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The Palaeontology Newsletter

Contents

Reminder: The deadline for copy for Issue no 76 is 14th February 2011.

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

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Association Business

Annual Meeting 2010

54th Annual Meeting of the Palaeontological Association University of Ghent, 17–20 December 2010

The 54th Annual Meeting of the Palaeontological Association will be held at the University of Ghent, organized by Dr T. Vandenbroucke. Online registration are now available on the Association website, and full details are provided on the website and in this *Newsletter*.

Notification is given of the 2010 Annual General Meeting and Annual Address

This will be held at the University of Ghent, on 18th December 2010, following the scientific sessions. Please note that following the October Council meeting, additional items may be added to the agenda.

AGENDA

1. Apologies for absence
2. Minutes of the 53rd AGM, University of Birmingham
3. Trustees Annual Report for 2009 (published in Newsletter 74 and in the abstracts booklet)
4. Accounts and Balance Sheet for 2009 (published in Newsletter 74 and in the abstracts booklet)
5. Election of Council and vote of thanks to retiring members
6. Palaeontological Association Awards
7. Annual address

H. A. Armstrong
Secretary

DRAFT AGM MINUTES 2009

Minutes of the Annual General Meeting held on Monday 14th December 2009 at the University of Birmingham.

Apologies for absence: Prof. N. MacLeod

1. **Trustees Annual Report for 2008.** Agreed, proposed by Prof. J. Callomon and seconded Prof. E.N.K. Clarkson.

2. **Accounts and Balance Sheet for 2008**. Proposed by Prof. G. Sevastopoulo and seconded by Prof. M. Hart, the accounts were agreed by unanimous vote of the meeting.

3. **Election of Council and vote of thanks to retiring members**. Prof. R. J. Aldridge extended a vote of thanks to Prof. MacLeod and Dr A. McGowan, the retiring members of Council. Dr E. Harper and Dr Modesto were retiring as scientific editors. The following members of Council were elected to serve on Council:

President:	Prof. R. J. Aldridge
Vice Presidents:	Dr Thomas Servais Dr P. Orr
Treasurer:	Prof. J.C.W. Cope
Secretary:	Dr H. A. Armstrong
Chair of Publications Board:	Prof. M. P. Smith
Editor Trustee:	Dr Dr P. C. J. Donoghue
Book Review Editor:	Dr C. Jeffrey-Abt
Publicity:	Dr M. A. Purnell
Newsletter Reporter:	Dr L. Herringshaw
Newsletter Editor:	Dr R. J. Twitchett
Web Officer:	Dr M. Sutton
Ordinary Members:	Mr W. Fone Prof. S. Donovan Dr J. A. Rasmussen Dr C. Underhill Dr E. Rayfield Dr C. Buttler Dr D. Schmidt

Prof. J. Francis was co-opted as “President elect” and Mr P. Winrow was co-opted to stand as Treasurer at the AGM 2010. Dr Harrington and Dr Vandenbroucke remain on Council as Annual Meeting organisers.

4. **Association Awards.** The following awards were made:

- Lapworth Medal to Prof. B. Runnegar (Director of the UCLA Astrobiology Center, and of the NASA Astrobiology Institute)
- President’s Medal to Dr K. Peterson (Dartmouth College)
- Hodson Award to Dr E.J. Rayfield (University of Bristol)
- Mary Anning award to Mr Magne Hoyberget

Honorary Life membership was awarded to Prof. R. Fortey, Prof. C. Paul, Prof. E.N.K. Clarkson and Mr S. Baldwin. Sylvester-Bradley Awards were made to Sallan, Brewer, Butler, Hopley, Nunn, Peralta-Medina and Lecuona. The President’s Award was made to R. Garwood, and Council Awards to N. Crumpton and L. Darras.

The Annual Address entitled “Digital dinosaurs: Unlocking the riddles of the past using advanced 3D imaging” was given by Prof. L. Witmer (Ohio University College of Osteopathic Medicine).

Grants, awards and prizes

Palaeontological Association Research grants

Council has agreed that Association funds should be made available to support primary palaeontological research. Awards will be made to assist palaeontological research up to a maximum value of £15,000. Typically grants could support single research projects or 'proof of concept proposals' with an aim of supporting future applications to national research funding bodies. Online guidelines and the application form are available for the deadline of **1st March**.

Lapworth Medal

The Lapworth Medal is awarded by Council to a palaeontologist who has made a significant contribution to the science by means of a substantial body of research; it is not normally awarded on the basis of a few good papers. Council will look for some breadth as well as depth in the contributions in choosing suitable candidates.

Nominations must be supported by a resumé (single sheet of details) of the candidate's career, and further supported by a brief statement from two nominees. A list of ten principal publications should accompany the nomination. Council reserves the right not to make an award in any one year. Details and nomination forms are available on the Association Website and in the *Newsletter*. The deadline is **1st May**. The Medal is presented at the Annual Meeting.

President's Medal

Council is instigating a mid-career award for palaeontologists in recognition of outstanding contributions in their earlier career, coupled with an expectation that they are not too old to contribute significantly to the subject in their further work.

Nominations are invited by **1st March**, supported by a single sheet of details on the candidate's career, and further supported by a brief statement from a seconder. A list of ten principal publications should accompany the nomination. Council reserves the right not to make an award in any one year. Details and nomination forms are available on the Association Website and in the *Newsletter*.

Grants in Aid

The Palaeontological Association is happy to receive applications for loans or grants from the organisers of scientific meetings that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organiser(s) of the meeting using the online application form. Such requests will be considered by Council at the March and the October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>, and requests should be sent by **1st March**.

Grants-in-Aid: Workshops and short courses

The Palaeontological Association is happy to receive applications for loans or grants from the organisers of scientific workshops or short courses that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. Application should be made in good time by the scientific organiser(s) of the meeting using the online application form. Such requests will be considered by Council at the March and the October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>, and requests should be sent by **1st March**.

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

The Palaeontological Association runs a programme of travel grants to assist student members presenting talks and posters at the Annual Meeting. For the Ghent meeting, grants of **up to £100** (or the Euro equivalent) will be available to student presenters who are travelling from outside Belgium. The amount payable is dependent on the number of applicants and the distance travelled. Payment of these awards is given as a disbursement at the meeting, not as an advance payment. Students interested in applying for a PalAss travel grant should contact the Executive Officer, Dr Tim Palmer, by e-mailing <**palass@palass.org**>, once the organisers have confirmed that their presentation is accepted, and before **8th December 2010**. Entitle the e-mail 'Travel Grant Request'. No awards will be made to those who have not followed this procedure.

ASSOCIATION MEETINGS

54th Annual Meeting of the Palaeontological Association
Department of Geology, Ghent University, Belgium *17 – 20 December 2010*

The 54th Annual Meeting of the Palaeontological Association will be hosted by Ghent University in Belgium, organised by members of the Department of Geology and Soil Science, in collaboration with the Department Géosystèmes of the University of Lille 1 (France), the University of Namur (Belgium), the Royal Belgian Institute of Natural Sciences (KBIN – Brussels, Belgium) and Kunsthal St-Pietersabdij (Ghent, Belgium). As in previous years, this meeting will cover new and exciting developments in the fields of palaeontology and palaeobiology. Please check the Association's website <**www.palass.org**> for all details and updates.

The programme and abstracts for the 54th Annual Meeting of the Palaeontological Association are included in the supplement on the coloured pages of this *Newsletter*.

Venue
The conference will take place at two of Ghent University's conference venues in the historical city centre of Ghent. The 'Aula' is the University's official ceremonial hall, and will be the venue for the palaeoclimate thematical symposium and reception on Friday (address: Volderstraat 9, 9000 Ghent). The second venue, 'Het Pand', is the University's official conference centre, and will be the site for the scientific sessions on Saturday and Sunday (address: Onderbergen 1, 9000 Ghent; see circulars for maps).

Accommodation
Delegates must make their own arrangements for accommodation. Rooms were reserved for the conference in a variety of hotels at a range of prices and within easy reach of the venues up until 30th October. Some likely will still be available in these establishments, although this can no longer be guaranteed. Rooms there and elsewhere can be booked using the links on the Annual Meeting pages on the Association's website (<**http://www.palass.org/**>). We also suggest using <**http://www.visitgent.be/**> to explore all further possibilities. **In the run-up to Christmas the city will be busy at weekends so we suggest you arrange accommodation early.**

Travel
For all travel information, we refer you to the Annual Meeting pages on the Palaeontological Association website (<**http://www.palass.org/**>).

From neighbouring countries, it is probably most convenient to take a high-speed train to Brussels. Ghent is on the crossroads of the international lines London–Brussels–Köln and Paris–Lille–Antwerpen–Amsterdam. Eurostar connects London St. Pancras to Brussels South Station in just under two hours; from Brussels South, take the train to Ghent St.-Pieters railway station (about 30 minutes). When you are flying to Belgium, we recommend flying into Brussels Airport (Zaventem). Many (European) airlines fly directly into Belgium's main airport and SN Brussels Airlines probably has one of the most frequent flight schedules. From the airport, we suggest taking the train to Ghent St.-Pieters railway station (allow one hour for the journey). For international transport, we recommend booking early, as planes and trains usually get busy close to Christmas.

Registration at the conference

Registration on Friday 17th December will take place in the Aula (Volderstraat 9). The registration desk will be open from 13:00 to 18:30. Registration on Saturday 18th and Sunday 19th December will be in 'het Pand' (Onderbergen 1), where the registration desk will be open from 08:30 (Saturday) or 09:00 (Sunday) until 17:00.

Symposium

A special symposium entitled "'Biological proxies in climate modelling, or why palaeontologists and climate modellers should be thick as thieves?" will take place in the main lecture theatre of the Aula, beginning at 13:45 on Friday 17th December. This will be followed by a drinks reception in the same building, commencing at 18:00.

This symposium will document major steps in the evolution of Phanerozoic climate, its links to biotic change, and the ways in which these climates can be tracked by fossil proxies and simulated by advanced numerical computer models. It will showcase the importance of using (mainly fossil but potentially also other) proxy data to build and ground-truth these climate models. Sophisticated numerical climate models are nowadays at the forefront of climate change studies, but it remains essential to evaluate the robustness of output produced by such models through comparison to palaeoclimate proxies, such as synthesised (micro)fossil data (which are especially important for deep-time applications). With this symposium, we seek to promote further integration of geological and numerical approaches to facilitate the development of comprehensive reconstructions of Earth's past and future climate.

We have approached climate modellers, palaeoclimatologists and palaeontologists to give synthesis papers on complementary endeavours or integrated projects. The main themes that will be considered are: (1) Data-model comparisons, (2) Modelling Phanerozoic climates with General Circulation Models; (3) Climate events, extinction and recovery; (4) Large-scale Icehouse to Greenhouse transitions and their control mechanisms; (5) Deep-time warm periods and how they can aid our understanding of Cenozoic and recent climate change, and of the impact of future warming; (6) new proxies for deep-time climate.

Oral and poster contributions

All oral and poster presentations will take place in 'het Pand'. At the conference, each poster will be assigned a poster board. Posters will be available for viewing throughout the conference, and there will be a dedicated poster session from 9:00 to 10:30 on Sunday 19th December.

Annual Address

The annual address will be given at 17:15 on Saturday 18th December at 'het Pand' by Professor Andrew Gale on "Ancient origin of the deep sea fauna: new evidence from the fossil record" (see page 9).

Drinks Reception and Annual Dinner

There will be a drinks reception followed by the Annual Dinner in St. Peter's Abbey (St. Peter's Square, Ghent) on Saturday 18th December. The drinks reception will commence at 19:00 and the dinner at 20:00. Afterwards, delegates will have the opportunity to try our finest Belgian beers in the Abbey's crypt bar.

Field excursion
The field excursion will leave Ghent centre early on the morning of Monday 20th December. Participants should assemble at the main entrance of 'Het Pand' at 07:40 from where we will guide you to the bus stop (a 1 km walk), or directly at the bus stop "Bijlokekaai" at 08:00 (K&R2 – see circular for directions). During the morning and early afternoon we will visit two quarries in the Mons Basin of South Belgium. Field guides will be Johan Yans (University of Namur) and Jacques Verniers (Ghent University). We will then drive to Brussels and visit the Royal Belgian Institute of Natural Sciences, where the famous Iguanodon specimens of Bernissart are on display. We will also see some of the spectacular vertebrate finds of the Messel site.

The visit will end around 17:30–18:00. Participants can then choose to be dropped off at the railway station in Brussels (Brussels South Station, and from there take high speed trains – Eurostar, Thalys – home, or a local train to the airport), or can choose to stay on the bus that will return to Ghent.

Programme and summary of dates

- Friday 19th November 2010: Final deadline for registration

Friday 17th December 2010

- Registration from 13:00 to 18:30 (Aula, Ghent University)
- Symposium "Biological proxies in climate modelling" (Aula, Ghent University)
- Reception (Aula, Ghent University)

Saturday 18th December 2010

- Scientific sessions: talks and posters (Pand, Ghent University)
- AGM and Annual Address (Pand, Ghent University)
- Reception and Annual Dinner (St. Pieters Abbey)

Sunday 19th December 2010

- Scientific sessions: talks and dedicated poster session (Pand, Ghent University)
- Presentations of awards (Pand, Ghent University)

Monday 20th December 2010

- Field excursion to the Mons Basin and KBIN Museum visit

Travel grants to student members
See page 6 for information about grants for student presenters who will be travelling from outside Belgium.

Acknowledgements
We would like to express our appreciation to the following who provided generous financial support: Wiley-Blackwell, Taylor & Francis, Cambridge University Press, Carl Zeiss NV – Belgium, the Research Foundation Flanders (FWO-Flanders), and the Faculty of Sciences of Ghent University.

We look forward to seeing you in Ghent!

Thijs Vandenbroucke, Stephen Louwye, Jacques Verniers

Annual Address 2010

"Ancient origin of the deep sea fauna: new evidence from the fossil record"

Speaker: Prof. Andy Gale,
School of Earth & Environmental Sciences,
University of Portsmouth,
Portsmouth,
UK

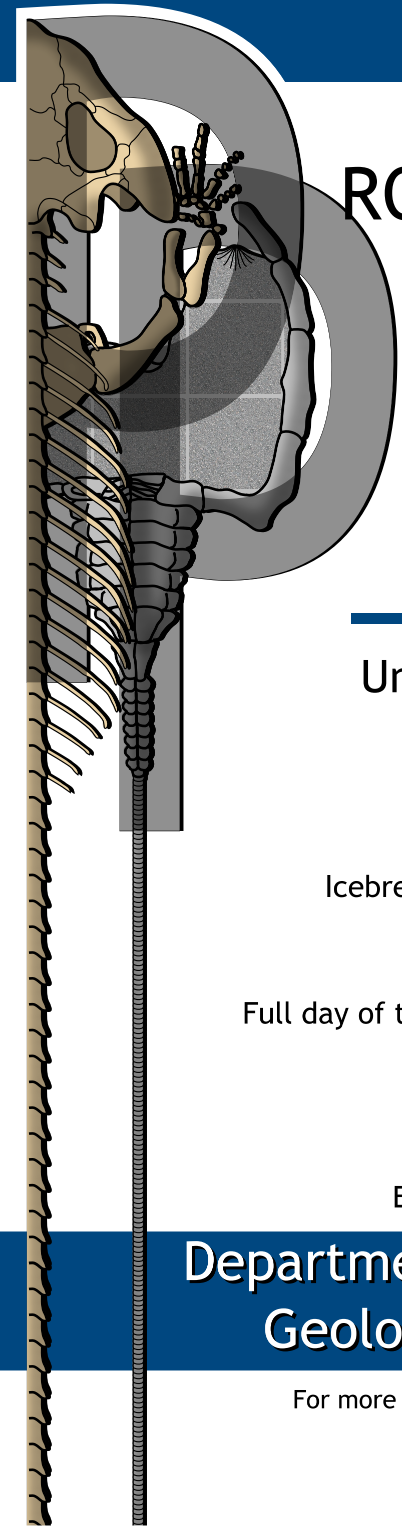
Abstract:

The origin and possible antiquity of the spectacularly diverse modern deep-sea fauna have been controversially debated since the beginning of deep-sea research in the nineteenth century.

Recent hypotheses have thus far mostly been based on biogeographical distribution patterns and molecular clock estimates, and have predominantly suggested a latest Mesozoic or Cenozoic date of origin. Mesozoic Oceanic Anoxic Events and the mid-Cenozoic cooling of deep water masses have been considered to have eradicated pre-existing deep-sea communities which were successively replaced by re-colonisation.

However, in the near absence of direct fossil evidence, considerations on the origin of the modern deep-sea fauna have been highly speculative. Well preserved body fossils of a Lower Cretaceous (114 Ma) echinoderm assemblage from bathyal (1km+) sediments in the NE-Atlantic, consisting of diagnostic disarticulated skeletal parts, have recently been discovered. The composition of the assemblage at family and genus level is similar to modern deep-sea echinoderm communities. It is therefore likely that at least part of the modern deep-sea fauna is considerably older than previously assumed, which is supported by independent evidence from diverse crustacean and other arthropod groups.

It can be demonstrated that many Mesozoic benthic families lived in both deep and shallow habitats, but were progressively excluded from the continental shelves during the Cenozoic.



ROGRESSIVE

ALAEONTOLOGY

LEICESTER, MAY 2011

University of Leicester (UK)

Provisional Programme

Wednesday 4th:

Icebreaker reception in the New Walk Museum

Thursday 5th:

Full day of talks and posters in the Department of Geology

Annual dinner

Friday 6th:

Excursion to a local fossiliferous site

Department of Geology

University of Leicester

For more information: Laurent Darras (ld101@le.ac.uk)
David Riley (dar13@le.ac.uk)

And on www.palass.org

>>*Future* Meetings of Other Bodies

One day conference on Evolutionary Constraints
Zoological Society Meeting Rooms, Regent's Park, London *8 November 2010*

A one-day conference on Evolutionary Constraints is being held on 8th November 2010, starting at 9am (registration from 8:30) at the Zoological Society Meeting Rooms, Regent's Park. The talks are all focused on constraints but include developmental, physiological, functional and ecological constraints that might affect evolutionary processes. There are several palaeontological speakers (plants, dinosaurs, mammals) and we are trying to attract attendees from a wide range of disciplines. The registration fee is £5 (at the door) to cover tea and coffee.

Prof. Lewis Wolpert (Opening Remarks)

Confirmed Speakers: Marcus Clauss (Universität Zürich); Dianne Edwards (Cardiff University); Frietson Galis (VU University Medical Center); Anjali Goswami (University College London); Victoria Herridge (Natural History Museum); Jürgen Hummel (Universität Bonn); John Hutchinson (Royal Veterinary College); Jukka Jernvall (University of Helsinki); Shigeru Kuratani (RIKEN CDB); James Mallet (University College London); Marcelo Sánchez (Universität Zürich); Martin Sander (Universität Bonn); Harald Schneider (Natural History Museum); David Stock (University of Colorado at Boulder).

Speakers are by invitation only. Posters will be considered. To register, please e-mail <**jennifer.fish@kcl.ac.uk**>. For further information visit the meeting website at <**http://www.ceevol.co.uk/workshops-and-symposia/**>

Neogene Park – Vertebrate Migration in the Mediterranean and Paratethys
Scontrone, L'Aqulia, Italy *1 – 3 March 2011*

The conference aims to promote an interdisciplinary discussion between palaeontologists, eco/ethologists, zoologists and geneticists focused on Neogene vertebrate migrations in the Mediterranean and Paratethys as well as stratigraphers, sedimentologists and regional geologists involved with paleogeographic reconstructions and palinspastic restorations of these regions in the same time span. For details visit <**http://www.comune.scontrone.aq.it/pdf/CircularOct2009.pdf**>

Chemosymbiotic molluscs and their environments: from intertidal to hydrothermal vents
Natural History Museum, London *7 April 2011*

The discovery of hydrothermal vents in the 1980s triggered an enormous biological interest in chemoautotrophic organisms dependent on previously unknown symbioses with sulphide and methane oxidising bacteria. Molluscs, particularly bivalves, are the most diverse and widespread group of chemosymbiotic animals, ranging from the intertidal to hadal depths. Talks at this meeting will review their biology, diversity, evolution, host-symbiont interactions and habitats.

The meeting, which runs from 10am to 6pm, is organised by John Taylor and Emily Glover on behalf of the Malacological Society of London and Department of Zoology, The Natural History Museum, London.

There is no registration fee, but for catering purposes please inform the organisers if you plan to attend. For further details and information please e-mail <**j.taylor@nhm.ac.uk**>.

