Basic statistical methods, will be a review for many readers. It is, however, a good reference and familiarises the reader with the layout of the book. In addition, it provides an excellent framework for the process of univariate data analysis. Statistical vocabulary is covered in brief, and then a dozen tests presented sequentially. The tests are laid out independently so a reader may dip into this section to look up a particular item but, when necessary, connections are also drawn. For example, reading about the Shapiro-Wilk test reveals that this test, used to check for normal distribution, can be used to determine if parametric or non-parametric tests are more suitable for testing the data further.

The third chapter is a very cursory introduction to some common multivariate data analysis techniques; specific techniques are left for later chapters. The proceeding chapters (4–8), are focused on a field of study: Morphometrics, Phylogenetics, Palaeobiogeography & Palaeoecology, Time Series Analysis and Biostratigraphy. Each chapter details statistical methods as they are applied to problems in the area. The morphometrics section is excellent. It is one of the longest and most detailed sections of the book, perhaps reflective of Hammer's own interests, or because this area of palaeontology is examined quantitatively most often.

In contrast, the section on phylogenetics is the shortest. I believe this is because it is very difficult to treat this subject in the brief manner that the structure of this book demands, and this topic is covered comprehensively by a morass of other books. Also, although PAST supports cladistic analysis, it is limited compared to more comprehensive programs such as MacClade and PAUP, which tend to be the software of choice for cladists. However, the authors venture forward and do a good job by explaining the principles behind good phylogenetic analysis and briefly discussing some of the methods. As with the other sections, Phylogenetic analysis often references other sources to which the reader may refer for a more elaborate explanation or discussion of the topic.

Palaeobiogeography & Palaeoecology, another long chapter, explores the two topics together as the methodologies overlap greatly. This chapter provides an excellent example of how Harper and Hammer demystify the conditions of a statistical test, the reason for choosing it and its potential implications. For example, I myself have read papers and wondered why the author chose a particular test for the data. Which multivariate test is preferable: PCA, PCO or NMDS? Why choose DCA over CA? What do these confusing acronyms even mean? The authors try to explain the circumstances in which certain tests are favoured, the reasoning behind the selection, and in some cases the technical implementation. For example, Correspondence Analysis (CA) produces artefacts, distorting the results of the tests. Detrended Correspondence Analysis (DCA) 'adjusts' the result by rescaling and detrending the data, making analysis clearer; this is why DCA is often favoured over CA.

The last two chapters, Time Series Analysis and Biostratigraphy, are areas that are often not as well-understood by palaeontologists in general. These chapters start right from the basics and make these intimidating topics an easy read. Techniques are illustrated with a variety of classic and recent examples from the work of authors such as Benton, Gradstein, Nielsen, Raup, and Sepkoski. The two appendices, Plotting Techniques and Mathematical Concepts and Notation, are not designed as full lessons, but rather as a useful reference and review. The book ends with a thorough reference section and excellent index.

There are very few recommendations I can make to improve this book. A table summing up the tests in Chapter 2 would be useful and a couple of the diagrams could have been formatted better. Chapters can be enhanced by the use of more pictures and illustrations of the organisms such as those used in the case studies of Chapters 2 and 4.

There are few references to the software package PAST. I suspect this is a conscious attempt on the authors' parts to ensure this book is flexible and useful to non-PAST users. However, it is not hard to see how the book and the software are integrated as PAST is fairly straightforward and implements all of the analytical techniques discussed in the book.

If you are looking for in-depth knowledge of statistical techniques on a specific topic this is not the book for you and it does not claim to be. However, if you are looking for a manual-style, common sense, solid introduction to quantitative palaeontology or a good reference book, you will find it here. *Paleontological Data Analysis* is an excellent addition to any palaeontologist's bookshelf and a perfect companion to *Numerical Palaeobiology* (Harper 1999). An informal survey of my colleagues suggests that the £40 price tag from Amazon is on the steep side for students. However, having delved deeply into the book, and considering there is no other comparable text available, I believe it represents excellent value for money. Keep an eye out for the Blackwell Publishing stand at the

PalAss annual meeting where the book was sold for £30 last year. Although I have had my copy for only a couple of months it is already beginning to get dog-eared, a testament to its utility.

Sarda Sahney
Department of Earth Sciences, University of Bristol, Queen's Road, Bristol BS8 1RJ, UK
<s.sahney@bristol.ac.uk>

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HARPER, D. A. T. 1999. *Numerical Palaeobiology*. John Wiley and Sons Ltd, New York.

ZELDITCH, M. L., SWIDERSKI, D. L., SHEETS, H. D. and FINK, W. L. *Geometric Morphometrics for Biologists: A Primer*. Elsevier Academic Press, London.

Bursting the Limits of Time

Martin J. S. Rudwick (2005). University of Chicago Press. ISBN 0-226-7311-1, $45 (cloth). Paperback $30, due out Spring 2007.

I thought to begin this review along the lines that 'scientists lack historical insight, and historians have illusions about science that make the history of science an area of activity to be avoided by all but the retired who have no reputation to lose….' But that seemed a bit unkind. I then remembered an article by Stephen J. Gould entitled 'The Power of Narrative' in which he briefly refers to the author of this extraordinary *tour de force:*

> 'Since the history of science is usually written by scholars who do not practice the art of science, they usually impose on this greatest of human adventures a subtle emphasis on theories and ideas over practice. I except Rudwick, who had a first career as a distinguished palaeontologist before switching to the history of science.'