XVII International Congress on the Carboniferous and Permian
Perth, Western Australia *3 – 8 July 2011*

International congresses on the Carboniferous and Permian run every four years – the previous one was in Nanjing in 2007. The venue for the 2011 congress will be the University of Western Australia. The hosts are UWA and the Geological Survey of Western Australia.

Perth lies in the central Perth Basin which is one of a series of basins extending from Timor in the north that formed part of the East Gondwana rift system. We will be running excursions to the Canning, Carnarvon and Perth basins in Western Australia and to Timor Leste. As well as highlighting Permian and Carboniferous exposures, we will be visiting the World Heritage Shark Bay (with the famous stromatolites), Ningaloo Reef – an exceptional modern coral reef that has been nominated for World Heritage listing – and the Devonian reefs of the Canning Basin.

We invite you to participate in the Congress and to join us on one or more of the associated field excursions. Full information on the Congress is provided at <**http://www.iccp2011.org/**>.

The 15th International Symposium on Dental Morphology
Northumbria University in Newcastle upon Tyne, UK *24 – 27 August 2011*

The 15th ISDM will be held on 24–27 August 2011 at Northumbria University in Newcastle upon Tyne, sponsored by the Newcastle University School of Dental Sciences. This symposium will bring together scholars from around the world to present research in all aspects of dental morphology. The range of presentations will be broad and include topics such as dental anthropology, dental evolution, dental function, growth and development, dental tissues, and the genetics and clinical aspects of dental morphology. For information, registration and accommodation bookings, please visit our website at <**http://www.ncl.ac.uk/dental/ISDM/index.htm**>, or for other queries e-mail <**Wendy.Dirks@ncl.ac.uk**>.

SVP 71st Annual Meeting
Las Vegas, Nevada, USA *2 – 5 November 2011*

Esteemed Friends and Colleagues of the Society of Vertebrate Paleontology, the 71st Annual Meeting of the Society of Vertebrate Paleontology will be held in fabulous Las Vegas, Nevada!

The Host Committee consists of individuals from a number of institutions, with expertise in many facets of southwestern vertebrate palaeontology, and we look forward to highlighting this information-rich region to you. During the course of the meeting, there will be field trips to Palaeozoic and early Mesozoic marine units, terrestrial Mesozoic units in southern Nevada and Utah, and famous Cenozoic deposits in and around the Las Vegas Valley. We sincerely hope that you will be able to join us on one of these fantastic trips that we have in the works. In addition to the offered field trips, we have made arrangements with several known regional institutions for comparative collections visits.

We sincerely hope you are able to join us and we can't wait to be your hosts for this showcase of the Southwest!

For more information please visit <**http://www.vertpaleo.org/meetings/2011annualmeeting**>.

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

From our Correspondents

The fossils came from outer space

It was a quarter past four in the afternoon, on Christmas Eve, 1965. Arthur Crow had just left his work at Harvey's factory, to turn for home, when he heard the distant explosion. He thought little of it. He had almost reached home, when the loud whizzing noise gave him the shock of his life. '*Someone's firing rockets at me!*', he thought, as he dived against a wall for cover. He heard a thump against the ground.

At exactly the same time, Joseph Grewcock, who lived nearby, was also startled, as a window of his house shattered. He went outside to investigate. Lumps of rock and white powder lay scattered about. He picked up one of the rocks; it was warm to the touch. He called the police. One P.C. Scott came to investigate, and gathered up the rocks. They were clues, for sure – but what kind of crime had been committed?

This was all in the little village of Barwell, in Leicestershire, and civic peace had been disturbed as the largest known meteorite ever to fall on Great Britain – in historical rather than geohistorical times, that is – came to Earth. It caused quite a sensation, and the roving reporter of the *Hinckley Times* was soon busy gathering eyewitness accounts. And, by the time enthusiastic volunteers had finished scouring the countryside (for a time it was a little like a gold-diggers' camp), 103 pounds of space-rock had been found – not including those fragments undoubtedly spirited away in various back pockets as souvenirs. Fireballs had been seen – three at least – from Shropshire to Berkshire, while the explosions were heard from Wiltshire to Leicestershire.

It would make the start of a fine science-fiction film, would it not? Reality, of course, had by 1965 already been artistically pre-empted, not least by the redoubtable *It Came From Outer Space*, made a decade earlier. This has become a tiny part of Hollywood mythopaeia, not least for the splendidly spine-tingling title[1]. For life to follow art, hence, one of those Barwell meteorites would have had to be a *bit* larger, and from the ensuing crater, at the dead of night, would have, er, ambulated, the mobile mega-eyeball. Leaving a trail of sparkle-dust, the interstellar interloper would borrow the bodily image of a few villagers, pilfer some copper wire, repair the crashed spaceship, and speed on its way before alarm and despondency had been spread among us primitive humans. Tactful as well as tentaculate, this alien has a heart of gold.

Not all aliens are so benevolent. A little later in filmic history, a considerable part of the nation sat glued to the box as Professor Quatermass, over six 35-minute episodes, uncovered the fossil remains of another crashed spaceship, complete with Martian skeletons from the mid-Pliocene epoch. The resultant mayhem literally let the Devil loose amid the ruins of London, and uncovered the beast within the human frame (though that transformation, to be fair, does not always need extra-terrestrial intervention).

[1] Though of course in the long run, we have all come from outer space, being made mostly of stardust, together with stuff directly forged in the Big Bang – all that hydrogen in the water molecules within our bodies. Something to ponder on when next time you add to your primordial content as you drink your pint of beer (though maybe, on second thoughts, this particular bit of pondering is best held back for the *second* pint).

Luckily, some space-creatures have not landed yet, and the ones that most filmgoers would put top of the list of the creatures to be separated from by as many light-years as possible, are the eponymous aliens of *Alien* and *Aliens*, the scariest, the most be-fang'd, the most skeletal, the most monstrous über-tyrannosaurs of all – and the ones, naturally, most adept at selecting *exactly* that right dramatic moment to pick off their next victim. (Just their rotten luck, of course, to encounter Sigourney Weaver as she hit her finest hour).

H.G. Wells, one might recall, got there first, and the space-hopping Martians of *The War of the Worlds* rival the Aliens in the horrific indifference with which they feast on their human prey (in this respect, their other rivals are, of course, humans as they – as we, that is – happily munch their – our, alas – way through the Earth's other species; but, as this is a family column, we will delicately draw a veil over *that* particular analogy and hurriedly return to the main plot).

The real Martians, famously (or notoriously, according to taste), may have really landed on Earth. They perhaps hitched a ride – posthumously, luckily – on ALH 84001, one of the dozen or so known meteorites that, from their isotope chemistry, are regarded as almost certainly derived from Mars, blasted off that planet's surface into interplanetary space, and then eventually falling to Earth.

For a while the putative space bugs became the most famous fossils in the world, as on the 7th of August 1996, when President Clinton spoke on the South Lawn of the White House. He told the world that through this discovery 'the American space program will put it's (sic[2]) full intellectual power and technological prowess behind the search for further evidence of life on Mars'. Well, the euphoria took a little while to die down, and now most of the scientific world has come to consider that this meteorite most likely contains only pseudofossils – inorganic mineral blobs – and not the remains of real microbes, (formerly) metabolizing and reproducing and so on. However, these cosmic phantoms have not *quite* been put to rest, microscopic stakes through their other-worldly hearts, and last year there were Developments (which at the time quite passed me by). Most intriguing they are too, for the plot has thickened somewhat.

It's worth recounting the story from the beginning, for it shows the thrills and spills with which exopalaeontology started (and that will certainly continue as this science develops). The ALH stands for the Allan Hills, in Antarctica, that happy hunting ground for meteorites, where this particular lump of rock was found, in 1984. It fell to Earth some 13,000 years ago, as estimated from traces of carbon-14 on it (that formed from its exposure to cosmic rays in outer space, and then ceased forming once it was buried in the Antarctic snow and ice – hence starting this particular clock). Prior to that, it had been in outer space for something like fifteen million years (again, estimated from isotopes of helium, neon, argon produced by those cosmic rays).

Its origin from Mars seems secure. The oxygen isotope ratios within its minerals are quite unlike anything formed on Earth, and it contains traces within it, still, of Martian atmosphere – a unique thing in the Solar System, with an unusual and distinctive combination of particular isotopes of nitrogen, argon and xenon. It is an old piece of rock, and igneous, to boot – so nothing like the kind of sandstone or mudstone that palaeontologists normally make a beeline for when hunting fossils. It is mainly composed of crystals of orthopyroxene, that crystallized from a magma some 4.5 billion years ago – that is, only shortly after Mars, the Earth, and the rest of the Solar System

2 Yes, this really is a rogue apostrophe – from the very heart of US government, too. Tsk! – or, perhaps, t'sk!

formed. The pattern of rubidium and strontium isotopes, though, suggests that it was shocked by something (presumably by a meteorite impact earlier than the one which kicked it into space) a few hundred million years later. This shock would have produced fractures within the rock (which lay some distance below the ancient Martian landscape), and it is sometime later, within these fractures, that our biodrama – or, alternatively, chemodrama – took place.

ALH 84001 became an instant celebrity when the research team led by David McKay of NASA published the paper in *Science* that garnered the presidential press release[3]. McKay and colleagues pointed to three separate types of potential fossil in the meteorite, all hosted within fractures in the rock, and all, they said, suggestive of some kind of underground microbial life. All of these were in, or associated with, distinct mineralogical features that were scattered along the fracture walls – flattened 'globules' or 'pancakes' of a mixture of calcium, magnesium and iron carbonate minerals. These seem to be Martian features (rather than, say, terrestrial contaminants) as isotopic ages of this material – which is, admittedly, difficult to date – have suggested that they are more than a billion years old. It is most plausible to see these as crystallizing from Martian groundwater circulating, a long time ago, within the buried fracture system. The proposed life-forms would then have been, too, living in this groundwater.

On to the evidence for life itself. Firstly, and most notoriously, the alleged fossils: clusters of rounded, segmented rods visible on scanning electron micrographs of broken surfaces of the calcite globules. They look superficially like very tiny bacteria. The most famous one, that looks as if it had the misfortune to have passed through Salvador's Dali's hands at some stage in its existence, wasn't in fact in the paper, but was shown (minus scale bar) at the ensuing press conference. These suggested fossils are illustrated as shapes only, though they are most likely preserved as some sort of cast made of one of the carbonate minerals. They're terribly small, at only a few tens to a hundred or so nanometres (billionths of a metre) long – so about an order of magnitude smaller than the smallest bacteria then known.

Now, such objects had already been found in terrestrial limestones, by no less a figure than Robert Folk who, indeed, coined the term 'nannobacteria' – but it was the Martian examples that shot them into the spotlight. This started off a hunt for further examples, alive or dead, and in the posthumous world they soon turned up everywhere – particularly in limestones. The ooids of oolitic limestone, for instance, seem to be largely made up of concentric layers of such objects – and so the clock tower in the centre of Leicester (for instance), largely built of the stuff, would be just a stony mass of nanobacteria.

But it was the search for living, metabolizing and pathogenic (for surely there was money to be earned here) nanobacteria that stirred up some fine controversy. Thus, living examples were announced and denounced in broadly equal measure, the debunking lately taking the upper hand (the biological equivalent of cold fusion, it has been called). A recent review of these, by John Young and Jan Martel, plausibly puts them firmly in the land of the un-living, but suggests they might be part of an interesting pre-life scenario. Thus, an accumulation of dissolved proteins can prevent minerals such as calcium carbonate or calcium phosphate from crystallizing into nice regular crystals, instead making them form tiny rounded blob-like shapes. The Martian

[3] The paper being in one of the ultra-posh journals, the descriptions and discussions therein are a touch more elliptical than one would wish – but shortly afterwards Allan Treiman wrote a nice, very even-handed explanation and context: <**http://www.lpi.usra.edu/lpi/meteorites/life.html**>.

fossils (and all the terrestrial examples) therefore seem to emerge as a fascinating but abiotic phenomenon (but what supplemented Mars with those proteins, one wonders?).

McKay and company reported a second line of evidence: the presence in those fractures of significant amounts of polyaromatic hydrocarbons (PAHs). Now there are thousands of such compounds on Earth, so one obvious line of attack is that this simply represents terrestrial contamination of ALH 84001 after it fell onto this planet. It's not so simple, though. The PAHs within the meteorite become more abundant from the outside to the inside of the meteorite (suggesting that they were there before Earthfall). Also, they are only represented by a restricted number of chemical types, different than might be expected from a typical terrestrial assemblage today (with much human-produced input from fuel exhausts and such) or those found in ice representing pre-industrial times. They might resemble, though – said McKay *et alii* – the kind of chemicals that could result from the breakdown of bacteria – by implication *Martian* bacteria. That last point is more speculative, if not downright dodgy, but nevertheless Treiman thought the PAH evidence the most convincing of the three lines of evidence cited (although he was careful not to say how convincing he thought that might be, on any scale that runs from 'pretty convincing' to 'utter codswallop').

The third line, now, and this is one that has lately been re-animated[4], is the presence in the carbonate globules of tiny (nanometre-sized) crystals of more or less pure iron oxide – magnetite. These look very similar to the magnetite crystals that certain Earthly bacteria have within themselves (which they manufacture, it is thought, to help them detect or use the Earth's magnetic field). This was met also with the riposte that such crystals could be explained in non-biological terms, most obviously from the heat-induced breakdown of iron carbonate within the globule (to give iron oxide and carbon dioxide), the heat being derived, say, from impact (either the early impact on the Martian surface, or the later one that took it into space, or the one as it finally slammed into Antarctica).

This is where the McKay team (this time led by microscopist Kathie Thomas-Keprta) took a closer – a *much* closer – look at these objects. Publishing in 2009 in *Geochimica et Cosmochimica Acta* – not quite such a prestigious organ as *Science* (though it's not half bad) – they could indulge in a more thorough description, and good hyper-detailed stuff it is (regardless of whether one buys the biological story or not).

Firstly, the carbonate globules. Well, to be precise (and this quality will be needed in exopalaeontology, as well as an iron resistance to all B-movie imagery), they're geometrically not globules, or pancakes, or rosettes – as they had been termed. They are, to be precise, inverted conic frustrums. A new one on me, that was, but the authors explain (and draw) it as the base of a cone, the apex of which as been cut away and removed. It's inverted, because the smaller circular(ish) surface rests on the orthopyroxene of the fracture surface, and in fact sits within a distinct depression that exactly fits the conic frustrum (or 'disk', a less precise term that the authors thereafter used for simplicity). Thus, whatever range of processes precipitated the carbonate disk onto the fracture surface, previously dissolved a neat hole out of the rock for the disk to sit in.

[4] One would wish to say this happened at midnight, in the highest turret of the ruined tower of the abandoned castle, as lightning crackled around and the incautious heroine in the white nightshirt stepped out into the grounds to find out *what was going on out there...* Exopalaeontology is a land of strange temptations, to be sure.

There are quite a lot of these disks, that occur singly or in clusters. A very few of these were very, very closely examined by the finest electron microprobes and ion beams that the team could lay their hands on, individual sacrificial disks being given names such as 'Ear', 'Texas' and, most intriguingly, 'Poster Boy'.

Each disk itself is zoned, with a narrow rim comprising a kind of iron carbonate–magnesium carbonate–iron carbonate sandwich, around a core which is more calcium-rich at its centre, with a more magnesium-rich carbonate around this. In itself this argues for some complicated chemical evolution going on in that water-soaked environment beneath the surface of ancient Mars. There was also the mystery of – why carbonate? The predominant decay product of an orthopyroxene should be clay, of which there are negligible amounts in this meteorite (although clays have been detected and indeed mapped on the Martian surface elsewhere). Curiouser and curiouser, as the team (in effect) admitted.

The disks play host to the magnetite crystals. These were particularly abundant in the outer iron carbonate-rich layers, but were also scattered within the calcium–magnesium rich core of the disks, and also within tiny mineral-filled fractures that cut the disks themselves. Most of the paper is devoted to countering the charge that they are most likely non-biological, and in particular that they formed by thermal decomposition of iron carbonates – not least via the development of this non-biological scenario by Allan Treiman in 2003. To this end the team took some terrestrial iron carbonate, heated it – and looked at the result. For sure, small magnetite crystals had formed, but these tended to have some magnesium in them (something the Martian crystals don't have – even where they are embedded in magnesium-rich carbonates). There is a good deal more detail besides, but the upshot is that the NASA team still argues that a biological origin for these crystals seems more likely than a non-biological one (while the latest Treiman-led riposte appeared this year). This debate will doubtless have legs, perhaps abiotically manufactured.

The debate has been conducted largely in the physico-chemical realm, even on the pro-biology side, with not much on the inferred palaeontology or, indeed, palaeoecology of the could-be-fossils. For, if even part of these magnetite grains did crystallize inside Martian bacteria, there is surely a thread here to be followed. To start with, there are *lots* of these crystals inside each carbonate disc. This groundwater system, thus, did not just contain the odd microbe, but it played host to a proper, thoroughgoing infestation – even within one of the more unpromising lithologies on that planet.

Now, if one was to pursue this scenario a little (though perhaps peering over one's shoulder a touch nervously, in case the good Dr Treiman was in the vicinity to keep things in order), then it suggests that the early Mars, below ground and on the ground surface, was a pretty microbial place; after all, once the bugs begin to get a hold, there tends to be no stopping them. Thus, as the next lander lands, the kind of thing one might search for in the right strata, is sedimentary evidence of long-dead microbial mats – those wrinkle marks and elephant-skin textures that are the tell-tale signs that bacterial slime has held sedimentary laminae together, and that one picks up, with a little practice, in Precambrian (and younger) successions, as Jim Gehling has shown in his exploration of Precambrian death-masks. Perhaps there will even be stromatolites, to be picked up by the cameras of son-of-Spirit or maybe even by those of daughter-of-Beagle.

And then, once Mars has frozen and freeze-dried and been blasted by the solar wind, a billion years into its existence, the surface bacteria die. The survivors, then, are those inhabiting fractures at joints at depth, where the base of the permafrost layer meets the residual heat coming up from the Martian mantle. There is, you may recall, methane being released, here and there, from the Martian surface, even now, spotted by the all-seeing multispectral eye of the satellites that we have placed in orbit.

We are, of course, in the realm of the what-might-be. And what there might equally well be, in truth, is a planet that was always perfectly sterile, with no call for any palaeontologist of any stripe or specialization: with some perfectly respectably chemical means of growing nanoscale crystals of pure magnetite, and an absence, a century hence, of those avidly sought-after wrinkle marks or stromatolites, and completely microbe-free local dehydration of serpentinite mineral at depth beneath the Martian crust to release Martian methane. Better to be on tenterhooks, after all. After such a fine mystery, the finding of life, living or dead, on Mars, might almost come as an anticlimax.

Say that conclusive evidence did turn up, though, to show a once or presently living Mars. Such microbes, once they put on their travelling shoes, might come in handy to explain life on our very own Earth. For the exciting early years of our planet are squeezing the time in which life might have incubated on home territory. I was reminded of this by some recent discussions of stratigraphical terminology. This is a topic that can often be accused of being a touch dry and arcane (all too often, with some justice). Here, though, it was anything but.

These are in general exciting times for Precambrian stratigraphy, what with the newest geological period, the Ediacaran, being recently set up (so the fossils of Charnwood Forest have a respectable temporal home), and with the time before that, of the mysterious Snowball Earth, moving closer to being formalized as the Cryogenian. *Much* farther back, we have the time of some four billion years ago, before a stratal record is preserved, the Hadean; that evocative term is also gathering momentum.

This name-proposing has now gone yet further, with appropriately classically-driven élan. Colin Goldblatt and colleagues this year suggested a formal subdivision of Earth's earliest years – indeed, they reach back to the time before the birth of Earth. Not content with mere periods, they reach for the very largest new unit of time, and propose a new Eon, which they termed the Chaotian. This, they say, marks the time between the formation of the Solar System (more specifically, the separation of solid phases from gas in the solar nebula), and the event that created the modern Earth – the moon-forming impact with the Mars-sized, if short-lived, planet Theia. The Chaotian might just catch on (for they bring on the big guns, and quote in support John Milton, and *Paradise Lost*).

The Chaotian is divided into two eras – the Eochaotian, which starts when the solar nebula had detached itself from the parent giant cloud of gas and dust, and the Neochaotian, that starts with the first light from the sun. And, of course, before the Earth splashed into and merged with Theia, it was not really the Earth at all, but it was some other planet, noticeably smaller, and with some other future, some other evolution, some other life (or not) that was instantly annihilated, at the moment of that frightful impact. For that other planet, they suggest the name Tellus. Will that catch on? – well, it's a nice idea, but I'm not so sure. Not yet, at least, for the idea of Theia, and of the impact, and of the pre-impact Tellus is still, just, the hypothesis that best explains the existence and nature of the Moon. It is not yet solid, nailed-down reality-that-was.

Coming into more familiar (hah!) territory, it is the end of the Hadean that we now aim for. For the ending of it is, also, not quite nailed down. In general it ends around 3.8 billion years ago, when the Earth begins to have, rather abruptly, something like a continuous, preserved rock record – which shows, in some respects, a familiar Earth, with oceans and land and an atmosphere and – then or very soon after – life. But as yet, there is no formally designated age for it, let alone an officially designated and agreed golden spike.

What, then, were late Hadean days like? Well, they were quite scary, as I was reminded by Goldblatt and colleagues, in yet another name they proposed, for the latest part of the Hadean: the Promethean Period, citing Aeschylus *('Sky and sea rage indistinguishably/The cataclysm advances visibly upon me'*) in invoking Zeus's rage at Prometheus. It is the Late Heavy Bombardment, a battering by asteroids dislodged – it is said – as Jupiter (aka Zeus) moved into an orbit resonant with that of Saturn: the largest of these would, in their words, 'have vaporised the oceans and exterminated any pre-existing life'.

If that was the case[5], then that would mean that life has only a couple of hundred million years to be sparked, and not the best part of a billion. And if that was the case, then seeding the Earth with microbes from another planet, one that perhaps had a more benign infancy, might provide a means of bringing life.

Are we all colonists then? One does not have to go as far as did Fred Hoyle and Chandra Wickramasinghe, when they notoriously invoked such panspermia to shower the Earth with viruses during every flu epidemic. But microbes are tough, and some, at least, might survive space travel. What will be really fascinating is not whether Mars has life or not, for that now seems to have become almost banal – but whether that life has DNA or not. And if so, to which planet should be assigned the patent?

Tantalizing times, for sure. Can one ever hope to become a palaeontologist on Mars – or perhaps on Titan, picking away at the strata that have accumulated there, washed by methane rivers into methane lakes? Or digging into the ice on Enceladus, seeing what might have been frozen in from the geyser-spray of that distant moon? Dabbling in exopalaeontology can be hazardous, mind. That urge to speculate may well have cost Fred Hoyle a Nobel Prize (though it might have been that famous rudeness, too – Yorkshire has always had a touch of the Promethean about it – or his assault on the *Archaeopteryx*, and denunciation of it as a fake).

So tread carefully, if your mind is set on Earthly honours. But, if you follow your calling for the sheer hell of it, then now might be the time to plunge in regardless. After all, when the next satellite comes to land on Mars, exopalaeontology is being tipped to trump exobiology. It could be quite unEarthly fun.

Jan Zalasiewicz

[5] I'm not convinced of this, mind, for somewhere those rock-dwelling microbes of the deep biota might have hung on, a kilometre down beneath the surface.

REFERENCES

FOLK, R. L. 1993. SEM imaging of bacteria and nannobacteria in carbonate sediments and rocks. *Journal of Sedimentary Petrology* **63**, 990–999.

FOLK, R. L. 1999. Nannobacteria and the precipitation of carbonates in unusual environments. *Sedimentary Geology* **126**, 47–56.

FOLK, R. L. and LYNCH, F. L. 2001. Organic Matter, Putative Nannobacteria, and the Formation of Ooids and Hardgrounds. *Sedimentology* **48**, 215–229.

GEHLING, J. 1999. Microbial mats in terminal Proterozoic siliciclastics; Ediacaran death masks. *Palaios* **14**, 40–57.

GOLDBLATT, C., ZAHNLE, K. J., SLEEP, N. H. and NISBET, E. G. 2010. The Eons of Chaos and Hades. *Solid Earth* **1**, 1–3.

KERR, R. A. 2010. Growing prospects for life on Mars divide astrobiologists. *Science* **330**, 26–27.

MCKAY, D. S., GIBSON, E. K., THOMAS-KEPRTA, K. L., VALI, H., ROMAREK, C. S., CLEMETT, S. J., CHILLIER, S. D. F., MAECHLING, C. R. and ZARE, R. N. 2010. Search for past life on Mars: possible relic biogenic activity on Martian Meteorite ALH84001. *Science* **273**, 924–930.

MCKELLAR, J. B., MEADOWS, A. J. and SYLVESTER-BRADLEY, P. C. 1966. The Barwell Meteorite. *Transactions of the Leicester Literary and Philosophical Society* **60**, 22–28.

THOMAS-KEPRTA, K. L., CLEMETT, S. J., MCKAY, D. S., GIBSON, E. K. and WENTWORTH, S. J. 2009. Origin of magnetite nanocrystals in Martian meteorite ALH84001. *Geochimica et Cosmochimica Acta* **73**, 6631–6677.

TREIMAN, A. H. 2003. Submicron magnetite grains and carbon compounds in Martian meteorites meteorite ALH84001: Inorganic, abiotic formation by shock and thermal metamorphism. *Astrobiology* **3**, 369–392.

TREIMAN, A. H. and ESSENE, E. J. 2010. Metamorphic origin of sub-micron magnetite crystals in ALH 84001: re-evaluation of equilibria, thermochemistry and experiments. Astrobiology Science Conference 2010. <**http://www.lpi.usra.edu/meetings/abscicon2010/pdf/5150.pdf**>

YOUNG, J. D. and MARTEL, J. 2010. The rise and fall of nanobacteria. *Scientific American* (January 2010), 52–59.

<**http://www2.jpl.nasa.gov/snc/clinton.html**>

PalaeoMath 101
Principal Warps, Relative Warps and *Procrustes* PCA

If you've hung in there through the last two columns you'll be happy to know that the worst of the mathematics in what is typically referred to as geometric morphometrics is over. Thin plate splines and principal/partial warps are irreducibly complex mathematical topics that can only be simplified to provide a general introduction to a certain extent. This is one reason why so few users understand them fully. The good news is there's only one more warp-based method left to learn, relative warps. The bad news, which will hopefully be corrected with this column, is that, despite being the most useful of the warp-based methods for routine morphometric data analysis, relative warps are also, arguably, one of the least well-understood by practitioners. So, to quote the immortal Bard, "Once more unto the breach, dear friends, once more".

First, let's remind ourselves of the ultimate goals for any geometric morphometric analysis – to define a mathematical space in which we can compare sets of landmark configurations that (1) ordinates shapes on the basis of their similarity, (2) treats these configurations as a whole entity rather than as an accumulation of independent parts, (3) respects the conventions of the Kendall shape space, (4) supports shape modelling, and (5) is stable in the face of minor changes to the sample and/or reference shape. If we think back many columns ago now, a classic principal components analysis (PCA) of linear distances between landmarks ordinates shapes on the basis of their mutual similarity and is reasonably stable in the face of minor changes to the sample. The spaces formed by classical PCA can also be modelled, albeit only with difficulty (Gnanadesikan 1977, Everitt 1978). But sets of linear distance data do not comprise a geometric entity in their own right or conform to the strictures of the Kendall shape space (see MacLeod 2009a). Accordingly, this approach is not considered especially 'geometric' in its treatment of morphometric data.

The thin plate spline (TPS) is a technique that creates models of shapes described by landmark configurations as unified deformations. As such, the TPS is not a shape ordination method at all. Rather, it's a graphical tool that can be used to compare any two landmark-defined shapes.

Principal and partial warps ordinate landmark configuration-defined shapes on the basis of their mutual similarity and supports shape modelling. In a sense though, these methods ignore the Kendall shape space entirely insofar as they are based on a single shape—the reference shape—that is used to define a series of hypothetical deformations based on the arrangement and spatial scale of that shape's landmarks. These deformations are then used to create a set of spatially ordered deformational modes that can be used as shape-variation descriptors. While these descriptors (or warps) are consistent with the conventions of the Kendall shape space, they don't exploit its power.

So, despite having spent the last four—arguably the last six—columns developing aspects of the tools we need to realize our goal of achieving a truly geometric description of shape variation, we don't seem to be there just yet. Nevertheless, today, we'll arrive at our destination.

Most presentations of relative warps follow on from a discussion of principal warps. While this is perfectly reasonable from a mathematical point of view, the convention has led to substantial and largely needless confusion over the nature of relative warps. I'll try to clear up this confusion here and, at the end, provide an easy way to calculate the bit of a relative warps analysis most morphometricians are interested in.

Recall, principal warps are the principal components of the bending energy matrix (L_p^{-1}). This is the inverse of the matrix L_p that expresses the spatial pattern of proximities of the landmark configuration's shape coordinates.

$$L_p = \begin{bmatrix} 0 & U_{1,2} & U_{1,3} & \cdots & U_{1,p} \\ U_{2,1} & 0 & U_{2,3} & \cdots & U_{2,p} \\ U_{3,1} & U_{3,2} & 0 & \cdots & U_{3,p} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ U_{p,1} & U_{p,2} & U_{p,3} & \cdots & 0 \end{bmatrix} \tag{21.1}$$

where,

$$U\left(r_{ij}\right) = r_{ij}^2 \ln r_{ij}^2 \tag{21.2}$$

In equation 21.2, r^2_{ij} is the square of the distance between the shape coordinates of landmarks i and j in the reference configuration and $\ln$ is the natural logarithm function (base *e*).

If the L_p matrix expresses the proximity of landmarks to each other in the shape coordinate space, its inverse expresses the reciprocal of proximity. Accordingly, in the bending energy matrix relatively large values are assigned to comparisons between landmarks that lie proximate to one another and relatively small values to landmarks that lie at a distance from one another.

Taking the inverse of the L_p matrix quantifies our metaphor of shape change as a deformation that minimizes the 'energy' required to map one configuration of landmarks into another when that mapping is expressed as an interpolation surface or plate. This mode of interpolation differs from the more widely used elastic interpolation model because elastic deformations do not attempt to achieve global minimization of overall amount of deformation specified by the interpolation. In quite a profound sense use of the thin plate spline metaphor encompasses the philosophical stance of trying to explain the features of nature by invoking models of minimal change. However, it needs to be emphasised that, while this is a convenient underlying, logical assumption and an elegant mathematical constraint, it may not adequately express the manner in which shape changes actually came about from either mechanistic biological or evolutionary perspectives. It is also very important to remember that the bending energy matrix is derived solely from information supplied by a single shape – the reference shape.

An eigenanalysis of the bending energy matrix (L_p^{-1}) defines the set of principal warps. These are a set of mutually uncorrelated, non-linear modes of shape variation ordered in terms of spatial scale. The eigenvalues (principal values) derived from this eigenanalysis represent the relative amount of bending energy subsumed by each deformation mode.

The eigenvectors (principal warps) represent the geometries of the deformation modes themselves. High-energy modes express deformations whose geometries are relatively localized. Low-energy modes express deformations whose geometries are relatively generalized. Regardless, all modes specify a pattern of deformation that encompasses all landmarks. Although the differences between these modes lie in the extent of their relative regionalization, none can be regarded as being strictly regionalized in the sense that they involve only a subset of the existing landmarks. Computationally, all landmarks are always included in—and must be taken into consideration when interpreting—all principal warps.

The only advantage principal warps provide is a means whereby the configuration of a reference shape's landmarks is transformed from a simple set of shape coordinate values to a complex series of spatially ordered deformational modes. When these modes are taken together they constitute a redescription of the original bending energy matrix. This is analogous to a standard covariance-based PCA of any data set. A PCA does nothing more (or less) than provide a redescription of the original data in terms of a series of variance-ordered vectors (components) formed from the original variables (see MacLeod 2005). Like PCA, principal warps can be used to form the axes of a high-dimensional coordinate system into which landmark configurations other than the reference shape can be projected and the set of projections viewed as an ordination plot (see MacLeod 2010a). Such plots provide a visual sense of the degree to which these non-reference landmark configurations are similar to, or differ from, the reference configuration in a manner that is weighted by the geometric mode of deformation being expressed by each principal warp.

The easiest way to achieve this projection is simply to multiply the matrix of eigenvectors of the bending energy matrix (E, the principal warps) by the matrix of deviations of the landmarks of the shapes you wish to project into the principal warps space in the x (X') or y (Y') directions from the reference shape. This yields the weight matrix (W).

$$\begin{aligned} W_x &= EX' \\ W_y &= EY' \end{aligned} \tag{21.3}$$

Bookstein (1991) suggested that, prior to this multiplication, the principal warps matrix be scaled by the inverse of the square roots of the principal values. The geometric result of this weighting is to emphasize large-scale deformations when determining the final values of W. However, like all weighting schemes in data analysis, this re-weighting needs to be justified in the context of each analysis.

Operationally, this weighting is accomplished by the following equation.

$$E' = E\Lambda^{-\alpha/2} \tag{21.4}$$

where Λ is the diagonalized matrix of principal values and α is the weighting factor. For Bookstein's (1991) weighting scheme $\alpha = 1$. If $\alpha > 0$ large-scale variations will be weighted more highly in the determination of W. If $\alpha < 0$ smaller-scale variations will receive greater weight. If $\alpha = 0$ variations at all scales will be accorded equal weight.

Because of the obligation to justify all weighting schemes, a prudent default value for any principal warps analysis is $\alpha = 0$. Nevertheless, the ability to set the α parameter to any desired value does give the analyst scope (albeit limited and rather crude) to fine-tune their analysis by allowing it to be focused, to a greater or lesser extent, on a generalized category of spatial variation. While adjustment of α can make a dramatic difference to principal warp ordinations, users should avoid the temptation to use this parameter to try to make any partial warps ordination fit any particular hypothesis. Usually such an exercise is futile owing to the non-linear character of the principal warps themselves; they just don't behave in a regular, predictable manner. However, in all cases such *post hoc* adjustments are indefensible. [Note: those interested in assessing the effect of adjusting the α parameter should consult the *PalaeoMath 101-2: Principal-Partial Warps* spreadsheet, which can be downloaded from the *PalaeoMath 101-2* web page (see below).]

Once we've re-expressed the shapes in our sample as a set of W-matrix scores the hard part of relative warps analysis is over—or so most textbooks would have you believe. A classic relative warps analysis takes the complete set of these scores for both W_x and W_y and uses these as input into a standard covariance-based PCA.

On first inspection you might wonder "What's the point of that?". After all, a covariance-based PCA of a complete set of PCA scores should yield the original set of PCA scores. Nothing is gained by doing a PCA of a PCA. But recall that the basis for a principal warps analysis is not the sample of shapes you're interested in, but only the spatial information supplied by the reference shape. Moreover, the bending energy matrix is not a complete representation of shape variation within the reference shape, only the non-linear (= non-uniform) part thereof.

This strict dependence of the principal warps on the reference shape is the source of its most interesting and seductive feature: the fact that the principal warps are sample independent. Because of this feature the principal warps can be used as a geometric reference system that is completely independent of any sample. Unfortunately, it also means that each system of principal warps is fundamentally tied to what is essentially an arbitrary choice of reference. This choice can be made a bit less arbitrary by adopting the standard convention of using the sample mean shape as the reference. But while this convention has the very desirable property of ensuring that the linear relative warp spaces defined as combinations of the non-linear principal warp deformation modes are placed at a reasonable location within the set of shapes of interest, it also means the analyst has sacrificed the sample independence of their principal warps analysis unless the (equally arbitrary) decision is made to stop computing or updating the mean shape for other samples or subsequent analyses.

Setting these issues aside, a PCA of the total W matrix will result in a summary of shape variation that's been optimised for a particular sample. If pursued in the standard mode, this summary will focus strictly on the non-linear aspects of shape variation (*e.g.*, those that have a bending energy). It will also encompass variation at all spatial scales, though these might be differentially weighted (see the discussion of the α parameter, above).

Going back to our original goals for a generalized shape analysis system, relative warps analysis provides the best fit in all categories: it ordinates landmark-based shape configurations on the basis of their mutual similarity, treats these configurations as unified geometric entities, respects the conventions of the Kendall shape space, supports shape modelling across all aspects of the geometric spaces formed by the relative warps, either through thin plate splines or through direct back-calculation to the modelled landmark positions (see MacLeod 2009b, 2010b, and below), and owing to its sample-based character does not display the instabilities that come from referencing the shape spaces calculated to a single real or hypothetical specimen. In addition, relative warps analysis is quite flexible in terms of the data it will accept. For example, if it would be advantageous to add in scores calculated on the basis of the uniform component of shape variation, this is easily accommodated under relative warps analysis. It's also possible to use the α parameter to focus the secondary relative warps analysis on variation existing as higher or lower spatial scales, provided there's a clear justification for doing so (*e.g.*, a desire to investigate allometric relations among the shape variables). Although not usually recommended, it's even conceivable, at least in principle, to envision a relative warps analysis conducted on a subset of the principal warps, thereby achieving a more complete contrast between shape similarity patterns at higher and/or lower spatial scales. These and many other data analysis variations are all possible in the context of relative warps analysis.

To illustrate the calculations involved in, and the interpretations that can be made from, relative warps results, let's take our trilobite cranidial landmark data through the procedure. To do this we'll use the complete set of $2(2k\text{-}3)$ principal warps weights (= scores, where the number of landmarks $[k] = 10$ for the trilobite dataset) and the weights on the uniform component of shape change (see the *PalaeoMath 101: Relative Warps* spreadsheet). Table 1 shows the eigenvalue data table for the covariance-based decomposition of these data.

Table 1. Eigenvalues for the trilobite principal warp weight data

Relative Warp	Eigenvalue	Variance (%)	Cumulative Variance (%)	Relative Warp	Eigenvalue	Variance (%)	Cumulative Variance (%)
1	0.010165	32.054	32.054	9	0.000379	1.195	98.421
2	0.008737	27.551	59.605	10	0.000226	0.711	99.133
3	0.005782	18.233	77.838	11	0.000119	0.375	99.508
4	0.002277	7.180	85.018	12	0.000083	0.262	99.769
5	0.001594	5.027	90.045	13	0.000048	0.151	99.920
6	0.001098	3.463	93.508	14	0.000019	0.059	99.979
7	0.000663	2.089	95.598	15	0.000005	0.016	99.995
8	0.000517	1.629	97.226	16	0.000002	0.005	100.000

Unlike principal warps, none of the calculated eigenvector axes have been forced to adopt a value of 0.0 by the *Procrustes* alignment, though some of the eigenvalues for the higher-level relative warps are quite small. For these data 95 percent of the observed shape variation in the plane tangent to the *Procrustes* shape hemisphere at the sample mean shape is represented by the first seven relative warps.

The complete table of eigenvectors for this relative warps decomposition is too large to list here (see the *PalaeoMath 101: Relative Warps* spreadsheet). The loading coefficients for the first three of these relative warps axes are listed in Table 2. Together these relative warps account for over 75 percent of the shape variation recorded in our data. Looking in detail at this subset of the complete relative warps result will suffice for the purposes of our discussion.

Table 2. Eigenvectors for first three relative warps of the principal warp weight data

Variables	RW-1	RW-2	RW-3	Variables	RW-1	RW-2	RW-3
7_x	-0.01609	0.00009	-0.03613	3_x	-0.01479	0.05742	0.11671
7_y	0.11465	0.22508	-0.11939	3_y	-0.15088	0.33290	0.16358
6_x	0.03289	0.04351	-0.10082	2_x	-0.21862	-0.73287	-0.16674
6_y	0.17190	0.23071	0.19009	2_y	-0.06492	-0.01871	-0.08939
5_x	-0.23806	-0.31562	0.16125	1_x	-0.03415	-0.07068	-0.01909
5_y	0.01569	0.06115	-0.00477	1_y	0.76768	-0.30589	0.37800
4_x	-0.06303	0.07008	-0.49319	Uniform_x	-0.47599	0.01294	0.66704
4_y	-0.02969	0.10878	0.02883	Uniform_y	0.04622	-0.15432	0.06069

The relative warps eigenvectors represent a set of displacements at each landmark location across the form as mediated by the non-uniform and uniform shape deformations specified by the partial warps scores (= weights) that served as the variables in this analysis. These scores denote a varying system of weights applied to each partial warp variable that, together, summarize all observed shape-based variations exhibited by the 18 trilobite specimens included in the sample, ordered by the amount of shape variance being summarized along each relative warp.

This loading table may be interpreted in a manner identical to that of a standard principal components loading table. For the trilobite data, the first relative warp axis (RW-1) expresses a geometric contrast between partial warps 1_y and (to a lesser extent) 6_y with respect to the Uniform_x warp and (to a lesser extent) partial warps 5_x and 2_x. Specimens projecting to positions high on the RW-1 axis represent shapes that exhibit high covariance with partial warps 1_y and 6_y, and low covariance with partial warps 5_x and 2_x and with the uniform component of shape change along the x-axis. All the other relative warp axes are interpreted in a similar manner.