This scientific training gives Martin Rudwick the edge in his writings: he writes with sound common sense, he writes beautifully, and he has given us the results (or at least the first half of the results: a second volume is promised) of a lifetime of study of the great journey our subject made in the late 18th and early 19th centuries, when the earth was slowly recognised to be old beyond the calculations of Archbishop Ussher, with a vast pre-adamite history. *Bursting the Limits of Time* is the story of the discovery of deep time, but the book has a subtitle: 'The Reconstruction of Geohistory in the Age of Revolution'. By this subtitle the author draws our attention to the background of the times about which he writes, encompassing as it does, the French Revolution and the Napoleonic Wars, 'Haydn to Schubert … Fragonard to Goya'. The remarkable feature of the study of geology (the word dates from 1735) – and indeed of the scientific world at large at this time – is the internationalism of the subject. Fans of Patrick O'Brian will

recall the correspondence and visits of Steven Maturin to his colleagues in continental Europe and beyond at this time: historical fact and historical fiction are in harmony, it would seem.

In arranging his book, Rudwick gives we scientists a lesson (p. xxiii) on the nature and value of the footnote in the writing of historical accounts, and then leaves us to follow our journey without them if we wish, placing them conveniently at the bottom of each right-hand page. He also provides an unusual, perhaps unique, arrangement of his sources. A section deals with places where things were and can be seen, including the appropriate map needed to locate the subject of discussion in the field. The repositories of critical objects, rocks and fossils, are, in contrast, presented in footnotes. A pity, for a list of museums holding and displaying the collections of some of the key players would add further inspiration to the geotourist.

Geology is an observational subject. In the early nineteenth century, speculation gave way to field study and collecting. This, in turn, gave rise to a literature in which the image is crucial. The publications of this period include a wealth of representations of geological phenomena, intended to inform the observer, and support argument. Many of these savants were competent illustrators: pen, brush and sketchbook were the cameras of their day. Sketch is transformed into lithograph and engraving. As the subject progresses landscape is transformed into geological cross-section: art into science. Rudwick has explored these visual sources throughout his career, and this volume is no exception, with 145 well-reproduced half tones. Here we see Saussure climbing to the summit of Mont Blanc in August 1787 (figure 1.1), and descending again (figure 1.4). Sir William Hamilton, painted by Joshua Reynolds in 1777, has Vesuvius as a backdrop, and demonstrates the lava flows to the King and Queen of the two Sicilies in brilliant colour on the cover (if you have not read David Constantine's *Fields of Fire*, there is a treat in store). Images of fossils include Brander's exquisite illustrations of equally exquisite Barton snails (1766), and the discovery and detail of the Maastricht animal – a pre-adamite creature that was the sensation of its day, which was hauled off from Maastricht by the French as a trophy on 8th November 1794. It remains in Paris to this day, in spite (as Rudwick notes) of a recent attempt at politically correct "cultural repatriation."

William Smith gets his due, but we are reminded in no uncertain terms of the work of Cuvier and Brongniart in the Paris Basin, where they used fossils not only to identify strata but also to understand the conditions under which the rocks they occurred in had been laid down. Cuvier looms large here and elsewhere in Rudwick's book, as the great comparative anatomist of the era, with tapirs, ibis and much else. He was also the author of the *Discours préliminaire* (1821) that introduces his great *Recherches sur les Ossemens Fossiles*. Later, separately printed, editions spell out the contents in full: *Discours sur les Révolutions de la surface de la globe, et sur les changements qu'elles ont produits dans la règne animal*.

So, revolutions of the Earth in the age of revolutions… With this, Rudwick brings us back to Britain and stratigraphy, Smith, Conybeare and Phillips. Napoleon is defeated at Waterloo. Britain is reunited with the continent. Buckland, Conybeare and Greenough take off in 1816 for their great continental tour, visiting Goethe in Weimar, and Werner in Freiberg (Greenough was not impressed). The Deluge looms large. Buckland visits Kirkdale Cave, and is awarded the Copley Medal of the Royal Society for his work. Cuvier visits England.

And there we stop. Cuvier is the hero of this volume. In the sequel, *Worlds before Adam*, it will be Lyell. Agassiz meets Buckland. The Flood becomes the Great Ice Age. Charles Darwin leaves

Plymouth at 2pm on 27th December 1831, and takes Humboldt, Milton, The Bible and the first volume of Lyell's *Principles Of Geology* with him.

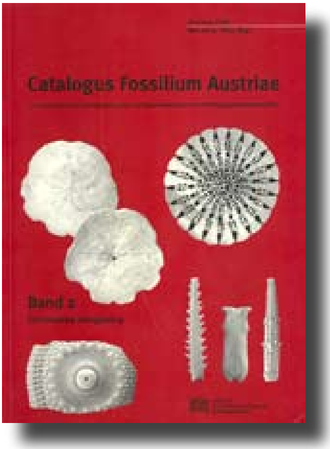
In *Bursting the Limits of Time*, Martin Rudwick has produced a masterpiece. This book should be in the library of every civilised geologist (and palaeontologist, for that matter…).

Jim Kennedy
Oxford University Museum of Natural History, Parks Road, Oxford, OX1 3PW
<jim.kennedy@oum.ox.ac.uk>

Catalogus Fossilium Austriae. Band 2. Echinoidea Neogenica

Andreas Kroh (2005). Österreichischen Akademie der Wissenschaften, Wien.
ISBN 3-7001-3491-6, (paperback), €146.00.

Whenever the Miocene is mentioned, I think of the late Derek Ager's comment that it was "the age of echinoids" (1993, p. 27). Of course, recognising any major geological pattern depends where you're sitting at the time; the South Pole probably wasn't the best place to observe the end of the last Ice Age. My own experiences of collecting Miocene echinoids have been limited to the case hardened limestones of Jamaica, which yield some fragments (if you know where to look) and locally abundant, but poorly preserved, *Clypeaster* tests; hardly the stuff to set the pulse racing. In contrast, Andreas Kroh, lucky fellow, discusses a glut of taxa from the Paratethyan region, particularly Austria.