The scores along these relative warp axes represent covariances between the observed shapes and these sets of latent, non-linear shape variables. These scores are calculated in a manner identical to that of PCA scores, and can be plotted in two or three dimensions to assemble a picture of the dominant patterns of shape similarity/difference existing within the sample (Fig. 1).

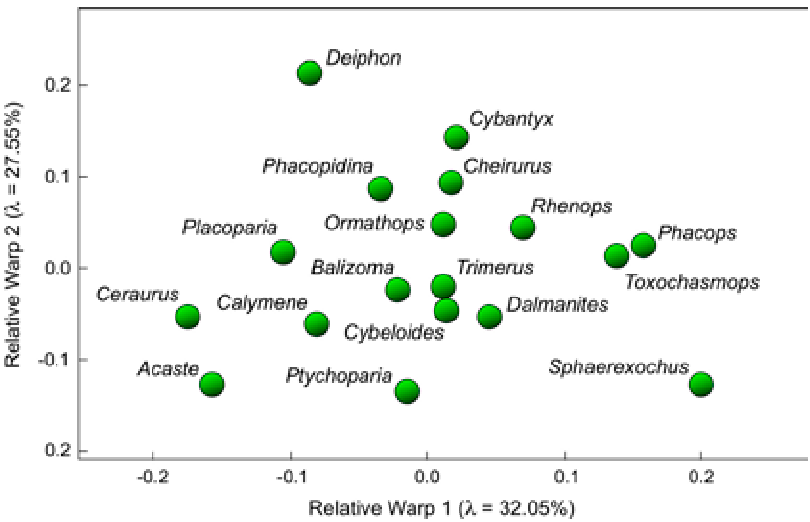


Figure 1. Scatterplot of trilobite cranidium landmark configuration scores in the plane of the first two relative warps of the principal warps and uniform shape component data.

As we have seen before in other analyses, the dominant shape contrast in this dataset occurs between the landmark-defined shapes of *Acaste–Ceraurus* and *Sphaerexochus*, with the most important subdominant contrast being that between *Acaste–Ptychoparia–Sphaerexochus* and *Deiphon*. On the basis of this analysis *Deiphon* and *Sphaerexochus* also can be seen to have relatively unique shapes within this sample—shape outliers in a sense—while the landmark-defined shapes for all the other genera form a broad band of shape variation oriented at an angle to the two dominant shape-variation trends.

Take the time to note how different this representation of shape variation within the sample is from any of the principal warps scatterplots I included in the last column (MacLeod 2010a, Fig. 4). The shape variation information present in each of those principal warps plots has been included in the construction of Figure 1 (above). In the same way as a scatterplot of PCA scores from any data set will look very different from plots of any two included variables, Figure 1 represents a summary of the information included in *all* the partial warp plots. This is a primary reason why relative warps are preferred to principal warps for most morphometric applications.

More than this however, Figure 1 represents the projection—in a linear space—of the positions of the various trilobite landmark configurations that represent these genera in their geometrically correct places on the surface of the *Procrustes* shape hemisphere. As such, this plot represents a better summary of geometric shape variation in these data than any other available to us at this time. We can (and will) collect other sorts of data from these specimens and take a look at what alternative summaries of cranidium geometry might tell us in upcoming columns. But so far as these landmark data are concerned, we have, at last, reached the end of our data analysis journey. There is no better summary of the geometry of these data that I can show you or teach you how to calculate. The only thing that remains is for you to calculate these types of summaries for datasets of your own.

But I do have one last trick up my sleeve that you might find interesting. As I'm certain you appreciate, taking the path to a relative warps analysis that leads through principal warps analysis is conceptually complex and computationally intensive. Software can ease the computational load, but not the conceptual intricacies of selecting reasonable options and interpreting the results. Is there no shorter, more direct route between our data and the relative warps results we need to use to interpret those data? As it turns out, there is.

The more direct solution to the calculation of relative warp ordinations is implicit in prior published discussions of the relative warps technique and, indeed, implicit in the presentation you've just read. The problem is, unless you were already very familiar with the principal warps and/or very experienced in reading descriptions of mathematical procedures, you probably missed it.

Recall, I said that principal warps constituted a "redescription of the original data in terms of a series of variance-ordered vectors (components) formed from the original variables". Recall also that I said "a covariance-based PCA of a complete set of PCA scores should yield the original set of PCA scores". A covariance-based PCA of the complete set of PCA scores obtained from any dataset will be precisely the same as a PCA of the original data, save for minor differences due to rounding error. Accordingly, one might suppose that, since the complete set of principal warp weights is a redescription of the original *Procrustes* superposed shape coordinate data, and since a standard relative warps analysis is a PCA of the complete principal warp weight matrix (W), the same result could be obtained directly from a PCA of the *Procrustes* superposed shape coordinates.

Table 3 lists the eigenvalues for the PCA decomposition of the original *Procrustes* aligned trilobite cranidium landmark data.

Table 3. Eigenvalues for the Procrustes superposed data

Principal Component	Eigenvalue	Variance (%)	Cumulative Variance (%)	Principal Component	Eigenvalue	Variance (%)	Cumulative Variance (%)
1	0.010167	31.972	31.972	10	0.000226	0.711	98.997
2	0.008739	27.483	59.455	11	0.000127	0.401	99.398
3	0.005788	18.201	77.655	12	0.000110	0.345	99.742
4	0.002277	7.159	84.815	13	0.000056	0.177	99.919
5	0.001595	5.014	89.829	14	0.000019	0.059	99.978
6	0.001099	3.455	93.284	15	0.000005	0.016	99.994
7	0.000677	2.130	95.414	16	0.000002	0.005	99.999
8	0.000522	1.641	97.055	17	0.000000	0.001	100.000
9	0.000392	1.231	98.286	18	0.000000	0.000	100.000

Note the close correspondence to the values listed in Table 1 (above). Similarly, Table 4 lists the eigenvectors of the PCA decomposition of the original *Procrustes* aligned trilobite cranidium landmark data.

Table 4. Eigenvectors for first three principal components of the *Procrustes* superposed data

Variables	PC-1	PC-2	PC-3	Variables	RW-1	RW-2	RW-3
1_x	0.18735	0.18834	0.18539	6_x	0.04657	-0.03620	-0.01481
1_y	0.54793	-0.13417	-0.00605	6_y	-0.29915	-0.03074	0.27713
2_x	0.15313	0.00395	0.11021	7_x	0.12554	0.51104	-0.19220
2_y	-0.08223	-0.00822	-0.09660	7_y	-0.02902	0.13086	-0.36697
3_x	-0.19078	-0.39566	0.25921	8_x	0.03099	0.16922	0.30528
3_y	-0.12871	0.22154	-0.28985	8_y	-0.14356	0.22891	0.32788
4_x	0.01393	-0.20102	-0.28655	9_x	-0.16064	0.09850	-0.27932
4_y	-0.12405	0.15837	0.36320	9_y	-0.05696	0.01036	-0.11567
5_x	-0.03780	0.03002	0.01764	10_x	-0.16830	-0.36819	-0.10484
5_y	-0.24675	-0.31172	-0.15267	10_y	0.56249	-0.26517	0.05961

These vectors are aligned differently than those derived from the principal warps data (compare with Table 2, above). After all, there are 20 variables in this system and only 16 in the principal warps system. Nevertheless, when the original cranidial landmark data are projected into the space formed by the first two *Procrustes* principal components and plotted …

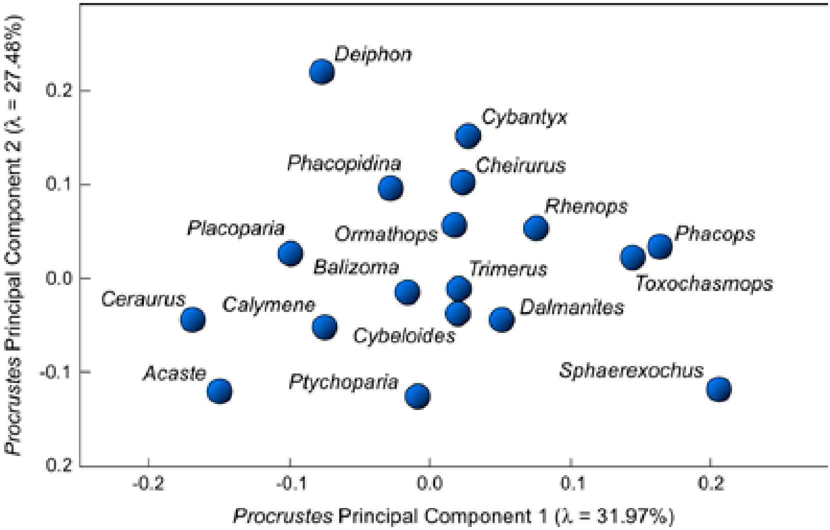


Figure 2. Scatterplot of trilobite cranidium scores in the plane of the first two principal components of the Procrustes *superposed shape coordinate data.*

… the resultant ordination is essentially identical to that of the formal relative warps ordination (compare with Fig. 1). Note this ordination is also identical to the one we generated in our discussion of *Procrustes* shape coordinates (see MacLeod 2009c).

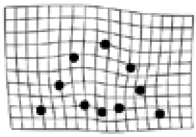
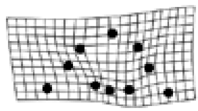
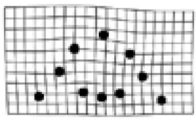
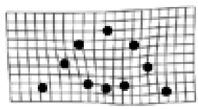
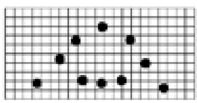
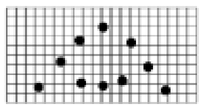
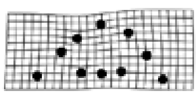
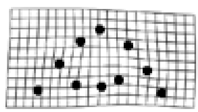
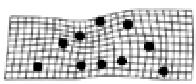
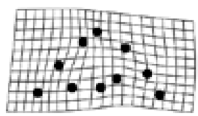
The close link between relative warps analysis and a PCA of *Procrustes*-aligned shape coordinate data has been known, appreciated, and used by experienced morphometricians for many years, even to the extent that it is routinely alluded to in presentations of the method at technical meetings. But for some reason this useful equivalence has only rarely made it into published articles and textbook treatments, and even then the relation tends to be described in obscure ways.

For example, in the Zelditch *et al*. (2004) morphometrics primer the term 'relative warps' is not included whereas a discussion of *Procrustes* PCA is. The fact that the former is absent from the text *because* the latter has been included is not mentioned. Similarly, Jim Rohlf's *tpsRelw* program requires users to calculate the principal warps decomposition before they can produce a relative warps result. This reinforces the impression that principal warps analysis is a necessary precursor to relative warps analysis. While taking the formal route through principal warps might be necessary if a user intended to take advantage of the ability to use the α parameter to alter the spatial focus of the resulting relative warps analysis, the default value of the α parameter in Jim's program is set to 0, making the ordination identical to that which would be obtained more directly from a *Procrustes* PCA.

Add to this the fact that the *Procrustes* PCA alternative also produces a set of eigenvector loadings that can be interpreted more readily in terms of the original superposed shape coordinates, and that can be used to create thin plate spline models of the deformations characterizing any part of the ordination space in a straightforward and computationally simpler (= more easily understood) manner than the method required by formal calculation from the principal warps weight matrix, and you can appreciate the clear advantages of performing this analysis via *Procrustes* PCA rather than by calculation from principal warps weights (= scores).

Finally, Table 5 illustrates the advantages of calculating the along-axis shape models when making interpretation of the *Procrustes* PCA/relative warps axes, with the models represented (in this case) as thin plate splines (see MacLeod 2010b; note the modelling method discussed in MacLeod 2009b could also have been used as an alternative). Comparing the geometry of these models down each shape space axis makes the geometric interpretation of each axis a quick and easy process.

Table 5. Along-axis thin plate spline models illustrating dominant (Axis 1) and subdominant (Axis 2) modes of shape variation in the trilobite cranidium as expressed by landmark data. Numbers below each model express coordinate position in Figure 2 reconstructed.

Procrustes PCA	Axis 1	Axis 2
Model -2	 (-0.106, 0.045)	 (0.018, -0.07)
Model -1	 (-0.044, 0.045)	 (0.018, -0.013)
Mean Shape	 (0.018, 0.045)	 (0.018, 0.045)
Model 1	 (0.080, 0.045)	 (0.018, 0.103)
Model 2	 (0.142, 0.045)	 (0.018, 0.16)

For our trilobite data, the *Procrustes* PCA/relative warps Axis 1 represents a dominant shortening of the cranidium in the anterio-posterior direction and a subordinate asymmetrical twisting of the shape from right to left down the axis. This twisting is, in all likelihood, not a biological signal, but rather a preservational artefact present in the specimens used in this dataset and emphasized as an important shape-variation trend (primarily) due to the small number of specimens included in this dataset. Along the *Procrustes* PCA/relative warps Axis 2 the (likely) artifactual twisting is also present, but this time as the dominant mode of shape variation and oriented in the opposite sense (from left to right) as one moves down that axis. As a statement of the power of the *Procrustes* PCA/relative warps approach to shape analysis it's worth noting here that none of the other shape analysis procedures to which we've submitted these trilobite cranidial data have revealed the preservation issues existing within this set of trilobite specimens in so clear and obvious a manner.

Since most palaeontologists have access to PCA software that can be used to analyze any dataset, because of the more direct nature of the calculations, and because of the more readily interpretable nature of the results, I advocate the *Procrustes* PCA approach to the summarization/exploration of shape variation trends in a sample of shapes described by landmarks. Once the *Procrustes* shape coordinates of a set of landmark data have been obtained, any quality PCA routine that allows use of the covariance (as opposed to the correlation) matrix as a basis of the eigenanalytic decomposition can be used to analyse the sample. The Morpho-tools website (<**http://www.morpho-tools.net/**>) has a *Procrustes* PCA option that you can use to analyse any set of landmark data online. Those wishing to undertake a formal principal warps analysis—there are good reasons to do this—are encouraged to use Jim's *tpsRelw* program (downloadable from <**http://life.bio.sunysb.edu/morph/**>), which remains the morphometric industry standard.

All of the analyses performed for this essay were undertaken using *Mathematica* routines that I would be happy to supply to readers on request. Finally, all of the calculations needed to perform a *Procrustes* PCA could also be done in MS-Excel provided a plug-in module has been installed to allow MS-Excel to calculate an eigenanalysis (*e.g. PopTools*, <**http://www.cse.csiro.au/poptools/**>). Now you really have no excuse not to start using *Procrustes* PCA/relative warps analysis today.

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REFERENCES

BOOKSTEIN, F. L. 1991. *Morphometric tools for landmark data: geometry and biology*. Cambridge, Cambridge University Press, 435 pp.

EVERITT, B. 1978. *Graphical techniques for multivariate data*. Amsterdam, North Holland, 117 pp.

GNANADESIKAN, R. 1977. *Methods for statistical data analysis of multivariate observations*. New York, John Wiley & Sons Inc., 311 pp.

MacLEOD, N. 2005. Principal components analysis (eigenanalysis & regression 5). *Palaeontological Association Newsletter*, **59**, 42–54.

MacLEOD, N. 2009a. Shape theory. *Palaeontological Association Newsletter*, **71**, 34–47.

MacLEOD, N. 2009b. Form & shape models. *Palaeontological Association Newsletter*, **72**, 14–27.

MacLEOD, N. 2009c. Who is Procrustes and what has he done with my data? *Palaeontological Association Newsletter*, **70**, 21–36.

MacLEOD, N. 2010a. Principal & partial warps. *Palaeontological Association Newsletter*, **74**, 35–45.

MacLEOD, N. 2010b. Shape models II: the thin plate spline. *Palaeontological Association Newsletter*, **73**, 24–39.

ZELDITCH, M. L., SWIDERSKI, D. L., SHEETS, H. D., and FINK, W. L. 2004. *Geometric morphometrics for biologists: a primer*. Amsterdam, Elsevier/Academic Press, 443 pp.

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

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

Meeting REPORTS

Attending NAPC: a Madagascan student's perspective
University of Cincinnati, Cincinnati, Ohio, US *21 – 26 June 2009*

This account of last year's North American Paleontological Convention – NAPC – meeting is from a PhD student in Madagascar who wishes to thank Arnie Miller, the NAPC organising committee, and the Palaeontological Association, for funding his attendance at his first international conference.

At first sight, my trip was too long and tiring: I left Tana International Airport [TNR] on Thursday 18th June 2009 on board an Air Madagascar flight, stopping in Johannesburg for six hours before leaving at 11pm to reach Amsterdam by a KLM Flight. I arrived in Amsterdam on 19th June at about 9am, then three hours later left for Detroit on a Northwest Airlines flight, to land in Dayton. When I got there, I called for the taxi previously arranged by **Arnie Miller**, the Chair of the Organization Committee, to pick me up on arrival. The duration of the trip from Dayton to Cincinnati was about one hour and I finally got to the Calhoun Residence where most of the participants were housed. It was a huge University Building located at the campus which can receive up to 360 participants and I was warmly welcomed by the desk reception.

On the following morning (Saturday), I was warmly received by Arnie Miller at the Tangeman University Center, where I needed to use a computer to prepare my oral presentation. As a graduate student in Palaeontology from the University of Tananarive, Madagascar, my first participation in such a huge and special event was an opportunity to discover the reality and the progress of palaeontological research in the developed countries. I was also very interested in the

Student/postdoc social event

multidisciplinary nature of palaeontology, that is, in the use of physical and mathematical tools for the interpretation of research results.

My oral presentation was at the Tangeman University Center on 23rd June 2009, at 5.15 pm, and was included in topical session 15 about paleobiogeography and systematics. It focused on the importance of osteoderms in classification, even when not associated with articulated remains. Autochthonous crocodiliform skeletal material found with osteoderms facilitates the recognition of previously described taxa such *Araripesuchus tsagantsagana*, *Mahajangasuchusinsignis* and *Simosuchus clarki*. However, the palaeoecology of the three known taxa was deduced by a comparative osteology approach in addition to a morphological survey (of shape, size and ornamentation). Identification of isolated osteoderms is problematic, so we suggested the grouping of four or more additional morphotypes according to similarity of texture, size and shape. This generates some controversy because recent studies related to the fossil crocodiliforms from localities in the Upper Cretaceous of the Maevarano Formation, Majunga Basin, North-West Madagascar, suggest that there was morphological variation during ontogeny.

Meeting Highlights

The meeting had a strong impact on the foreign researchers coming from developing countries like Madagascar. The participants had the opportunity to share with each other their own experiences and skills through the different kinds of oral presentations, symposia and poster sessions. The meeting was made even more enjoyable because the participants had access to the Recreation Center, which consisted of gymnasium and swimming pool for getting rid of any stress! Each room was well equipped with refrigerator and microwave, in addition to blankets, pillow and towel. Before the opening ceremony, on Sunday 21st, there was an exhibit of different organisations that continued until Thursday. The list of exhibitors included University of Chicago Press, Indiana University Press, Publishers Cooperative Display, Paul Gritis Books, Paleontological Institute at the University of Kansas, Joggins Fossil Institute, Lizard Clayworks, The Paleobiology Database, The Paleontological Society, Ohio Geological Survey, Indiana Geological Survey, Cincinnati Dry Dredgers, Kentucky Paleontological Society and Cincinnati Museum Center. All these exhibitors displayed their own products to excite the graduate and postgraduate students. The occurrence of a student/postdoc social event allowed the younger participants to share views and experiences, and to discuss future projects in palaeontology or related to the palaeobiology database.

My participation was a great and first opportunity to make contact with several potential palaeontologist researchers, including museum-based scientists, PhD candidate students, a postdoc and a professor. I was able to attend 26 oral presentations. In addition, the integration of the topic of evolution into the NAPC program, including in the plenary session, helped my understanding of the origination or speciation of living and fossil animals. As a high school teacher, this helped to show the way to teach students or high school pupils to have an interest in palaeontology, as well as presenting strategies for defending the teaching of evolution. Group discussion at the end of each session plays an important role in the development of palaeontology education, not only at university but also at high school, in different ways.

Finally, emphasizing the use of statistical tests for evaluating hypotheses, making tables, graphs and other mathematical tools seemed very important to each oral presentation. In conclusion, in seems to me that research related to palaeontology is a combination of mathematical tools and natural

At the NAPC 2009 Celebratory banquet in the Cincinnati Museum Center

knowledge. My first participation in such an international congress has inspired me to make an effort in the early stage of my research career and advance my PhD project.