This weighty tome is beautifully produced in an A4 format on high quality paper. The core of the book is 199 pages of echinoid systematics, with comprehensive synonymy lists, excellent descriptions and detailed comparisons of every species with closely related taxa; this is the sort of detail that will make this volume an essential reference for other systematists. I particularly enjoyed some of the asides in the text, which make some 19th Century workers more human, in particular, the delicious comment on Cotteau's artist (p. 138), whose illustrations were "… nice but often not very accurate"! The supporting documentation is very comprehensive, including good locality data and maps, a systematic index and a reference list with *circa* 900 entries. A glossary of morphological terminology is supported by detailed labelled figures of many of these terms inside the front and back covers, making them easy to access wherever you are in the book. All this and the plates are mouth watering.

I do have one big complaint about *Echinoidea Neogenica* which I am going to get off my chest before I enthuse about the content. I am not complaining about the science, but the editing. To be blunt, what the Österreichischen Akademie der Wissenschaften obviously needs is an experienced copy editor for whom English is the first language. This monograph represents an heroic effort by the author, writing in a language of which he is not a native speaker. As a benefactor of the presentation of this work in English, it may be churlish to be critical, but linguistic errors are common in this volume. Kroh would have been well served by an Editor from Hell who would have attacked these flaws with gusto. All are minor, yet they are too numerous to avoid comment. There, it is off my chest; I now want to talk echinoids.

Some of the species are well preserved, others are only known from scrappy material, yet all are treated with the same even hand. I fully approve of Kroh's devotion to detail, providing, for example, pages of plates of cidaroid spines, including sections that show internal structure. It is apparent that the taphonomic patterns shown by the Austrian material are similar to those shown by the Caribbean Cenozoic echinoids, perhaps not unexpected, but nevertheless worthy of note. For example, diadematoids are known only from indeterminate spines and test fragments, whereas (p. 21) "Identification of small regular echinoids of the cohort Echinacea is notoriously difficult" – amen! It is strangely comforting to know that such material is problematic wherever it may originate.

Of course, most of the complete specimens are to be found among the irregulars, such as those Sherman tanks of the echinoid world, *Clypeaster* spp. and other clypeasteroids, and *Echinolampas* spp. and an assortment of spatangoids. Kroh reminds the reader of the systematic minefield associated with some of these species; over 480 nominal species/subspecies of *Clypeaster* and almost 300 nominal *Echinolampas* species, for example (pp. 45, 103). There are sufficient names available for a 'pigeon hole' to be found for each Austrian member of these genera, thank goodness, apart from the various poorly preserved specimens and obscure records in the literature that are welcomed into the gaping maw of open nomenclature. I particularly compliment the author on his able treatment of the spatangoids, which all too often have fine detail such as fascioles lost due to abrasion/corrosion, or obscured by well-lithified sedimentary rock.

Echinoidea Neogenica is a very fine contribution and should be on the shelf of anyone with a serious interest in Cenozoic echinoderms. Reading a thick systematic publication from cover to cover can be daunting, but I have thoroughly enjoyed the experience. Congratulations, Andreas.

Stephen K. Donovan
Department of Geology, Nationaal Natuurhistorisch Museum, Postbus 9517, NL-2300 RA Leiden, The Netherlands
<donovan@naturalis.nl>

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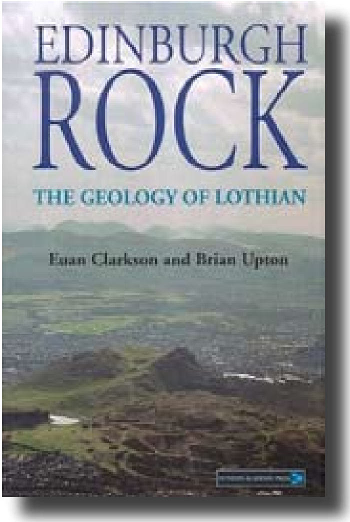
Edinburgh Rock: The Geology of Lothian

Clarkson, E. N. K. and Upton, B. G. J. (2006). Dunedin Academic Press, Edinburgh. ISBN 1-903765-39-4 (Hardback), £17.95.

Having studied at Edinburgh University as an undergraduate of Geology, I have always had a hankering for information on the geology of that region. It is not quite nostalgia as I also enjoy reading about novel interpretations and details of more recent discoveries from the Lothians. So



it was with great pleasure that I read this book, written by those who first inspired me to follow my present career in palaeontology.

Despite the title, the authors extend occasionally beyond the region to include examples from around Scotland. They even mention examples from Glasgow! The 'Bearsden Shark', *Akmonistion*, certainly is an unusual fish and deserves a mention in any book on Scottish geology. Its punk-like Mohawk dorsal spine has intrigued both palaeontologists and the public alike.

Reconstructions of fossil plants are uncharacteristically bright and colourful. Why uncharacteristically? Carboniferous plants are normally depicted almost as dull as the rocks in which they are found. The choice of bright colours gives them a life they have not experienced for over 300 million years. The photographic images of the fossils are a testament to the artistic and technical skills of Professor Clarkson as well, a fine balance of tone, sharpness and contrast difficult to achieve with modern digital photography. The only image I could find that has suffered the pixel scourge of the digital age is of the Salisbury Crags sill, where the detail is lost in the lower resolution.