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International Palaeontological Congress – IPC 3
London *28 June – 3 July 2010*

IPC3 – a report of sorts

The first International Palaeontological Congress was held in Sydney in 2002, the second in Beijing four years later, and now 2010 brought London's turn. If it sounded like mimicry of the Olympic Games, maybe it was, and in his opening address, chair of the organizing committee **Dick Aldridge** suggested it might be nice to hold IPC4 in Rio de Janeiro. It remains to be seen if the new executive acquiesces.

With 800 delegates from dozens of countries giving scores of presentations, IPC3 was popular, international, and incredibly diverse. Such success, however, does make it rather tricky to write a meaningful meeting report, so all I can do here is to give my highlights of the talks I saw, and the science I sampled. I apologize if there is a footballing flavour to some of my observations, but the World Cup was taking place at the same time, and I am nothing if not easily distracted.

After the introductory remarks from Prof. Aldridge, and a welcome from **Keith O'Nions** (Imperial) and **Norm McLeod** (NHM) on behalf of the host venues, **Wolfgang Kiessling** (Leibniz Institute, Berlin) kicked off proceedings. He began the plenary symposium by emphasizing that palaeobiologists are in the unique position of being able to assess Red Queen (biological) processes and Court Jester (geological) processes. But what drives origination and diversification in the oceans? Kiessling used the PaleoDatabase (<**www.paleodb.org**>) to argue that reefs are the cradles of diversity, especially in the Palaeozoic, and recommends that everyone interested in assessing deep time biodiversity should get to grips with this wonderful resource.

Emily Rayfield (Bristol) then gave a fascinating talk on the value of Finite Element Analysis (FEA) in assessing functional morphology. FEA is becoming an increasingly widely applied tool, and Emily used it to show that many skeletal structures (living and fossil) are far from optimally engineered. Modelling a 'perfect' skull, for instance, allows the skulls of ancient vertebrates to be put to the test: Emily demonstrated that, through time, archosaurs increase their palate size and close their suborbital fenestra, providing better skull integrity and better biting capacity. FEA is also being employed in conjunction with tooth microwear to investigate whether early mammals could have been insectivores, and is helping researchers to break away from the age-old circularity of assessing functional morphology using morphological phylogenies.

After a short break for refreshments, **Gene Hunt** (Smithsonian) led the players back out with a talk on patterns and processes in microevolution. By examining 53 lineages (predominantly microfossils) across 251 time series, Gene showed that directionality was rarely observed (~5% of the time). His year-on-year examination of Nevadan varves then revealed that, in the lake's sticklebacks, major morphological change happened early, followed by a long interval of stasis, a micro-evolutionary pattern which would not be possible to recognize in most palaeontological studies.

And from metazoans, we moved onto plants, as **Geoffrey Eglinton** (Bristol) noted that a little leaf wax goes a long way (but no longer than 35 minutes, or the session chair will drag you off stage). Leaf waxes are difficult to degrade, travel a long way, and can therefore be used as palaeobotanical biomarkers, especially once you analyse the chain lengths and carbon isotopes of n-alkanes. These appear to correlate closely with CO_2 over the last 70 ka, and a chain length signal can be picked out for forest-grassland changes in Africa across the Last Glacial Maximum. I imagine FIFA understood this when selecting the best South African playing surfaces for the World Cup.

Out of Africa came the hominids too, even Wayne Rooney's ancestors, and **Svante Pääbo** (Max Planck Institute, Leipzig) ended the morning symposium with his work on molecular palaeoanthropology. The questions over our relationship to Neanderthals are fundamental to the understanding of what it is to be human, and Svante's new data shed some extraordinary new light on the topic. Studying the nuclear genome of Neanderthals has only just become possible, but exceptional specimens from a Spanish cave now show that they diverged from *Homo sapiens* around 825 ka. More intriguingly, the Neanderthal genome is much closer to that of non-Africans than of Africans. Svante asked whether this meant that *Homo sapiens* met the Neanderthals after leaving Africa, interbred to some degree, diversified, and thus kept alive some Neanderthal genes in all non-Africans?

I was unable to attend them, but the afternoon saw thematic sessions – talks and posters – on brachiopods, geomicrobiology, chemosynthetic communities, Palaeozoic climate modelling, functional morphology, and Chinese palaeontology.

Wednesday morning brought the Lyell Symposium – 'Comparing the rock and fossil records: implications for biodiversity studies' – but I was in Lecture Theatre 2.28 of Imperial College for the

Sean Carroll's lecture *(Photo: Daniel Marty)*

session on major transitions in the early evolution of life. **Andy Knoll** (Harvard) gave the keynote address, looking at Proterozoic evolution from a physiological and metabolic perspective, and the driving mechanisms behind a 2.4 Ga oxygenation event.

Martin Brasier (Oxford) spoke on the earliest fossils and the necessity to be critical about complexity, noting that 'stromatolites' can be formed inside exploded steam boilers, such that they may be a branch of physics rather than biology. Spheroidal carbonaceous microstructures from Earth's oldest siliciclastics, the Moodies Group of South Africa, were interpreted by **Emmanuelle Javaux** (Liège) as very old, large, microfossils, as there was no plausible inorganic explanation, and **Nora Noffke** (ODU, Norfolk) went even further back in time. By comparison with modern analogues, Nora argued that microbially induced sedimentary structures were present in the 2.9 Ga Pongola Supergroup, also in South Africa. Clearly the place to be in 2010.

Cris Little (Leeds) studied filamentous jaspers in 1.74 Ga rocks in Arizona, wondering if they were biogenic. Filamentous iron oxides are common in the Phanerozoic, often in hydrothermal vent environments, thanks to filament-forming protobacteria that can tolerate low-oxygen conditions. If the ancient jaspers formed in this way, maybe some Palaeoproterozoic deep-water settings were sub-oxic.

After coffee, the biscuits were supplied by **Stefan Bengtson** (NRM, Stockholm) who stepped into the murky field of Precambrian macrofossils, and some 2.1 Ga structures from Gabon. Pyritized organic sheets with a radial fabric, these 'biscuits' were interpreted as macrofossils, but show no evidence of cell differentiation, so perhaps were not multicellular ones. Making sense of the earliest 'animals' was the next topic, as **Martin Brasier** (Oxford) returned to the stage with new insights into the Ediacarans. Some taxa may be different life stages of the same organism, whilst others may be taphotaxa, but all seem to have plant-like morphogenic control.

Body fossils from before the Marinoan glaciation were the subject of **Adam Maloof**'s (Princeton) talk. South Australian breccias include 'bioclasts' that high-resolution reconstruction indicates are remains of sponge-grade metazoans. Staying down under, **John Paterson** (UNE, Armidale) re-examined *Parvancorina* and showed that oriented specimens were not in a hydrodynamically stable position, suggesting motility, but found little evidence for an affinity with arthropods. **Emily Mitchell** (Cambridge) used a theoretical ecological approach to examine Ediacaran feeding behaviour, her models asserting that taxa such as *Charnia* and *Fractofusus* had to have been osmotrophs, with only a few possible filter-feeders. An osmotroph-dominated biomass would have led to very stable ecosystems, explaining the slow turnover of late Neoproterozoic species. The session was concluded by **Kirk Domke** (USC, Los Angeles), who focused on the alteration of *Cloudina* specimens and the erroneous recognition of new taxa that were actually just diagenetic variants of the same species.

Post-lunch, **Liam Herringshaw** (Memorial University of Newfoundland) examined the trace fossil record of ecosystem engineering across the Precambrian–Cambrian boundary, before **Bertrand Lefebvre** (Lyon) demonstrated the impact of the Cambrian Substrate Revolution on echinoderm autecology. All Early Cambrian taxa were adapted to life on matgrounds, and as these disappeared, echinoderms had to adapt or die. A new technique for quantifying bedding plane bioturbation was introduced by **Katherine Marenco** (Bryn Mawr), enabling better understanding of ecological changes in Early Cambrian successions.

Agnostids fossilized inside both hyolithids and trilobites were interpreted by **Oldrich Fatka** (Charles University, Prague) as scavengers feeding on carcasses, whilst **Jean Vannier** (Lyon) looked at the gut contents of *Ottoia* to find hyolithids, agnostids and brachiopods, a selection of food items strongly indicative of predation. To complete the session, and a triumvirate of palaeo-enterological talks, **Jean-Bernard Caron** (Royal Ontario Museum) examined *Herpetogaster* and its extra-long stolon, which may have been used for attachment to sponges.

After Wednesday's talks were over, and a spot of dinner had been consumed, attentions turned to the Royal Geographical Society and the Lethaia public lecture. Evolutionary biologist **Sean Carroll** (Wisconsin) told us that he 'wouldn't know shale from sheep-shit', but his speech on 'Remarkable Creatures – Epic Adventures in the Search for the Origin of Species' was absolutely first-rate. I really can't remember when I last enjoyed a talk so much. It undoubtedly helped that Sean discussed not only Darwin and Wallace, but also Henry Walter Bates, an oft-overlooked 19th century naturalist from Leicester. Bates' adventures were unquestionably epic, as he spent 11 years in the Amazon, but Sean showed that he and Wallace probably need never have gone there if Darwin had only had the nerve to publish his theories earlier. With a fudge that natural selection was 'beyond the scope of this [Beagle] journal', Darwin inadvertently left Wallace in a leaky lifeboat adrift in the Atlantic, as the ship containing all his South American samples burnt and then sank. Only after Wallace had gone to the Malay Archipelago for a second go at data collection, conceiving his own theory of evolution whilst in a malarial fog, did Darwin get on with publishing. Bates' enormous array of insect specimens – 'a glimpse into the laboratory where nature manufactures her species' – did at least end up providing Darwin with fabulous supporting evidence for his big idea. Sean ended his presentation with an airing of the U2 song 'Beautiful Day', which surprised a few people, but did mean that audience members were one-up on the returning Glastonbury festival-goers, who got only a last-minute withdrawal of Ireland's biggest rock band. It was also a pleasant change from vuvuzelas.

Thursday was a day of workshops, and mine was virtual, but sadly, that didn't mean a lie-in. Neither did it mean I could avoid giving a presentation in person before the large audience gathered for the workshop organized by **Mark Sutton**. **Paul Tafforeau** (Synchrotron, Grenoble) began with a review of the many new insights that Synchrotron has been able to bring to palaeobiology, noting that the European facility is approaching 50% palaeontology in its usage. The first case study was provided by **Renate Matzke-Karasz** (Ludwig-Maximilians, München) and the giant sperm of a 100 Ma ostracod (truly a seed shrimp in this case), before **John Cunningham** (Bristol) applied it to early embryos: *Markuelia* might be a stem priapulid, and *Olivooides* could be a cnidarian. **Carsten Kamenz** (AMNH) tried something different, using depth of field changes to resolve the morphology of fossils from the Rhynie Chert, and then **Joachim Haug** (Ulm) asked us to don our 3-D glasses to look at Orsten material, showing that this was a cheap, low-tech approach that could be very useful in bringing virtual palaeontology into the classroom.

After coffee, **Richie Abel** (NHM) gave us a water's eye view (if water had eyes) of a hammerhead shark nostril, along with some Neanderthal skulls, Chinese coals, and a wombat tooth, to demonstrate the ways micro-CT, nano-CT and SEM can be used palaeontologically. Confocal laser scanning of dinoflagellate cysts gave **Suzanne Feist-Burkhardt** (NHM) 44 images for a 22 micron specimen, bridging the gap between TLM and SEM, and **Margaret Collinson** (Royal Holloway) found that Synchrotron 'taphonomy' was very useful for comparison with chemically prepared specimens, enabling structural layers to be unravelled.

Inexplicably donning a Leicester City shirt for his presentation, **Liam Herringshaw** (Memorial University of Newfoundland) talked on the ichnological applications of 3D visualization, from CT scanning marine aquaria to serially grinding large blocks of bioturbated sandstones, and **Mark Sutton** (Imperial) brought the workshop to a close with a discussion of other techniques that had not been mentioned previously, including LIDAR (good for large specimens), neutron tomography (good for organics, but in low resolution), and MRI (good for voids).

Conference dinner amongst the dinosaurs *(Photo: Daniel Marty)*

Thursday evening was the congress dinner, held beneath the *Diplodocus* in the palatial surroundings of the Natural History Museum. **Richard Fortey** (NHM) gave the after-dinner address, as Charles Darwin overlooked proceedings in marbled splendour. An hour or three later, and many of the delegates were splendidly marbled too, especially those who discovered the table of undrunk wine. I shan't reveal their identities.

I decided to start Friday with a dose of micropalaeontology, but the session had moved to a new room. Luckily, I spotted Dick Aldridge, and followed him on the assumption that he would know where he was going. I am pleased to report that he did, and also that keynote speaker **Ivan Sansom** (Birmingham) gave his talk whilst wearing a rugby shirt, which made me feel less foolish for my transgression in the previous day's workshop. Ivan's talk was excellent, arguing that the classical view of fish phylogeny was largely wrong, with microfossils indicating a much greater vertebrate diversity, including shark-like fossils in the Ordovician, and unequivocal sharks in the early Devonian. Ivan showed also that many 'well-defined' clades turn out to be paraphyletic.

Duncan Murdock (Bristol) then examined the origin of the conodont skeleton by looking at growth patterns in elements, **Michele Mazza** (Milan) applied cladistics to Triassic conodonts, and **Andrew Jeram** (Larne) tackled terrestrial arthropod microfossils across the Triassic–Jurassic boundary. **Dave Siveter** (Leicester) completed the session with a salutory lesson on the palaeontological problem of non-preservation of soft tissues. Dave showed that the shell morphologies of various Silurian ostracods are 'very disturbing', as without the preserved soft parts one would never interpret them as myodocopids. That is what they are, however, and very large myodocopids too, showing that one has to be very cautious when interpreting taxonomic positions based on hard parts only.

On Friday afternoon, I wended my way to a session on time-specific facies and the colour and texture of biotic events, with **Tony Hallam** (Birmingham) giving the keynote address. Unfortunately, the Royal College of Music was holding its graduation ceremony in the building next door, and when the windows were closed to block out the noise, the lack of ventilation turned the atmosphere inside to one of unbearable stuffiness. Tony assured us it was appropriate to be near the Albert Hall, as Queen Victoria wore time-specific fossils (Whitby jet) when mourning her beloved husband; he also argued that black shales are highly environmentally significant, whilst red-coloured rocks are much less so.

Shelf anoxia and dead zones caught **Martin Zuschin**'s (Vienna) attention, as he tried to link them to black shale deposition. Although the settings of modern and ancient examples are often different, the processes are probably similar, and we can look at what is happening in modern oceans to get a handle on ancient anoxia-related ecological changes. At this juncture, however, the temperature in the lecture theatre overwhelmed me, and I fled for somewhere less sweltering. As is so often the case, I found solace in a museum, and the NHM's exhibition 'The Deep', revealing the biological secrets of the ocean abysses. Coelacanths, chemosynthetic vent faunas, and sperm whales you could climb inside – it was cool in all the ways one could wish it so.

I did not return to the congress till Saturday morning, and the session on the Great Ordovician Biodiversification Event. **Alan Owen** (Glasgow) summed up the findings of IGCP 503, which examined why the Ordovician became so diverse. Many reasons can be invoked, but high sea levels (lots of localized marine populations), tectonic provincialism (lots of continental margins), tropical continents (cradles of biodiversity), meteorite bombardment (shelf collapse and renewal) and orogenies (nutrient supplies) have all been suggested as particularly important.

Jon Adrain (Iowa) reviewed trilobite extinctions in the late Cambrian and early Ordovician, finding five events that reduced species richness from 1,700 to 200. **Neo McAdams** (Iowa) looked at some Whiterockian telephinids, and **Talia Karim** (Kansas) showed the phylogenetic value of ontogenetic data in revealing previously cryptic Ordovician trilobite species. Bringing us up to the coffee break, **Stephen Westrop** (Oklahoma) used cluster analysis to demonstrate regional turnovers and biofacies changes (but not extinctions) in trilobites of Laurentia.

And that, for me, was the end of the conference. The talks went on for the rest of the day, but I had to go and meet some old friends in a room made of ice, so I cannot report on the unseen. The Ordovician discussions continued, with parallel sessions on biotic recovery after mass extinctions, rates of morphological change, phylogenetic approaches to large scale change, palaeobotany, and exceptional preservation. I doubt that the discussions ceased even once the final whistle was blown.

Congratulations to all on the IPC3 Organizing Committee for putting together such an excellent meeting. I can't list everyone here, so will simply thank Dick Aldridge and his team for a hard-working, non-stop, match-winning performance. If only the same could be said of the English footballers.

Liam Herringshaw

Alum Bay on the Isle of Wight – one of the IPC field excursions *(Photo: Daniel Marty)*

8th International Symposium, Cephalopods – Present and Past
University of Burgundy, Dijon, France *31 August – 3 September 2010*

The 8th International Symposium, Cephalopods – Present and Past (8ISCPP) was held in Dijon (France) at the University of Burgundy from 31st August to 3rd September 2010. Organized by **Pascal Neige** (University of Burgundy, Dijon – France) and **Isabelle Rouget** (University Pierre & Marie Curie, Paris – France), the Symposium brought together nearly 130 delegates from more than 20 countries working on extant or extinct cephalopods. The diversity of this group of molluscs, together with its broad temporal and spatial distribution, makes it a successful model for addressing key scientific issues. It was a unique opportunity for sharing research ideas and recent findings on all aspects of cephalopod biology and evolution, covering present and past cephalopods. The symposium was organized as a single programme divided into seven topical sessions: (1) Ontogeny, (2) Anatomy & Morphology, (3) Behaviour, Ecology & Palaeoecology, (4) Phylogeny & Systematics, (5) Evolutionary Patterns and Processes: from Micro- to Macroevolution, (6) Palaeobiogeography & Biostratigraphy, and (7) Mass Extinctions and their Aftermaths. Sponsorships from several institutions, including the PalAss, were mainly used to keep low fees for PhD and Masters students. The large number of junior scientists in the gathering is an indication of success for us.

We all enjoyed the quality of the speakers all through the meeting (nearly 60 oral presentations), and especially of the three keynote lectures given by **Vyacheslav A. Bizikov** (Russian Federal Research Institute of Marine Fisheries and Oceanography, Moscow – Russia): "Evolution of the shell in Coleoidea", **Neil H. Landman** (AMNH, New York – USA): "Mode of Life and Habitat of *Scaphites*", and **Frédéric Marin** (University of Burgundy & CNRS, Dijon – France): "The molluscan shell: formation, origin, evolution". For strategic reasons, poster sessions were organised in the same place as the coffee breaks. Mixing this strategy with the high quality level of the posters ensured the success of the sessions!

An additional special topical session "*Nautilus* as an endangered species" was organized with the participation of the CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). Although mainly focusing on the recent *Nautilus*, the question was not disconnected

Delegates outside the Natural Sciences building at the University of Burgundy, Dijon – France (photo J. Thomas) from palaeontological perspectives. Discussion about *Nautilus* resulted in the following statement, which was read during the closing session of the Symposium: "Many of the life history traits of *Nautilus* make this animal vulnerable to overfishing. These include long embryonic development (about one year), low fecundity (about 50 eggs per lifetime), slow growth rate (maturity in about 10-15 years), long longevity (about 20 years), low population sizes (but requiring further study), and spotty distribution. Based on these data, we are concerned that *Nautilus* is at risk at more than a single site throughout its distribution. Therefore, we think it is highly appropriate to actively pursue a proposal for CITES listing". After reading this statement, we invited those interested in receiving updates on this matter and contributing to this discussion to please list their name and email address. This statement has been sent to the CITES.

The *International Symposium, Cephalopods – Present and Past* traditionally honours some cephalopod workers from the host for their scientific contribution. This Dijon meeting was the opportunity to thank Sigurd von Boletzky (Banyuls-sur-Mer), Raymond Enay (Lyon), Didier Marchand (Dijon), and Jacques Thierry (Dijon). A friendship event around these members of the honorary committee was organised at the end of the first day. We were proud that these four scientists were present during the entire symposium and actively participated in the discussion. This definitively demonstrates that even if they are retired, these four colleagues are still very active!

Two fieldtrips were organized after the symposium: (1) A sunny day in Burgundy, including Jurassic outcrops and a visit to the Museum of Semur-en-Auxois (stratotypic town for the Sinemurian stage, Lower Jurassic), enjoyed by about 40 participants; and (2) four days in Jurassic and Cretaceous outcrops in Lyon and Digne-les-Bains ("Réserve Géologique de Haute-Provence" Geopark) areas. Twenty-two participants visited famous outcrops such as the "dalle à Ammonites" (a huge rock shelf covered with ammonites) and collected many fossils of cephalopods and other taxa…

All in all, we believe that the symposium was a success because of its scientific level, but also – which is really important – because of the friendly atmosphere. The next step is to publish the proceedings of the symposium (see the symposium website <**http://cephalopods.u-bourgogne.fr/**>). Finally, we wish good luck to Christian Klug (Zurich – Switzerland), the organizer of the next meeting (9ISCPP)…

Pascal Neige & Isabelle Rouget
Co-organisers

Organisers of the symposium together with the four members of the Honorary Committee. From left to right: Jacques Thierry, Didier Marchand, Isabelle Rouget (co-organiser), Raymond Enay, Pascal Neige (co-organiser), and Sigurd von Boletzky (photo J. Thomas).

MYSTERY FOSSIL 20

This issue's mystery fossil was sent in by **Jan-Peter Duda** (Bremen), on behalf of **Filiz Afsar** who wrote her MSc thesis under the supervision of Hildegard Westphal on the Upper Jurassic – Lower Cretaceous carbonates of the Neuquen Basin (Argentina). Jan notes that "some of Filiz's samples are characterized by mass-occurrences of organisms, which we could not identify (even with the help of some scientists of our institute)". The following description and figures, supplied by Jan, will hopefully be enough for someone out there to provide him and Filiz with the answer.

The mystery fossils have two characteristic shapes: spherical and heart-shaped. Both of these organisms occur abundantly in some samples, so they may represent the same organism, but in different sections (Fig. 1). The length of the main axis of the elongate heart-shaped form is approximately 112 μm, while the length of the minor axis is about 60-70 μm. The diameter of the spherical form is approximately 75 μm. Jan writes: "our first thought was that they could be cysts of calcareous dinoflagellates, but though the micro-organisms are well preserved they do not show typical calcisphere wall structures". They are rimmed by a kind of dark "micritic" rim (Fig. 2). The EDX measurements show that this rim is composed of SiO_2, while the core of the organism is made up of $CaCO_3$ (Fig. 3). In some samples, these organisms occur as nuclei of ooids, but in these cases they are also characterized by a dark "micritic" rim (Fig. 2). An additional SEM photomicrograph has also been supplied (Fig 4).

As usual, if you know what these structures may be then please e-mail me at the usual address: <**newsletter@palass.org**>

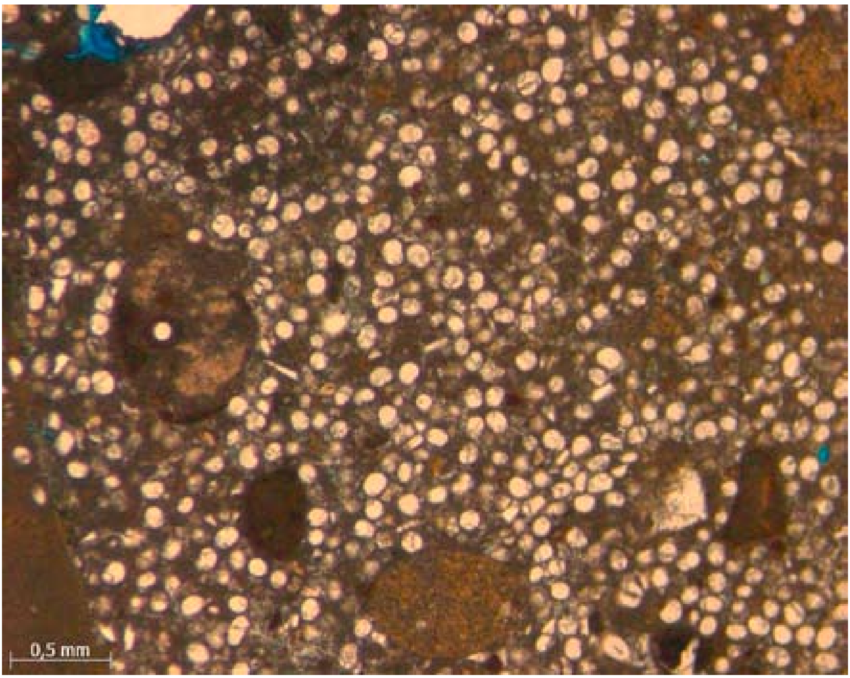


Figure 1.

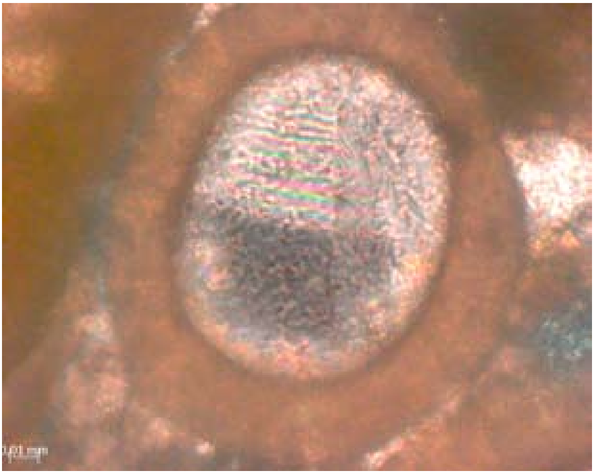


Figure 2.

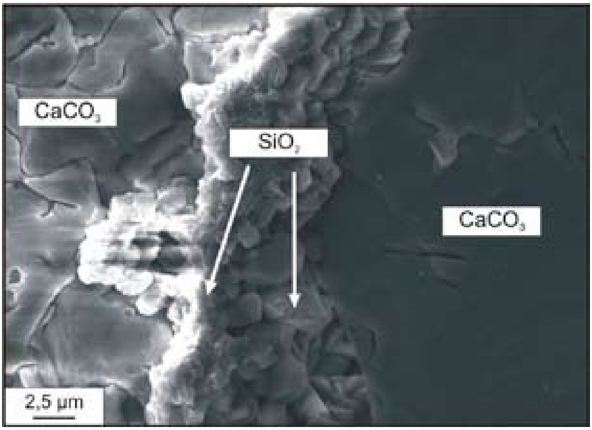


Figure 3.

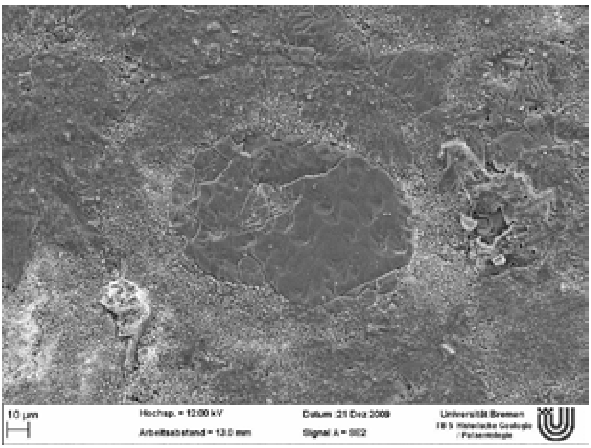


Figure 4.

Update on Mystery Fossil 19 (and 19a!)

The postbag was rather empty this time around and the only item of correspondence received was from **Joseph Botting** (Leeds Museum), with comments on both MF 19 and the unofficial 'mystery fossil' (MF19a?) that Jan Zalasiewicz managed to sneak in to the last *Newsletter* under cover of his essay column (see *Newsletter* **74**, p. 33).

Regarding MF19, which was sent in by **Jesper Milàn** (Østsjællands Museum, Denmark), and which was found by Claus Heinberg in the Maastrichtian limestone at Stevns Klint (Figure 5), Joe was somewhat dismissive: "That Cretaceous (even Late Cretaceous) denizens of Denmark were using tiles and plaster comes as quite a shock in itself, but the fact that they used the same method of cementing (in a circle) one to the other as we do today is truly remarkable. On the other hand, I suppose it could be more recent, given that several buildings and a graveyard seem to have crumbled down that particular cliff … but it makes for a much less interesting story". Despite requests, Joe has been unable to furnish additional evidence to support his identification. Furthermore, Jesper and colleagues have examined the specimen in question and are convinced it is genuine. So, *nil points* for Joe thus far and MF19 remains unidentified.

Figure 5.

It turns out that the specimen that really grabbed Joe's attention was the 'mystery disc' figured in Jan Zalasiewicz's essay (MF19a). According to Joe, it is apparently a nice example of the Tremadocian protomonaxonid sponge *Choiaella* (Figure 6).

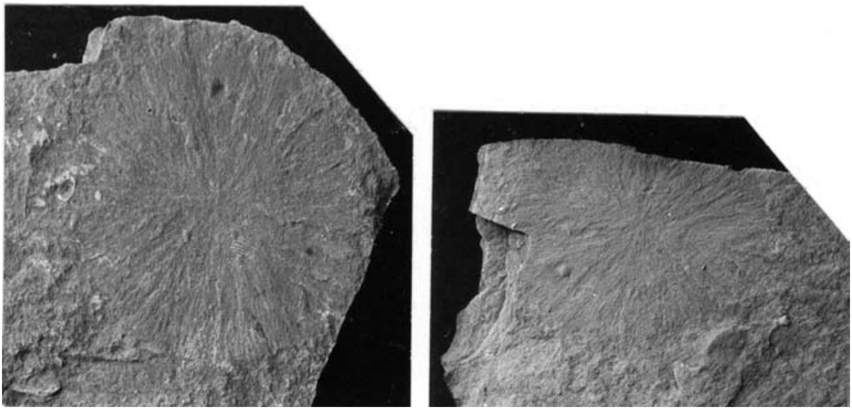


Figure 6.

Jan Zalasiewicz was particularly pleased that someone has solved this long standing mystery – the specimens themselves have been residing in the collections of the Sedgwick Museum for some time. Joe is currently planning a 'walking holiday' to the site that yielded the sponges in an effort to secure some more – we wish him well!

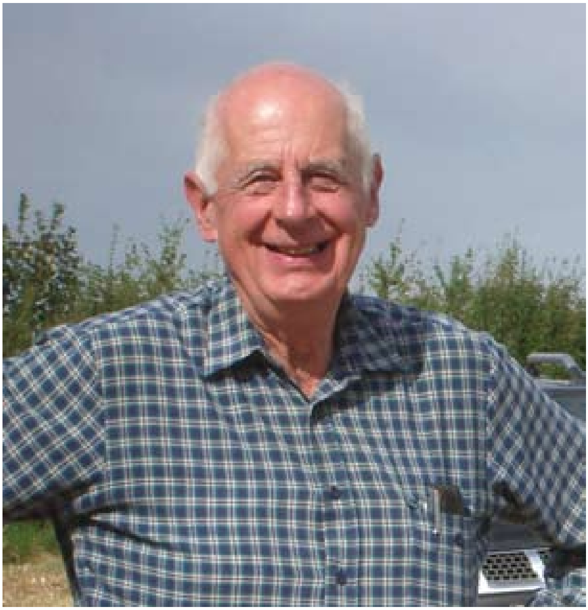
Richard Twitchett

——OBITUARY——

John Callomon
7 April 1928 – 1 April 2010

An appreciation

Members of the Association will have been familiar with the figure of John Callomon at our Annual Meetings for many years. He was a founder member of the Association and supported it fully over the years in his meticulous refereeing of papers. Many presidents over the years have called upon his critical abilities in judging posters or papers at the Annual meetings. His death on 1st April robbed the Association and the palaeontological community of one of its outstanding scientists.



John Callomon at Bradford Abbas, Dorset. Photograph by Robert B. Chandler

John Hannes Callomon was born in Berlin on 7th April 1928; his father was an electrical engineer with AEG and the family emigrated to Britain to escape the Nazi regime. Once in Britain the Callomon family were taken under the wing of Horace Sanders, a Birmingham engineer, who quickly enthused the young Callomon with his home workshop and his collection of fossils and minerals. The two of them visited the Wenlock Limestone of Dudley where corals and stromatoporoids could be seen in life position. Later, they ventured farther afield on a tandem, reaching the Lower Palaeozoic of the Welsh Borderland. John rapidly became fluent in English and attended grammar school in Edgbaston. From there he obtained an open scholarship to St John's College Oxford to read chemistry in 1947. On arrival there he bought a copy of the just-published *Geology of Oxford* by Arkell, and using this and his bike he started familiarising himself with the geology of the Oxford area. He was a frequent visitor to the University Museum and soon became well known to James Edmonds the curator. On one such visit Arkell was in the museum and John gained an introduction to him. Under Arkell's guidance his studies became more focused on ammonites, initially from the Oxford Clay.

John graduated with a first in Chemistry (1950) and then embarked on a DPhil in Oxford on spectroscopy. By then the bike had been replaced by a motorbike, allowing more extensive geological forays, and fellow chemistry postgrads were inveigled into helping him collect from the Oxford Clay and Corallian Group. Following research fellowships in Canada and University College London, John was appointed to a lectureship in UCL in 1957 and was successively promoted, gaining a personal chair in 1983. He retired as Professor Emeritus in 1993.

His first of over 100 geological publications (1953) was on the Corallian Group of the Oxford area, but much more significant was his 1955 paper in the *Philosophical Transactions of the Royal Society* (communicated to the Society by Arkell) in which John listed the criteria by which an ammonite might be judged mature and described sexual dimorphism in Oxford Clay ammonites. He proposed the terms macroconch and microconch to distinguish the two forms. This paper laid the foundations of his research into many ammonite groups, and John's ideas on sexual dimorphism totally revolutionised ammonite palaeobiology. He showed that in the *Treatise*, many dimorphic pairs of ammonites had been put into different subfamilies, and wrote a major review of the subject that was completed by 1958. However, the peer-review system completely failed, as the paper was rejected by *Palaeontology*, *Journal of Paleontology*, *Biological Reviews* and by the *Journal of Zoology*. Finally Peter Sylvester-Bradley published it in *Transactions of the Leicester Literary and Philosophical Society* in 1963, and ensured that reprints were freely available.

John's ideas have been totally accepted for ammonoids from the Devonian to the Late Cretaceous, and the terms macroconch and microconch universally used. One is hard pressed to think of another palaeontologist who totally revolutionised a subject with a single contribution.

John was invited to join Lauge Koch's Greenland expeditions in 1959 and this started a long association with Greenland; his last visit was in 1994. Amongst other things he collected cardioceratid ammonites from the Bajocian to the Kimmeridgian, and built up collections that enabled him to demonstrate an evolving dimorphic lineage that was initially confined to the Boreal regions, but which spread southwards in the Callovian. His detailed collecting and large number of specimens enabled him to show that at any one horizon there was one species of cardioceratid, often of very variable morphology (his story of the evolution of this lineage was published in *Special Papers in Palaeontology* **33**). This gave John a unique insight into what constituted an ammonite biospecies, knowledge he was able to use to good effect on many other ammonite groups subsequently.

As a result of one of John's lectures on dimorphism, he met Robert Chandler, an amateur who was making significant collections from the Inferior Oolite of Dorset, a thin condensed deposit, world-renowned for its well-preserved ammonites. John, together with Robert and his associates, later to become the Wessex Cephalopod Group, opened up a number of long vanished Inferior Oolite quarries and realised that not only were Buckman's (1893) hemeral divisions essentially reproducible, but they could be improved upon. The first paper, Callomon & Chandler (1990) proposed ammonite biohorizons for the Aalenian and Bajocian stages; this has been successively refined, with the latest contribution being published in 2009. John's discussion of Buckman's contribution to ammonite stratigraphy alloyed with a lucid exposition of the principles involved (*Geological Society Memoir* **15**, 127–150, 1995) should be read by anyone with stratigraphical aspirations.

John never gained the full recognition that his immense contributions to palaeontology deserved. The Geological Society awarded him the R.H. Worth Medal in 1967 and, in recognition of his contributions to Greenland geology, the Danish Geological Society awarded him the Steno Gold Medal in its centenary year (1993). He was deserving of much more.

I first met John as a first year postgraduate when he immediately pointed out the dimorphism in the Bolonian perisphinctid ammonites I had collected. Later he was to become external examiner for my PhD and I valued his friendship from that time. John was always happy to be in the field looking at Jurassic rocks. I shared that pleasure with him on many occasions and joined with him in showing some of our fine Jurassic successions to visitors from around the world. As well as using his own informal version of the geological timescale (Basement, Jurassic and Drift) he had one additional criterion for selection of a GSSP in addition to those listed by the IUGS; that there should be a good restaurant nearby. For that reason he firmly endorsed the selection of the basal Bajocian stratotype at Cabo Mondego, Portugal.

Just a few weeks before he died, John spoke warmly and in his usual eloquent way at the hundredth birthday celebration of Horace Sanders, the man who introduced him to palaeontology.

John was a very warm and hospitable person, though people who did not know him well may have found him rather aloof. He was certainly outspoken, and his physical science background gave him an acute critical faculty. He was condemnatory of sloppy science, and particularly scathing of examples where palaeontologists were ignorant enough to build upon a house of cards into ‘speciation events’ using a database of several hundreds of ‘species’ from a couple of Jurassic stages by combing two centuries of literature and accepting all specific names at face value. He had no time for the way in which palaeontologists sought ever more complex mathematical methods to distinguish species or evaluate evolutionary trends, pointing out that there is a far better discriminatory tool available to us, the human eye. This enables anyone to identify his mother within a crowd – a task that is beyond mathematical juggling.

John is survived by his wife Esther and his sons Peter, Martin and Paul.

John Cope

——OBITUARY——

Harry Blackmore Whittington
24 March 1916 – 20 June 2010

For those who did not have the privilege of knowing Harry, his published work shows him to have been a man who was clearly one of the world's greatest trilobite experts, and who also became, in the second half of his career, an outstanding authority on the Middle Cambrian Burgess Shale faunas with their astonishing variety of soft bodied organisms.

To those of us who were fortunate to know Harry and to have worked with him, he was far more than just an outstanding palaeontologist. He was an outstanding human being. He was friendly, compassionate, patient, exceptionally clever, always encouraging others, and he had the skill of using his time efficiently. He was a passionate teacher and, though he would never admit it, a skilled administrator. Despite the formidable quantity of research he undertook, he always had time to encourage or help others, be they undergraduates, graduate students or more junior staff. He was kind, gentle, thoughtful and exceedingly modest, and a good friend to a wide range of people both inside and outside his chosen profession. In his research he always insisted on having clear evidence from the specimens to justify his conclusions.

So where did this giant among 20th century palaeontologists come from? He was born in Birmingham, lost his father to influenza when he was three years old, and was greatly influenced by his uncles. He excelled at Handsworth Grammar School both academically and on the sports field, and he won a trade union scholarship to Birmingham University at the age of 17. His uncle Ernest, who studied geology under Lapworth as part of his engineering degree, persuaded the young Harry to study for a geology degree. He gained a first and stayed on to undertake research, studying the Ordovician rocks of the Berwyn Hills in N. Wales. His PhD was awarded in 1938 after less than three years postgraduate study. In 1938 he published his first paper, interestingly on the brachiopod faunas rather than on the trilobites. Thus even at the beginning of his career Harry's ability to complete work and get the results in print expeditiously was evident.

After completing his PhD Harry was awarded a Commonwealth Scholarship to Yale. There he met with a whole phalanx of North American geologists. It also led to a life-time friendship with

G. Arthur Cooper who invited Harry to work on the silicified trilobite faunas he had discovered in the Ordovician limestones of Virginia. This work, some of it jointly with William Evitt, over the years led to a huge increase in knowledge of the ontogeny of trilobites from the smallest larval stages up to the full adult form. It also led to a far greater understanding of the hard part morphology of trilobites, particularly of the inner surface of the exoskeleton.

This work was interrupted in 1940 when his Fellowship came to an end. The conditions of the Fellowship required him to return to Britain or some other part of the Commonwealth. By this time Europe was at war and Harry in all conscience felt unable to join the armed forces. He thus accepted a post at Judson College in Rangoon. During his time at Yale he had met Dorothy Arnold, a botanist, and in August 1940 they were married prior to sailing for the Far East. His stay in Burma (now Myanmar) was brief, though he did manage to undertake some geological work in the southern Shan States.

Following Pearl Harbour, Judson College – which was funded from the United States – closed and Harry and Dorothy joined Seagrave's mobile medical units on the Burma Road. Eventually they were chased out of Burma by the Japanese advance and ultimately ended up in Chengdu, China, where Harry joined the staff of Jinling College. Harry was very reluctant to talk of his time in the Burmese jungle, but it is clear that it could not have been pleasant! While in China Harry undertook some geological reconnaissance work in the Tibetan foothills which involved a trek of some 650 miles. Here they stayed until the Summer of 1945 when by some means a message reached him saying that if he could get back to Birmingham in time for the start of the new term there was a lectureship awaiting him. He and Dorothy made it with a few days to spare.