The diagrams, photos, sketches, paintings, drawings and tables are all essential to the plot. Nothing is superfluous. Nothing is omitted from the text – except drumlins? This book covers everything a geologist, interested amateur, teacher, or visitor to our shores would want to know about the geology of Lothian … and more. There are also ample, detailed explanations of the various geological phenomena that allow the reader to explore and learn. Where necessary, the reader can find sources of further, more detailed, interpretations of structures to advance their newly acquired knowledge one step further.

The appendix has been split into a 'select bibliography', an 'index of place names', and an 'index of geologists'. Is there a need for a general index and a glossary too? I don't think so. The chapters are the index, and the text is the glossary. The order of the chapters follows traditional logic – from the oldest rocks to the youngest. An introduction covering the geography of the region may be best read with the appropriate Ordnance Survey map beside you, as not all the places named are on the figure provided (although their general location can be deduced from the wonderfully descriptive text). The chapter following introduces the rocks and structure of the area with more useful facts than I have found from any other introductory publication on the region. Even earthquakes are covered, and palaeogeography from the mid Ordovician to the late Carboniferous! Although chapter 3 covers only plants and vertebrates of the Palaeozoic, the invertebrates are covered more extensively in the time-line chapters that cover the Ordovician to the ice ages. Despite the mention of the 'Bearsden Shark', there is no mention of *Pederpes* – the earliest terrestrially adapted vertebrate from Dumbarton. Admittedly not from Lothian, but neither is *Akmonistion*. The amphibians from Bathgate are covered from an interesting historical perspective rather than a purely scientific one. The world famous 'Lizzie the (not a) Lizard' is explained, emphasising its importance to our understanding of the early evolution of reptiliomorphs. The environment and ecology of the famous Bathgate locality, as well as that of others, is explained using exquisite and colourful imagery.

Rather than divorcing the industry from the rocks, the history of geology and industrial geology of the region is placed together within the context of the ages of the rocks. I certainly prefer this to reading about the economic aspects of the region at the end of a book, as is quite commonly the case elsewhere.

Having said that, the last chapter before the epilogue is on the building stones of Edinburgh. I suppose in the time-line context of the book, this is the recent geology with humans acting as the agents of transport and deposition. I would have liked to have seen the rock naming of building stones that has been going on in Edinburgh over the last few years mentioned. In 2001 in Hunter Square, Edinburgh, a Caithness flagstone was identified as such with the carved words "Caithness Flagstone. A Scottish rock formed during the Devonian geological period around 380 million years ago". More recently there has been a dolerite also similarly carved with "Dolerite. An igneous rock from Caldercruix that cooled from molten magma around 300 million years ago." (Source: <**http://www.scottishgeology.com/outandabout/built_environment/built_environment.html**>)

There is also the "Scotsman fish" (*Dipterus*) on a Caithness flagstone on the street corner outside the Scotsman newspaper building near the Scottish Parliament. I suppose this would have introduced an excursion-guide feel to the book. It is not, however, an excursion guide. Excursions can be obtained from other publications. It is a detailed narrative introducing the geology of Lothian in a clear and accessible manner. It identifies a gap in the market that has been successfully plugged for Lothian. Can we expect similar up-to-date guides to other regions of Scotland? I certainly hope so!

My recommendation? – Buy it.

Neil D. L. Clark
The Hunterian, University of Glasgow, Scotland
<**nclark@museum.gla.ac.uk**>

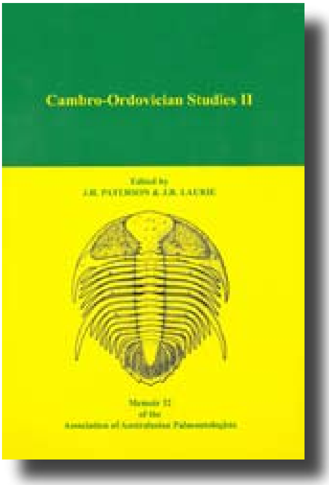
Cambro-Ordovician Studies II

John R. Paterson and John R. Laurie (eds) (2006). Memoir 32 of the Association of Australasian Palaeontologists. Canberra. 422pp. ISSN 0810-8889,
ISBN 0-9494663-0-1, (paperback). AUD$124 from Geological Society of Australia Inc (<**http://www.gsa.org.au/publications.html**>).

This copiously illustrated successor to the presciently named *Cambro-Ordovician Studies I* (Laurie 2004) includes a feast of trilobite taxonomy with side dishes to tickle the palates of workers on other arthropods, brachiopods and conodonts. The coverage of the 17 papers in the volume is fairly evenly distributed between the Cambrian and the Ordovician, and whilst the majority (13 papers) relate to Australian faunas, there are papers on fossils from Argentina, China and the United States. Most papers include at least one author resident in Australia, confirming that Lower Palaeozoic palaeontology is alive and well there. The volume as a whole will be of interest internationally.

The papers on trilobites range from considerations of individual taxa to descriptions of whole faunas. Several stress the wider significance of the taxa concerned. Sundberg presents a phylogenetic analysis of the widely distributed *Tonkinella*, a stratigraphically important indicator of the Middle Cambrian. Paterson uses a species of *Prosopiscus* to improve the correlation in the Middle Ordovician of New South Wales. Edgecombe *et al.* describe and reconstruct the first known species of the hitherto typically Laurentian *Bumastoides* in the Upper Ordovician of Tasmania and in describing a new species of *Sinocybele*, Edgecombe & Webby provide an important assessment of the taxonomic and palaeobiogeographical significance of the genus. The front cover of the volume is adorned by a reconstruction of their new species. Papers by Paterson & Jago and Laurie document Cambrian faunas from Australia whilst Laurie and Zhou & Zhou describe faunas from the Ordovician of Australia and Inner Mongolia respectively. The latter includes consideration of the palaeobiogeographical significance of some of the taxa involved, as does the assessment of new raphiophorids from Argentina by Vaccari *et al.* who use the trilobites to document the drift history of the Precordillera from Laurentia to Gondwana; still a hot topic in Ordovician palaeogeography. An equally controversial issue, in this instance for 40 years, is the concept and interpretation of 'biomeres'; extinction-bounded biostratigraphical units in the Upper Cambrian of Laurentia. The history and status of biomeres are reviewed by John Taylor, who includes something on the palaeontological background of many of the protagonists in the debate and provides an excellent 'way in' to the extensive literature on the subject. Whilst Taylor himself has been involved in the controversy, it is clear where his views differ from those of others and he has produced an entertaining and very readable account.

As with many of the trilobite papers, most of the contributions on other groups have wider implications. Holmer *et al.* describe the shell structure of the Lower Cambrian paterinate brachiopod *Askepasma* which has significant implications for understanding brachiopod phylogeny. Upper Cambrian lingulate brachiopods are described by Englebretsen from eastern Victoria and lingulates also figure prominently in a latest Early Cambrian fauna from New South Wales documented by Brock & Percival along with molluscs and a variety of 'small shelly fossils'. Skovsted *et al.* document an assemblage of bivalved arthropods from the Lower Cambrian of South Australia that facilitates correlation with faunas from other palaeocontinents and points to the possible identification of bradoriids and phosphatocopids amongst the problematic 'small shelly fossils' widely reported from the Lower and Middle Cambrian around the world.


Cambro-Ordovician Studies II

Bradoriids and phosphatocopids are also described from the Middle Cambrian of central Australia by Jones & Laurie who include a very useful review of the stratigraphical distribution of these groups in Australia. This will doubtless form the basis of an increasing use of these microfossils in correlation there. Biostratigraphical correlation of formations in the Upper Cambrian and Lower Ordovician of New South Wales on the basis of conodonts is the prime outcome of the contribution by Zhen & Percival.

This is clearly a volume largely for the Cambrian and Ordovician specialist, but it will have a long shelf life and papers within it should be widely cited both for the taxonomy and for the wider palaeobiogeographical, biostratigraphical and evolutionary significance of the fossils documented within them.

Alan Owen
Department of Geographical and Earth Sciences, University of Glasgow
<alan.owen@ges.gla.ac.uk>

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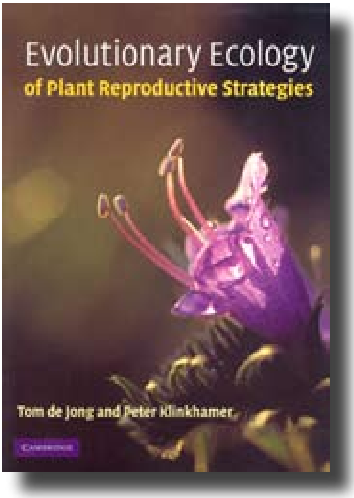
Evolutionary ecology of plant reproductive strategies

Tom de Jong and Peter Klinkhamer (2005). Cambridge University Press, Cambridge, ISBN 0-521-52894-1 (paperback), £35.00.

This is an authoritative account of plant ecology focusing on reproduction strategies, and is an important step in synthesising the available botanical data into a single textbook designed to match comparable zoological information. The contents are up to date and a wealth of recent literature has been utilised in the construction of the text. Without doubt it represents a significant contribution to its field and will prove to be a valuable addition to botanical bookshelves. However, is it of any interest to palaeobiologists? Sadly, the answer is probably not. When I agreed to review the book I was excited about the prospect of receiving something explicitly focused on evolutionary ecology of plant reproductive strategies, concluding that this was much needed and that it would represent an excellent opportunity to integrate information gathered from fossil plants as well as living taxa. After all, why get it reviewed in the *Palaeontology Newsletter* unless it is relevant to palaeobiology? Oh dear!

The book presents a ‘top down’ approach to plant evolution and explores information from living plants alone; it does not consider their deeper evolutionary history as evidenced from fossil data. Not even the slightest mention of fossil taxa or their relevance to the issues contained in the book, and no appreciation of the value of looking at evolutionary ecology from a ‘bottom up’ perspective. Is such information from fossils really needed? In my view yes, and if included would have changed what is, quite frankly, an excellent botanical book into a superb contribution on evolutionary plant ecology. This would allow readers to explore all aspects of the evolution of reproductive strategies and to identify and understand driving mechanisms for this change. I must reiterate, as a botanical text focused on modern population ecology it is remarkable, but for palaeobiology it remains a non-starter.

So what is missing? Far too much to be of interest to palaeobiological audiences, and what follows is but a short summary of major omissions rather than being an exhaustive critique. For instance, the book lacks a coherent phylogenetic structure without which it is difficult to see the evolutionary patterns of the different features elaborated upon. It would greatly help to be able to distinguish changes within lineages and to identify the underlying evolutionary perspective of patterns and processes. How can you study evolutionary ecology without having evolution?! Relevant, but overlooked, syntheses include the multiple origins of heterospory from homospory *(e.g.* Bateman and DiMichele, 1994), evolutionary development of reproductive strategies within fern groups (*e.g.* Bateman, 1994; Bateman 1996), patterns in the reproductive evolution within total group seed plants (*e.g.* Hilton and Bateman, 2006; Doyle, 2006), and not to mention the intricacies associated with the evolutionary origin of flowering plants (*e.g.* Doyle, 2006; Bateman *et al.*, in press). A series of cladograms with salient features mapped onto it would, in my view, bring this book to life and make it much easier to synthesise not only when changes happened within evolution, but allow the underlying causal factors to be elucidated.