He now resumed his trilobite studies and also his work in North Wales, where he commenced a major study of the stratigraphy and faunas in the Bala Area with Alwyn Williams and Douglas Bassett. In 1949 he was invited to the Museum of Comparative Zoology at Harvard and there he stayed until 1966. During this time he continued, among other things, his studies of silicified trilobites, and undertook a major research project on the Ordovician stratigraphy and faunas in western Newfoundland with C. H. Kindle, which resulted in beautifully illustrated descriptions of the trilobites. He also made significant contributions to the trilobite volume of the *Treatise on Invertebrate Paleontology*.

A further phase of Harry's career began in 1966. He was asked by the Canadian Geological Survey to lead a new study of the Middle Cambrian Burgess Shale faunas of the Canadian Rockies made famous initially by Charles Walcott in the early part of the century. At about the same time Harry was invited to take the post of Woodwardian Professor of Geology at Cambridge University. Fortunately he accepted both invitations. Although he did not cease to research on trilobites, much of Harry's career after 1966 was dedicated to the study of the Burgess Shale faunas, and he collected together a team of young palaeontologists to help – including David Bruton, Derek Briggs, Simon Conway Morris and myself. As with his previous research, Harry insisted that reconstructions of the Burgess animals must be based on evidence from the specimens and this led to a large number of extensively illustrated monographic papers which never reached a popular audience. It was the publication by Stephen J. Gould of his best seller *Wonderful Life* that was largely responsible for first bringing Harry's work into the wider public domain. Harry sadly did not learn of the recent exciting discovery in Morocco of a new Ordovician "Burgess type" soft bodied fauna, but would surely have been delighted that work on this involves one of his past students.

Harry was dedicated to the science of palaeontology, and he served his subject well. He was secretary to the Paleontological Society from 1956 to 1962 and President from 1965 to 1966; after moving to the U.K. he was a council member of the Palaeontological Association from 1967 to 1970 and President from 1978 to 1980. He thus became the first of only three people to be President of both these organisations.

He was rarely happier than when in the field teaching undergraduates. He mentored and nurtured a considerable number of research students, some of whom have gone on to glittering careers in the subject. Not surprisingly for one who worked for the greater part of his career in institutions with significant palaeontological museums, Harry was very supportive of the role museums play in safeguarding the specimens on which palaeontologists rely. He served as a Trustee of the British Museum Natural History (now the Natural History Museum) from 1980 to 1989. He was also a Trustee of the International Trust for Zoological Nomenclature (ITZN) from 1984 to 2002.

During his career Harry gained many awards, but among his most treasured was the Lapworth Medal of the Palaeontological Association, of which he was the first recipient in 2000. He was the first non-American to be awarded the Paleontological Society Medal (1983) and received the Wollaston Medal from the Geological Society (2001). In 2002 he received the Emperor of Japan's International Prize for Biology.

No obituary for Harry would be complete without mention of his wife Dorothy, with whom he spent some 57 very happy years before her death in 1997. Dorothy invariably accompanied Harry in the field and become an accomplished fossil hunter. Although they had no children they treated all their friends and students as if they were family, and the hospitality given at the Whittington home, both in Cambridge Mass. and Cambridge UK, is legendary. When Dorothy's health and sight began to deteriorate, Harry, under her guidance, became an excellent cook and cared for her while still continuing his research. After Dorothy's death Harry continued to look after himself and undertake research. It was only in the last couple of years or so of his life that he had to accept that the time had come to stop research and move into a care home. He settled in remarkably quickly and became a great favourite with the staff and other residents.

Harry's death ends a long and distinguished chapter in the history of trilobite and early arthropod research. His successors have much to live up to.

Chris Hughes

Tabloids, trilobites, and a surprise love of taxonomy

The communication of palaeontology to the public is of the utmost importance in promoting our science. Whether evolutionary theory, or environmental change, or even just the concept of geological time, there is always something causing a stir in the media, but how does the system work, and more importantly, *does* it work? Keen to find out more about the public perception of palaeontology (and of earth sciences more broadly, too), I have decided to don my reporter hat – a battered white cricketing sun-hat, in case you were wondering – and speak to the people on the front-line.

Of course, my front-line may not be *your* front-line. Indeed, my front-line may bear a startlingly close resemblance to the list of people I know who are both palaeontologically inclined and working in the media in some form or other. I cannot, therefore, pretend to be carrying out ground-breaking investigative journalism. Neither can I tell you how many issues of the *Newsletter* this will go on for, but I will say this: Canada's greatest-living poet[6] is signed up to give his thoughts on Cambrian trilobite biostratigraphy, and if that doesn't tempt you to stick with it, I really don't know what will.

I decided to begin, however, a little closer to home (the Association's home, not mine: I live in Atlantic Canada) and pick the brains of a palaeontologist who has become a journalist. Dr Colin Barras conducted his PhD research on the phylogeny and systematics of Jurassic echinoids, supervised by Andrew Smith, Phil Donoghue and Alan Thomas, and is now a Technology Reporter for *New Scientist* (<**http://www.newscientist.com/search?rbauthors=Colin+Barras**>). During IPC3 in London, I caught up with Colin to ask him what it was like being a fossiliferous journalist, whether more scientists should become reporters, and if palaeontology gets a fair crack of the media whip.

My first question arose as a consequence of something that had been said to me during IPC. I was at Sean Carroll's brilliant *Lethaia* lecture (of which more elsewhere) when a gentleman sitting next to me asked me why it was that there were still so many senior scientists who were poor public speakers. I had to say I didn't know, and decided I would ask Colin.

So, having settled down in a quiet corner of a pub round the corner from the *New Scientist* office (which is hidden confusingly in a building full of power-dressing city types), I began by throwing the question at him. Entirely reasonably, he said he didn't know either, and I realized this was a fairly unanswerable way to start, so I asked him something more sensible.

Given that they know you're a journalist, I wondered, and might have reservations about how their work will end up coming across, how straightforward is it to get scientists to speak to you?

"It's pretty easy to talk to people," Colin says, "and everyone's really keen to talk to you." Most academic researchers are well aware of the need to promote their work. He notes, however, that he is "asking people big favours. Often we're ringing up people and asking them to comment on something which isn't even their paper and asking for it TODAY! Sometimes they can just be really insulted. They'll say, 'Oh, by the way, have you seen *my* paper on this?'"

6 Don McKay, according to the scribes at *The Walrus* magazine, who probably know about such things.

Being something of a broken record, and not much of an interviewer, I ask how tricky it is to get the tabloids interested in science stories. "It's doable, actually," Colin says, much to my surprise. "The guys who are writing for them are really disciplined. [They are] amongst the best you're going to get anywhere, because within about 50 words they can get to the nub of it. However, it is very difficult because they're writing for an audience that don't really care that much about the science. Like having a *Spitting Image* puppet, though, it's actually quite an honour: if you're getting in *The Sun* you're doing pretty damn well."

He then lets me in on a secret – that some reporters (not at *New Scientist* he hastens to add) are guilty of 'churnalism', where they churn out articles that are just regurgitations of the press release they've been given, with no new information at all. I can't say this surprises me; you only need to read Ben Goldacre's *Bad Science* column every so often to realize just how many science stories are written by journalists who don't really understand what they're writing about. Are there simply too few science reporters? "I think that's true," Colin agrees. In many places, when fiscal push comes to reporter shove, "science is the first thing that goes."

But what about geology and palaeontology? Are there many earth scientists working as journalists? One of the advantages of his geological training, Colin tells me, is the variety of topics covered by a degree in the subject. "Geology is a kind of 'general studies' science," he says, which means "quite a few geologists end up doing quite well." *New Scientist* has one geologist who is an editor, and a lot of the magazine's freelancers and consultants are earth scientists, but Colin does note that palaeontology's relative simplicity (when compared with quantum mechanics, for example) makes it easy for someone coming in from another scientific background to do quite a good job of a palaeontological story. "It's a bit depressing," he says, "that although you have that knowledge it's not difficult knowledge to grasp."

I am pleased to say, though, that Colin does find his critical PhD research skills do come in handy. Every article is a mini research project, he says. "You still have to read a paper and understand *how* to read a paper, which is actually quite a difficult skill." Among the abilities Colin tells me he has developed further since becoming a journalist is knowing how to assess people's claims. "I've become much more critical," he says. "Just because something's in *Nature* doesn't mean it's a great paper." Publicity officers and PR agencies are also quite adept at trying to regurgitate old press releases by making them sound like a new piece of research, so you have to keep a close watch on what comes out.

Scientists can be reluctant to relinquish possession of 'their' stories, and some researchers, Colin tells me with a smile, "… love picking holes in our stuff. [But] you can't be a leading expert on everything, so you have to take a lot of things on trust from whoever you've been talking to. And also you're writing to tight deadlines. [It's] easy to pin the blame on the media, but it's not entirely their fault."

During the course of our conversation, it becomes apparent that one of the battles science journalists face is trying to preserve the scientific content (so that the sources of that information don't get annoyed that their message is being lost) whilst simultaneously keeping the audience content with what they're reading. This depends on the scientific know-how of the readership: *New Scientist* has something of a different demographic to that of the *Daily Star*, of course, but the principle holds true across the board.

To stir things up somewhat, I then ask a loaded question, as one invertebrate palaeontologist to another. Do journalists simply see palaeontology and vertebrate palaeontology as synonyms?

My ruse works.

"In three years I've been there," Colin responds animatedly, "one of my stories was a study of size increases in trilobites, and I think that's the only time they have been mentioned. For God's sake, that's trilobites!" Now he's really fired up. "It's so easy for dinosaur palaeontologists! All they have to do is find something and the job's half-done. For invertebrates to get in, it's never really about the find, but what the patterns of these groups tell us about extinction, for example."

So is it too challenging for journalists to write up research in invertebrate palaeontology, especially when they know they'll get a much bigger response by simply documenting something old and enormous that had sharp teeth?

"I think it just falls off the radar," Colin says. "People don't necessarily even think about it." He mentions that he saw a crinoid-echinoid press release, recently, "but I don't know if it got reported anywhere."

Palaeontology is not solely reptilian, though, Colin assures me. "Whales are one of those groups people are interested in, and people really do care about taxonomy."

My ears prick up. Readers of popular magazines care about systematics? This seems implausible, but Colin swears it's true. "It matters to a lot of readers – '*Do you mean hominid there? Are you sure it's not hominin?*' There was a big debate about the Neanderthal genome." A story along the lines of 'Why Neanderthals weren't the only ape humans bred with' apparently sparked a fierce online argument over whether the author therefore thought that humans weren't apes.

Does journalism need more taxonomists, then? "I think so. People who don't know about taxonomy think no-one really cares about it, but people do, and if you get it wrong you just look idiotic." There are science journalists out there labouring under the impression that all things living in the sea are fish, which gives a clue to the extent of the problem.

Government funding authorities take note – taxonomy matters, not just to palaeontologists, but to the public. Dismiss it at your peril!

It was time for Dr Barras to head back to the office, before his superiors got too suspicious of the dodgy character he was fraternizing with. As we got up to leave, I asked him for the breakdown of the qualifications and backgrounds of his colleagues: Colin told me that most of them had a science degree, but not all, and only a handful of the twenty-odd people in the office had a PhD. I also wondered if it was better to be a 'writer' or an 'expert'?

"Well," says Colin after a bit of consideration. "You don't have to be able to write wonderfully well to make it as a science reporter!"

So perhaps there should be more of us trying to do it then, especially if you're interested in bringing taxonomy to the tabloids.

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Sylvester-Bradley REPORT

The Permian shark Wodnika *and its relationship to hybodonts and early neoselachians.*

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The fossil shark *Wodnika* has been known and collected since the 1830s from the Late Permian Marl Slates and Kupferscheifer of Britain and Germany.

Wodnika striatula Münster, 1843 was first described from a partial specimen showing a dorsal fin spine and part of the fin. In 1840 Münster had described *Acrodus althausi* (teeth) and *Strophodus arcuatus* (teeth) (Figure 1). These are similar to the teeth of *Wodnika* (Figure 2) and were synonomised under the name *Wodnika althausi* by Woodward (1889). Schaumberg (1999), by comparison with later finds of *Wodnika,* also considered *Radamas macrocephalus* Münster, 1843 (anterior portion of body with a scapulocoracoid) to be the same as *Wodnika,* although he continued to use the name *Wodnika striatula*.

Figure 1. Strophodus arcuatus *teeth, from Münster 1840.*

Figure 2. Teeth of Wodnika striatula, *Schaumberg collection, specimen number SSK166a.*

A new, uniquely complete, in counterpart specimen of *Wodnika* from the County Durham Marl slates (Figure 3) is the basis of a re-examination of the genus *Wodnika* and its relationship to other early sharks including *Hopleacanthus*. It is extremely rare to find any articulated shark fossils from the Permian and this one is particularly complete. Such discoveries are very important in understanding the early evolution and diversification of sharks.

Figure 3. Complete specimen of Wodnika *from the Permian Marl Slate of County Durham, England. Natural History Museum, London, specimen number P.66677a.*

The English Marl Slates were deposited on the western margin, and the Kupferschiefer of Germany in the central and eastern part, of the Zechstein Sea. These deposits contain a varied fish fauna dominated by *Palaeoniscus freieslebeni* Blainville. The shark fauna includes *Janassa bituminosa* (Schlotheim), possibly *Ctenacanthus* sp., *Wodnika striatula* Münster and *Hopleacanthus richelsdorfensis* Schaumberg. *Wodnika* and *Hopleacanthus* are some of the rarest genera in the fauna. *Wodnika* is known from English localities by pieces of scales, teeth and a few fin spines, and from Germany from incomplete specimens. *Hopleacanthus* is only known from the Kupferschiefer of Germany.

Schaumberg (1977, 1982, 1999) described *Wodnika striatula* and *Hopleacanthus richelsdorfensis* based on partial specimens in German private and museum collections, and gave reconstructions based on several specimens. The new complete specimen of *Wodnika* will allow a more complete study of the anatomy of this genus and help determine its evolutionary relationships more precisely.

Wodnika was assigned to the Hybodontoidea by Zangerl (1981) and to the Sphenacanthidae by Maisey (1982) who described a second species, *Wodnika borealis*, based on a fin spine from the Permian of Alaska. Maisey concluded that *Wodnika* is not a hybodont or ctenacanth shark but may be a very early neoselachian, related to modern sharks and rays. I hope that this study may provide new data that will help test that proposal.

Figure 4. Naturkundemuseum im Ottoneum, Kassel, Germany.

The Sylvester-Bradley award allowed me to visit the Stadt Kassel, Naturkundemuseum im Ottoneum, Kassel Germany (Figure 4) to study specimens of *Wodnika* and *Hopleacanthus* (including the holotype) from the Schaumberg collection now deposited in that museum. The original type material of *Wodnika striatula* described by Münster has been destroyed and the Schaumberg specimens are now the most completely described material of this genus available for study. The specimens were examined in detail and several were borrowed for further study at the Natural History Museum, London. Several specimens have been X-rayed and some will hopefully yield information from future CT scanning. The study will be the subject of a future publication with co-authors John Maisey and Julien Kimmig.

Acknowledgements

I am grateful to the Palaeontological Association for the award from the Sylvester-Bradley fund to enable me to travel to Germany to study critical material. I would like to thank Dr Cornelia Kurz of the Naturkundemuseum im Ottoneum for her kindness and help with access to the Schaumberg collection and for permission to borrow specimens. I would also like to thank Julien Kimmig for much help with the project (especially for translation of German publications) and Dr John Maisey for help with interpretation of the anatomy of the specimens.

REFERENCES

MAISEY, J. G. 1982. Studies on the Paleozoic Selachian Genus C*tenacanthus* Agassiz: No. 2. *Bythiacanthus* St. John and Worthen, *Amelacanthus*, new genus, *Eunemacanthus* St. John and Worthen, *Sphenacanthus* Agassiz, and *Wodnika* Münster. *American Museum Novitates*, **2722**, 1–24.

MÜNSTER, G. G. zu. 1839–1843. Beiträge zur Petrefacten-Kunde. Vols **1–7**. Beyreuth.

SCHAUMBERG, G. 1977. Der Richelsdorfer Kupferschiefer und seine fossilien, 3. Die tierischen fossilien des Kupferschiefers. 2. Vertebraten. *Aufschluss*, **28**, 297–352.

SCHAUMBERG, G. 1982. *Hopleacanthus richelsdorfensis* n. g. n. sp., ein Euselachier aus dem permischen Kupferschiefer von Hessen (W. Deutschland). *Paläontologische Zeitschrift*, **56**, 235–237.

SCHAUMBERG, G. 1999. Ergänzungen zur Revision des Euselachiers *Wodnika striatula* Münster 1843 aus dem oberpermischen Kupferschiefer und Marl-Slate. *Geologica et Palaeontologica*, **33**, 203–217.

WOODWARD, A. S. 1889. *Catalogue of fossil fishes in the British Museum (Natural History)*. Vol. **1**. BM(NH), London.

ZANGERL, R. 1981. Chondrichthyes 1, Paleozoic Elasmobranchii. *Handbook of Paleoichthyology* (Ed. H. P. Schultze), **3A**. G. Fischer, Stuttgart, New York.

The museum or the mantelpiece: a moral dilemma

I am not usually much troubled with moral dilemmas, but I am always happy to confect one if space demands. Nick Stroud (who page-makes the newsletters for us) has told me that we have a couple of blank pages in this issue, and wonders whether we can do anything about it. For no other reason whatsoever would you get a trip down memory lane with the Executive Officer.

I have only ever found one dinosaur in my life. It so happened that it was on the very day that I started my doctorate, on my first morning in the field in the Oxfordshire Great Oolite, four beds up into the first stratigraphic section that I ever measured. This is going to be a doddle, I thought. There were two huge vertebrae, one very fragile and the other robust enough to be extracted in a plaster jacket by Philip Powell, and taken to the University Museum. It was looking rather dusty when I last saw it about 30 years ago. I don't know whether it is still a *Cetiosaurus*, but that is how we thought of it at the time. Certainly it was a large sauropod, and it even got a paragraph in the *Oxford Times*.

The bed was a fine clayey quartz silt, full of exquisitely preserved aragonite molluscs, charophytes, brackish and freshwater ostracods, and identifiable plant material of 'upland type' (designated so by Prof. Tom Harris at Reading). The underlying clay was pierced by rootlets and was drawn up into the overlying bed in large flame-like structures that I later realised probably represented dinoturbation. Clearly we were dealing with a brackish swamp close to the shore of the Bathonian London Landmass (as it used to be called) where huge beasts roamed and trampled. The bed even got christened the Monster Bed by Hugh Torrens (see *Proc. Geol. Assoc.*, **84**, 63 (1973)).

Embedded in the silt close to the vertebrae were two large pebbles of dark grey-brown quartzite, several centimetres across and at least five orders of magnitude larger than any other sediment particle in the bed. They are both well-rounded to very well-rounded and it seems to me that they are very unlikely to be anything other than gastroliths. Like many other people who get this Newsletter, the first appeal of fossils to me was romantic / aesthetic rather than coldly scientific, and these two gastroliths have become a favourite possession. They are on my desk as I type this. I enjoy looking at them, and I particularly like to hold them in my hand as if they are worry-beads. They click and clatter and squeak together, like some atheist's rosary (any characterisation of the microscopic wear-patterns on dinosaur gastroliths will not come from these specimens). My weird fondness for these superficially unremarkable objects lies solely in their extraordinary context and my memory of their discovery, and therein lies the moral dilemma. They ought to be in a museum, for I suspect that sauropod gastroliths are not that common in northwest Europe. But sure as hell I do not want to put them there, where no-one will ever think that they are romantic objects again, and where, at worst, no-one will ever look at them. It is even possible that some 'expert' may decide that they cannot be what I think they are (there are no drawers in natural history museums labelled 'dinosaur gastroliths'), and they will find their way into a skip.

It's not as if I am unwilling to share their curiosity value. My children were charmed by the allure of their story, even though, when young, they were disinclined to show too much interest in other aspects of geology. In 1st year tutorials, these two quartzite pebbles were an excellent basis for a discussion of grain shapes and sizes, and the importance of context. They even induced in some students, as they had in me, a feeling of thrill and awe – much more important than mere knowledge, which can always come later.

So I do not know what I am going to do with them. For the moment they can go back into the bowl on the mantlepiece, together with the huge *Torquirhynchia inconstans* and the enrolled trilobite from Ohio. In the longer term, the moral dilemma can simmer, in the hope that one possible course of action eventually prevails over the other. But it may very well not.