For me, a key element absent from the book is information on plant reproductive strategies and arrangements known from fossil data but no longer represented in the modern day flora. These represent important stepping stones in plant evolution without which the contents of the book cannot be a totality of information. Their omission is a problem, and, as such, this book falls firmly on the side of 'extant only' evidence rather than a 'total evidence' approach that would include extant *plus* extinct taxa.

While the book is a winner for botany, it is a loser for palaeobotany and has to receive a thumbs down for this review. It would be an entirely different matter if this review were destined for a neontological ecology journal, where the text would fit in well with the practice in population ecology of ignoring relevant palaeontological information.

Jason Hilton
School of Geography, Earth & Environmental Sciences, University of Birmingham, Birmingham
<j.m.hilton@bham.ac.uk>

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Pennsylvanian Footprints in the Black Warrior Basin of Alabama

Ronald J. Buta, Andrew K. Rindsberg and David C. Kopaska-Merkel (eds) (2005). Alabama Paleontological Society Monograph No.1, Birmingham, Alabama. ISBN 0-9769304-0-4 (paperback), $49.00.

This collection of papers is the result of five years collaboration between professional and amateur geologists after the discovery of the Union Chapel mine site by a middle school science teacher, Ashley Allen, in 1999. As with all multi-authored books the writing style is going to vary but there are some internal inconsistencies that the editors could have been expected to pick up – for instance which is the most common fossil at the site – *Treptichnus* or xiphosuran traces? Are invertebrate and vertebrate traces commonly, or seldom, found together? And which is the most common vertebrate ichnotaxon? These have important implications for palaeoenvironmental interpretations.

The book is divided into four sections: I Site Significance and Discovery, II Geology and paleontology, III Impact on Amateur and Professional Paleontology, IV Photographic Atlas of Union Chapel Mine Fossils.

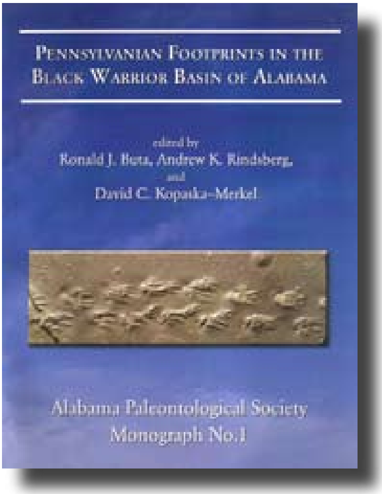
Part I is very short and only contains three papers. The first, by Hunt *et al.*, summarises the importance of the site and is a good introduction to the volume, reviewing its importance relative to other terrestrial trace fossil sites, and designating it a Konzenstrat–Lagestätte due to the large number of trace fossils that have been found. However, the paper has many headings each with only about a paragraph of text and numbered conclusions which make it seem very bitty. The second, very short, paper describes the site's initial discovery and includes photographs of the first fossils found. The third paper, by Buta *et al*., outlines the salvaging and documentation of the trace fossils from this site. This paper really sets the scene for understanding the site because it explains how the fossils were collected from the mine spoil piles, and also notes the different lithologies which preserve the different types of fossils. For instance, small tetrapod tracks such as *Cincosaurus cobbi* are most often found on clay shale while larger vertebrate tracks such as *Attenosaurus subulensis* tend to be found on grey siltstone. This might point to preservation biases or difference in environments.

Part II, Geology and Paleontology, comprises the bulk of the book. It is arranged with the reviews of the palaeoenvironment and stratigraphy first, and then more specific papers on the trace fossils, plants and the rare arthropod body fossils. The first paper, by Steven C. Minkin, *Paleoenvironment of the Cincosaurus beds*, is short, describing outcrop of the remaining highwall in the mine. No real evidence for an estuarine tidal-flat setting of the mine is presented, and inferences about shorelines and small trace fossils are similarly unsupported. The idea that the absence of tails and body traces is the result of all the tracks being undertracks is unconvincing. The quality of illustrations in this paper is very variable – the photographs are very good but some of the line drawings, especially figure 11, are very sketchy. The following paper by Jack C. Pashin is more substantial with excellent illustrations, detailed sedimentary sections and a thorough description and interpretation of the stratigraphy of the area. In addition, Pashin does a good job of explaining technical terms to the general reader.

The next few papers concern the vertebrate traces from the site. Martin and Pyenson discuss the fish swimming traces (*Undichnia*) as well as the common tetrapod *Cincosaurus* tracks. The fish traces are relatively rare in the collections, possibly a result of collecting bias, but are especially important as no fish body fossils have been found from rocks of this age in the south-eastern US; this site also preserves the oldest known evidence of schooling behaviour. The authors also analysed the size frequency distribution and trackway proportions of *Cincosaurus* and concluded that this was consistent with a single population/species. However Haubold *et al.*, in the following paper, state not all traces discussed in this paper are *Cincosaurus* – so it is difficult for the reader to determine what exactly was analysed. This is one area in which clarification of such issues would have been very useful in this edited volume. Martin and Pyenson also document some unusual behaviour in the tetrapod tracks, such as changes in direction due to obstacles – plants or invertebrates – sideways walking, and possible group behaviour. Unfortunately, this paper is marred by some blurry photographs, some photographs lacking scales, and some where the contrast is so poor that it is difficult to see the salient features. This is the first paper in the volume that, while recognizing the majority of these traces as undertracks, also notes that tracks are three dimensional structures and undertracks are not necessarily an inferior source of data.

Haubold *et al.* outline the different tetrapod ichnotaxa from the Union Chapel Mine, grouped according to purported trackmakers – temnospondyls, anthracosaurs or amniotes. Unfortunately while four of these ichnotaxa have a formal diagnosis and discussion section, *Attenosaurus* merely has a long discussion section, although it contains the same information; this makes the paper seem rather disjointed. Reasons for attributing these ichnotaxa to their respective trackmakers are rather brief. Insufficient data is given to assess the claims – for example, pace angulation is stated to be higher in amniote tracks than amphibian tracks, but values for pace angulation are not presented for the latter, so the claim is difficult to assess. As with many of these papers it would have been very useful to have the relative abundance of the different trackways tabulated – such information is often easier to 'take in' when in such a format. This paper is also marred by the quality of some of the line drawings, although the photographs are comprehensive even though they do not always succeed in showing the salient features.

Hunt & Lucas summarise Palaeozoic tetrapod ichnofacies which is interesting, although how it relates to this site is unclear; such an assessment would have been very useful. Once again the paper is marred by the quality of some illustrations.



Three more papers relate to the invertebrate traces. Andrew Rindsberg and David Kopaska-Merkel discuss the U-shaped burrows *Arenicolites* and *Treptichnus* which were most likely made by arthropod larvae. They introduce the new term "bioprint" to refer to a feature which can identify the tracemaker. This, together with the following short paper by Uchman which outlines experimental work on dipteran larvae producing *Treptichnus*-like traces in mud, make a tentative case for the producers of these traces having been dipterans. Dipteran body fossils are only currently known from the Permian onwards. Lucas & Lerner's preliminary assessment of the diversity of invertebrate traces from this site is brief but well-illustrated, with descriptions of the traces and interpretations of the producers; they state that the assemblage is consistent with an estuarine tidal flat environment. It would have been useful to have had a clear statement or a table summarising the proportions of the different invertebrate traces.

Dilcher *et al.* (2005) provide a taxonomic review of the fossil plants from the site which, for those of us interested more in the trace fossils, provides an excellent picture of the flora amongst which the animals lived. The illustrations in this paper are comprehensive and clear, and include a sketch reconstruction of the coastal lowland swamp trees. The authors take care to note that different parts of fossil plants may have different taxonomic names – information very useful to the general reader.

The Union Chapel Mine site has also yielded two wing impressions and a possible arachnid body fossil. It is only 15 million years younger than the oldest known winged insects (Atkinson, 2005) so these are very early forms.

The final paper in this section is a discussion of gas-escape structures by Andrew Rindsberg. These can easily be misinterpreted as rain drop impressions indicating subaerial exposure; gas escape structures, however, can form on subaerial or submerged substrates, but indicate the sediment was wet at the time of formation. This obviously has important implications for interpretation of the palaeoenvironment, but, unfortunately, the two structures can be very difficult to distinguish.

Part III, Impact on Amateur and Professional Paleontology, concludes the text part of this book with four short papers which round up the importance of the site – not just with respect to the science, but also highlighting the collaborations that amateur and professional palaeontologists formed to study the site and to save it from destruction. This section is mainly an appreciation of the contribution of amateurs to palaeontology, and, indeed, in the case of this site, amateurs were the driving force behind its preservation (Lacefield & Relihan, 2005).

Part IV, the photographic atlas, was the part I was really looking forward to – over a hundred pages of photos of trace fossils, including rare fish swimming traces, as well as 25 or so pages of fossil plant photos. This is the sort of feature that a volume like this needs. Approximately equal space is devoted to vertebrates and invertebrates. However, I was very disappointed with this section. On the whole the photographs were very good but there are several problems. It would have been very useful to have stated if the specimens were preserved in epirelief or hyporelief because the lighting direction is variable and can be difficult to determine. The quality of the photographs was highly variable; some were not in focus. In some the scale or the specimen number was too close to the trace fossil, and, in many cases, was crooked or in the centre of the photograph; it looks untidy and can be very distracting. In some photographs, the scale was a coin, the size of which is difficult to assess for non-US readers. However, the job of photographing all these fossils must have been considerable, and in a book like this it is great to be able to see multiple photographs of different types of trace fossils.

This book provides a comprehensive survey of the largest known Carboniferous tracksite, and at $49.00, despite some of the issues raised above, this is definitely good value for money for anybody interested in Palaeozoic terrestrial trace fossils or plants.

Joanna L. Wright
Department of Geography & Environmental Sciences, University of Colorado – Denver, Denver, Colorado 80217, USA.
<joanna.wright@cudenver.edu>

Early Silurian (Llandovery) orthide brachiopods from Anticosti Island, eastern Canade: the O/S extinction recovery fauna

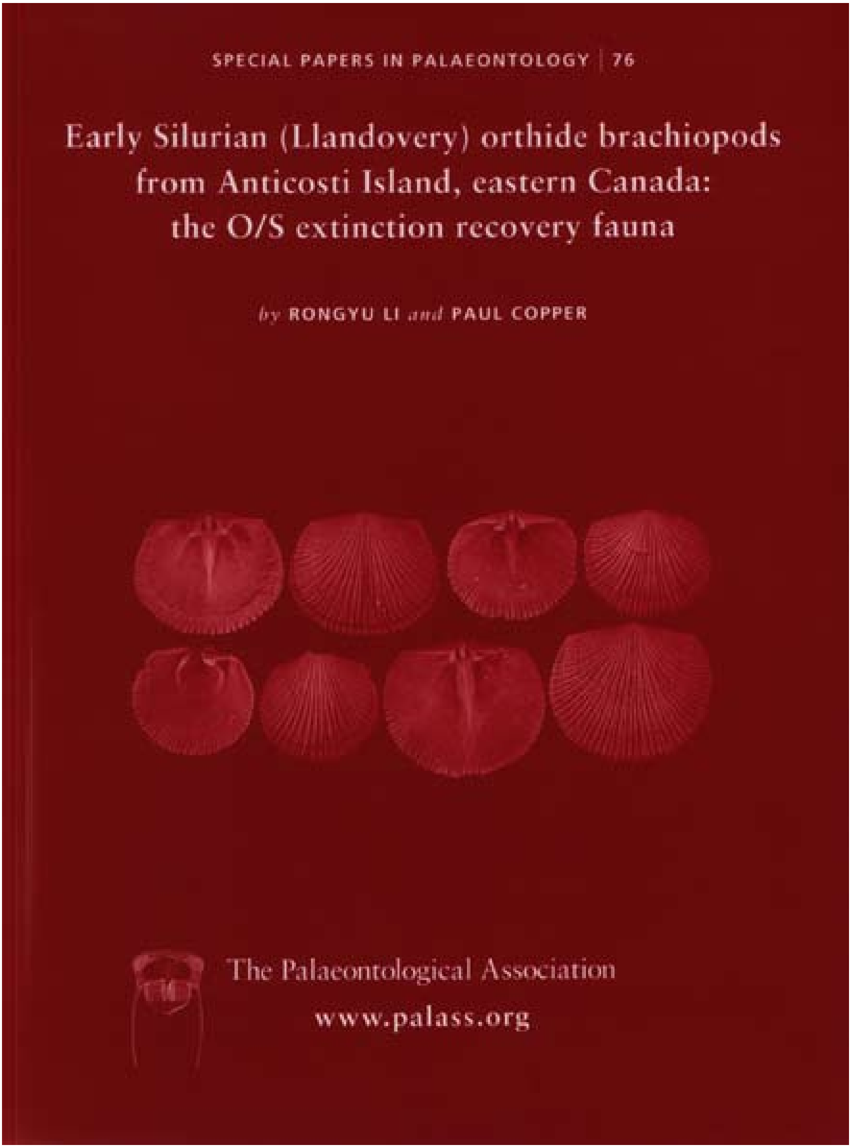
Special Papers in Palaeontology 76. 71 pp, 19 pls. ISBN 1-4051-6012-8, £39 (Members' price £19.50).

Rongyu Li and Paul Copper

Shell-rich Llandovery strata of the Anticosti ramp to shelf tropical carbonate sequence yielded 17 orthide genera, to which are attributed 23 species: 13 of these are new species, one a new subspecies, and one a new genus, *Jupiterella*, type *J. eumorpha* sp.nov. The other new species/subspecies are *Dalejina junonis*, ?*Diceromyonia ciona*, *Flabellitesia adaia*, *Glyptorthis marilara*, *Heterorthina cybele*, *Isorthis* (*Ovalella*) *natiscotekia*, *Levenea mera*, *L. rica*, *Mendacella udauberis*, ?*Pionodema hypermeca*, *Platystrophia hongueda* and *Platystrophia regularis aporegularis*.

Anticosti orthide species previously described in pioneering papers dating between 1857 and 1928 are revised, with 15 species placed in synonymy or regarded as *nomina nuda*, and others illustrated for the first time. The material includes some 9,200 shells, selected from a database that includes more than 1,600 localities, greatly expanding the old locality register and enabling the accurate placement of known and new species in a stratigraphic, evolutionary, as well as type locality framework.

During the Llandovery, orthides spanned the common Telychian benthic assemblages from the *Eocoelia* through *Pentamerus*, *Stricklandia* and *Clorinda* increasingly deeper settings, though such communities were not organized on Anticosti until the late Aeronian. In the carbonate shelf succession of the Jupiter Formation, there are no linear brachiopod community or assemblage belts truly identifying their relative water depth occurrences: only patchy distributions are typical. The discovery of a number of orthides in the Early Silurian of Anticosti, which ostensibly had disappeared at the end of the Ordovician, suggests that the Ordovician/Silurian mass extinction severity for brachiopods was more complex, and probably less severe, than usually portrayed. The delayed full recovery of orthide diversity did not take place until the middle Jupiter Formation, in late Aeronian through Telychian time, matching the *c.* 3–4-million-year delay seen in other brachiopod and coral species, as well as reefs.



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Early Silurian (Llandovery) orthide brachiopods
from Anticosti Island, eastern Canada:
the O/S extinction recovery fauna

by RONGYU LI *and* PAUL COPPER

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Overseas Representatives

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Australia: Dr K.J. McNamara, Western Australian Museum, Francis Street, Perth, Western Australia 6000.

Canada: Prof RK Pickerill, Dept of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3.

China: Dr Chang Mee-mann, Institute of Vertebrate Palaeontology and Palaeoanthropology, Academia Sinica, P.O. Box 643, Beijing.

Dr Rong Jia-Yu, Nanjing Institute of Geology and Palaeontology, Chi-Ming-Ssu, Nanjing.

France: Dr J Vannier, Centre des Sciences de la Terre, Universite Claude Bernard Lyon 1, 43 Blvd du 11 Novembre 1918, 69622 Villeurbanne, France.

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Japan: Dr I. Hayami, University Museum, University of Tokyo, Hongo 7-3-1, Tokyo.

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USA: Professor A.J. Rowell, Department of Geology, University of Kansas, Lawrence, Kansas 66044.

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