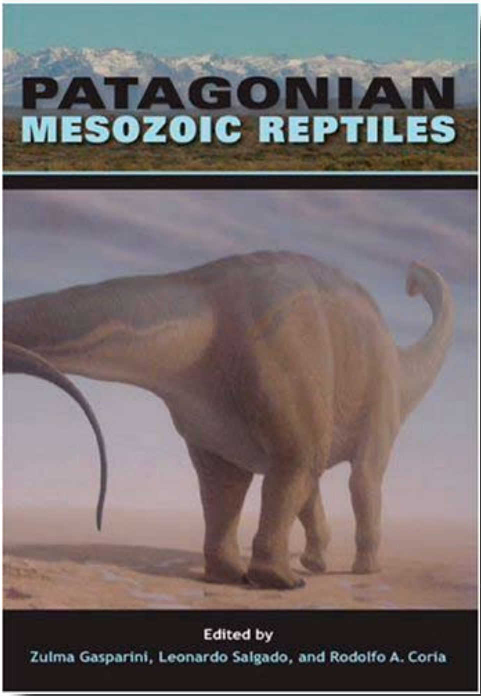
Tim Palmer

Quartzite gastroliths associated with sauropod vertebrae, Great Oolite Group, Oxfordshire. The larger is 50 mm long.

Book Reviews

Patagonian Mesozoic Reptiles

Edited by Zulma Gasparini, Leonardo Salgado, and Rodolfo A. Coria. 2007. Indiana University Press, Bloomington. 374 pp. ISBN 978-0-253-34857-9. $49.95/£33.00.



Indiana University Press has been one of the most prolific publishers of books on vertebrate palaeontological themes in the past ten years. Their series, *Life of the Past*, of which the present volume is a part, now totals more than 40 volumes. Palaeontologists should welcome such an investment in their subject area. However, with such publishing activity have come criticisms.

Perhaps too many of the Indiana books have been about dinosaurs, and perhaps too many have not had a clear purpose, being simply amalgamations of articles around a broad theme. Books have to establish their position in the modern world of online journals and the Science Citation Index, and they can only be justified if they provide a complete and authoritative overview of a topic. A mixture of reviews, descriptions of new species, and historical pieces just won't do. There have also been questions about the standard of editing of some of the Indiana books, and it has been suggested that chapters in some of the books would be unlikely to withstand the rigours of review by the standard journals.

I am glad to report that *Patagonian Mesozoic Reptiles* is an excellent book, and it avoids the criticisms just noted. The three editors clearly planned their book as a comprehensive overview of the Mesozoic vertebrate palaeontology of Patagonia (central and southern Argentina), and they are authors or co-authors of nine of the 14 chapters. The book then is *comprehensive*, covering the history of collection and geology of the area, and then in separate chapters, each of the reptile groups (turtles, lepidosaurs, crocodilians, pterosaurs, dinosaurs, ichthyosaurs, plesiosaurs) and birds, with closing chapters on trace fossils and on the faunal succession.

The individual group chapters provide both reviews of the literature as well as many original remarks. So, for example, in the chapter on crocodilians, Diego Pol and Zulma Gasparini present 12 taxa, each with full repository, age, and locality information. The authors have studied all the material themselves, and the figures are either original, or from recent papers by the co-authors. They offer incisive commentary on the materials and correct nomenclature, and then provide an up-to-date cladistic assessment of the animals in light of related forms from elsewhere in the world.

The authors have also, highly commendably, refrained from naming any new species (other Indiana University Press volumes do contain chapters in which new taxa are established, an entirely legitimate act, but frustrating for later researchers who may struggle to find the references).

The introductory historical chapter is a fascinating overview, taking the story from the days of early European settlers in the nineteenth century, and the first discoveries of fossil vertebrates, which were primarily Neogene mammals, collected by Charles Darwin among others. The great Florentino Ameghino (1854–1911) wrote copiously on these mammals, but also noticed a few dinosaur bones, and the first report of such finds appears to have been in 1883 in the newspaper *La Nación*. The English palaeontologist Richard Lydekker (1849–1915) was the first to write seriously about the Patagonian dinosaurs, and his key discovery was, in 1893, to identify titanosaurid sauropods in Argentina, very similar to those he had described earlier from India. Florentino Ameghino, meanwhile, and his brother Carlos, for all their enthusiasm, vast collections and prolific writings, were expelled from the Museo de la Plata, and dinosaur studies continued at a lowish ebb through much of the early twentieth century. It was only with the arrival of José Bonaparte on the scene in the mid 1960s, the first Argentinian specialist in fossil reptiles, that the volume and standard of work improved. The scene now is buoyant, with many distinguished researchers, some of them former students of Bonaparte's, and most of them with extensive international experience. Remarkable new dinosaurs and other fossil reptiles from Patagonia are being presented to the world every year, and the picture today has improved by several orders of magnitude since 1960.

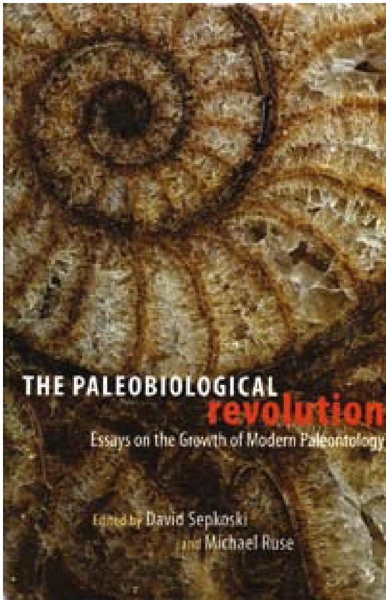
The book is so good and so well edited that it is churlish to be critical. However, some of the figures (*e.g.* 2.2, 6.9, 6.10, 7.6) are given too much space, and some tables (*e.g.* Table 6.12) might have been reconsidered. Two of the figures (12.1, 13.1) are pale and lose detail – these are maps that could have been standardized with maps in other chapters that are perfectly legible. Overall, the figures and print quality are excellent. The 12-page insert of colour plates offers some nice reconstructions, fossil pictures and palaeogeographic reconstructions.

The book is of especial value as a summary, in English, and to high standards, of more than 150 years of published accounts. Until 1980, most of the papers were published in Spanish and they were often brief in the extreme, and sometimes incomplete. New generations of Argentinian researchers have now revealed the astonishing diversity of dinosaurs and other Mesozoic reptiles in their home country, and we are privileged to have witnessed this explosion of new knowledge. *Patagonian Fossil Reptiles* is an excellent and essential guide.

Michael J. Benton
University of Bristol

The Paleobiological Revolution: Essays on the Growth of Modern Paleontology

Edited by David Sepkoski and Michael Ruse. 2009. The University of Chicago Press. 584 pp. £45.00 ($65.00). ISBN 978-0226748610.



Do you call yourself a palaeontologist or a palaeobiologist? If it's the latter then this book is aimed at you. The 26 essays in this volume concern the history of palaeobiology and whether its origin can truly be considered a scientific revolution. The editors, both historians of science, take as their jumping off point the 1984 welcoming back of palaeontologists to the high table of science by the geneticist John Maynard Smith (*Nature*, **309**, 401-402), perhaps in large part due to the products of the new discipline of palaeobiology. However, the contributions themselves are more eclectic.

The first section of the book covers some of the major innovations that helped shape palaeobiology. David Sepkoski's initial outline of palaeobiology's emergence is followed by accounts on biological signal in the fossil record (Michael Benton), Palaeozoic biogeography (Richard Fortey), the discovery of the conodont animal (Richard Aldridge and Derek Briggs), Precambrian palaeobiology's emergence (William Schopf), punctuated equilibria (Patricia Princehouse) and a neontological critique of molecular clock methods (Francisco Ayala). These are all excellently written by workers who can legitimately claim to have been present at the heart of their given topic (with the exception of the punk eek chapter). However, I found the most enjoyable chapters to be those by John Horner (on dinosaurs) and Tim White (on hominids), largely for their more antagonistic tone that is likely to raise a few hackles. Highlights include Horner's suggestion that critics of (former student) Mary Schweitzer's reported *T. rex* blood vessels are not even in sight of science's high table (p119), and White finishing a robust and broad critique (that even includes the premise of the book itself; p.123–124) by suggesting that "the generation of variation is just as important for intellectual evolution as biological evolution" (p.146).

The second section concerns the historical and conceptual significance of recent palaeontology, and hence is principally different to the first in not being written by those who were "there." Here, then, we find most of the philosopher and historian of science authors tackling topics such as empirical testing in palaeontology (Derek Turner), palaeobiology's impact on neontology (Todd Grantham), Reg Sprigg's discovery of the Ediacaran 'fauna' (Susan Turner and David Oldroyd), the German tradition in palaeobiology (Manfred Laubichler and Karl Niklas), the early reception of punctuated equilibria (David Sepkoski) and the stories of both the MBL model (John Huss) and the famous "consensus paper" (Arnold Miller). Again, these are well-written and informative accounts, although Grantham's (perhaps inevitable) conclusion that we've only had partial success in reaching our colleagues in neontology is disheartening. Two other chapters in this section particularly piqued my interest. The first of these is David Fastovsky's suggestion that the historical interpretation of dinosaurs has been influenced by social and political context. This challenges the widely held notion that we scientists are an objective lot, but I fear he may have a point. The other chapter of particular interest was Joe Cain's account of Stephen Jay Gould's "assassination" of G. G. Simpson. Such "ritual patricide", Cain submits, is common in science, if somewhat reprehensible.

The final part of the book is largely made up of personal reflections of some of the key figures of palaeobiology (Richard Bambach, Arthur Boucot, Anthony Hallam, David Raup and Jim Valentine). These are supplemented by a student's perspective (Rebecca German), a review of palaeobiology's major research themes and future (David Jablonski), and a contemplation of whether palaeobiology really does constitute a major scientific revolution (Michael Ruse). I particularly enjoyed the Raup chapter from this section as he is one of my intellectual heroes, and I was amused by an anecdote about an algorithm he wrote taking six months for Jack Sepkoski to decipher: "I write very, very dirty code" (p.464). Ruse's concluding chapter somewhat dodges the question over whether palaeobiology really constitutes a revolution, but for this reader at least, it is the interesting part of our science and I'm grateful that it exists.

Overall the book is well written and easy to read, although I got a bit lost with some of Ayala's stuff. There are limited figures as the focus is on essays, but where found they are appropriate and clearly laid out. There is a strong emphasis on both the Chicago school and the work of Stephen Jay Gould, which is hardly surprising, but my only major gripe with the book comes from what is *not* there.

Perhaps the most glaring omission is any mention – literally not a word – of the Red Queen hypothesis. This seems inexplicable, as it is a major component of evolutionary theory, was put forward by a palaeobiologist, is based on data from the fossil record, has truly crossed over into neontology, and has spawned numerous books and papers. Surely it deserved its own chapter.

Another frustrating omission seems to be the cladistic revolution's impact on the field. Prior to the advent of numerical taxonomy neontologists weren't "allowed" to speculate on phylogeny – it was up to palaeontologists to draw up the tree of life as we had the fossils (*i.e.* the ancestors). Now things have turned full circle, with neontologists happily creating phylogenies without any fossils at all and ancestors are reconstructed not identified. Of course cladistics does get mentioned here, but for my own part I would have liked to see a chapter devoted purely to the changes it wrought on palaeontology.

I would still recommend this book if for no other reason than that it stands alone as an attempt to document the birth and development of palaeobiology. Although many of you will be familiar with large chunks of what is here I suspect you would still learn something, and for those at an earlier career stage this book will help you understand a lot about our discipline (and its schisms). There is, after all, still a tension between palaeontological and palaeobiological approaches, but ultimately the latter needs the former as data, and the former the latter for relevance.

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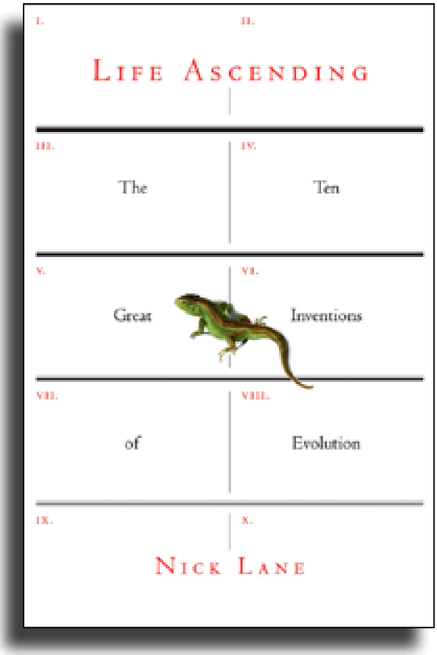
Life Ascending

Nick Lane (2009). W. W.Norton & Company. New York and London.
344pp, 30 illustrations. ISBN 978-0-393-06596-1. $26.95.



Most palaeontologists are interested in evolutionary theory, but if questioned, I suspect that most of us would say that we don't know enough and ought to know more. It is not always possible to find time to read constructively outside one's own speciality, and to expand one's own understanding by incorporating new knowledge – especially where relevant areas of science are expanding constantly and dramatically, as they all are. Accordingly, any book that addresses basic questions in evolution as lucidly as does this one should surely be essential reading.

Nick Lane is a biochemist at University College London, and he writes beautifully on basic questions of evolution. His erudition and breadth of knowledge are surely enviable, and he explains how new kinds of scientific knowledge give us a far deeper understanding of this history of life than was ever possible before. In this text he identifies ten 'inventions' of evolution which he regards as having transformed life on Earth. They are, in order, the origin of life, DNA, photosynthesis, the complex cell, sex, movement, sight, hot blood, and then, interestingly, he finishes with consciousness and death. There could have been other topics, but this seems to me to be a sensible selection; we shall see what he has to say about the latter two in due course.

The origin of life can be traced backwards as far as 3800 Ma. For a long time the Miller-Urey experiment of 1953 seemed to carry the germs of a final solution to how it happened. As is well known, Stanley Miller prepared a brew of methane, ammonia and hydrogen, the gases found in the atmospheres of the outer planets. He passed electrical discharges through it, simulating lightning. After a time he analysed the resulting mixture, and found the same amino-acids that form the building blocks of the proteins of living material. In other words a primordial soup of amino acids, just waiting to be turned into proteins. But there is nothing in the soup to react further; it is 'thermodynamically flat'. The building blocks were there, but there was nothing to glue them together. Concentration in evaporating hot pools, perhaps, or adsorption onto the surface of a crystal? Perhaps. But for many scientists primordial soup conception was going nowhere. Lane, like many other people today, prefers the Martin-Russell concept that hydrothermal vents on the deep-sea floor are the likely sites of life's origin. The arguments put forward are quite complex but the graphic model proposed is almost visual – the last common ancestor of life was 'a rocky labyrinth of mineral cells, lined with catalytic walls composed of iron, sulphur and nickel, and energised by natural protein gradients'. Which leads us to DNA.

The story of the discovery of DNA in 1953 is well-known but a readable version is given here. So we pass on to what has happened since, an evolving if remarkably complex tale, which cannot be read in a hurry, if one is to try to absorb it. But the discovery that archaea and bacteria are fundamentally different, and that life might have emerged twice at the hydrothermal vents, is surely of ultimate fascination. Likewise the discussion of photosynthesis brings up very new perspectives, and is right up to date. It seems that there was originally one ancestral photosystem, using sunlight acting on hydrogen sulphide to form sugars. But a second photosystem developed, derived from the former, but specialised for generating ATP via an electron circuit. We don't yet know how the two photosytems came to be assembled, but once they did we have a form of photosynthesis available for the ancestor of cyanobacteria. And while we are on about cyanobacteria there is a good account of the Brasier/Schopf disagreement on whether or not Schopf's famed 'microfossils' are really cyanobacteria (they seem now not to be). Finally watch out for little clusters of manganese atoms, linked to oxygen and calcium, which split water, releasing oxygen and hydrogen. And apparently, all the energy we are ever going to need……

Chapter 4 deals with the origin of eukaryotic cells – a 'fateful encounter' of different kinds of prokaryotes; the endosymbiosis of Lynne Margulis and other writers. But in eukaryotic cells there are two broad classes of gene, those with bacterial equivalents and those which are confined to the eukaryotes alone. The latter must have changed dramatically since their first incorporation. But it is not easy to work out a phylogenetic tree – we also have to take into consideration such processes as genome fusion and lateral gene transfer. The key elements in this story seem to be the mitochondria; the very few eukaryotes which do not possess them, lost them somewhere along the way.

Sex (Chapter 5) induces variety. But wouldn't cloning, by preserving 'good' gene combinations, be as good, or better? Sex, as the author comments, propagates selfish genetic parasites, places a burden on finding a mate, transmits venereal diseases, and systematically demolishes all the most successful gene combinations. Yet it produces ever new combinations upon which selection can act. The earliest eukaryotes were sexual. And if it were not for them we wouldn't be here at all.

Movement (Chapter 6), in any animal beyond a certain size, depends on muscle. In this eminently readable chapter we have a fine account of how muscles work, coupled with a history of the discovery of the sliding filament theory and other functions. Much of this knowledge has depended on technological advances, in electron microscopy and X-ray crystallography, and the realisation of how actin and myosin, which enable muscles to contract, actually do so. Movement is characteristic of all eukaryotes, and we would have a very different and very uninspiring planet without it.

Sight (Chapter 7). 95% of all animals have eyes, though they are confined to six phyla alone. And the Cambrian 'explosion' of life' corresponds very closely with the origin of many different kinds of eyes, certainly no coincidence as Nick Lane comments – and Andrew Parker has written extensively that the origin of eyes drove the Cambrian explosion. The eyes of trilobites are mentioned, of course, but there are many other kinds of eyes, which are indeed discussed here. Consider *Rimicaris*, a hydrothermal vent shrimp with naked retinas along its back, able to detect faint light invisible to us. Yet this strange creature uses the same protein as we do for vision. And the genes needed to make an eye in a mouse and a fly are the same.

Hot Blood (Chapter 7). This is all about metabolic rate. An animal with our body temperature, 37°C, has four times the power of one at 17°C. Excellent, but the problem is that we are stuck with it, whether we need it or not. We can't switch off, and the cost of living, in the cold, is 100 times greater for a mammal than for a lizard. We have to eat, or forage for food incessantly. But what mammals have, which lizards don't, is stamina. A lizard can dart away very rapidly. But it can't keep it up. Mammals can. Large mammals generate heat, smaller ones have problems. But they do have specialised tissues, like the 'brown fat' in rats, laden with 'hot' mitochondria. There are fascinating adaptations for respiration and heat retention described here. What an interesting chapter this is.

Chapter 9. Consciousness! Is this not the ultimate unsolved problem of all life? What do we know about it? Not very much at all. We don't have a simple solution, either from the erudite pen of Daniel Dennet, or from the (presumably conscious) beings who deny its existence altogether. Consciousness is surely widespread in the animal kingdom, and even those rare unfortunate humans born without a cerebral cortex can still express feelings of happiness and joy. Whereas the cerebral cortex undoubtedly elaborates consciousness, its roots lie in the ancient parts of the brain. Some amazing experiments are being conducted at present. They illuminate, but do not resolve, this ultimate problem.

Chapter 10: the final chapter is all about death. At the risk of being facetious I would suggest that as palaeontologists we are already expert thanatologists since the once-living organisms which fascinate us are all now dead. But going beyond this, why do we age? Can we eliminate age-related diseases? Up to a point. But not beyond a certain limit – the neuronal cells in our brains cannot be replaced when they die. Do many of us really wish to live beyond our span in any case? I doubt it.

A final Epilogue concludes the book, apart from useful notes and a reference list. I like the way it ends 'There is more than grandeur in this view of life. There is fallibility and majesty, and the best human eagerness to know".

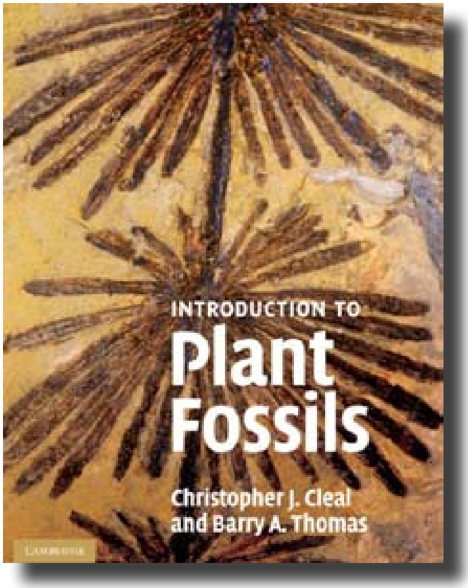
It took me a long time to read this book, not because it was intrinsically difficult, but because I was constantly encountering new concepts, and I wanted to take them in. I shall return to it time and time again for its inspiration and erudition. I'm truly glad to have read it and I would recommend it to anyone interested in the mystery of evolving life.

Euan Clarkson
Edinburgh

An Introduction to Plant Fossils

Christopher J. Cleal and Barry A. Thomas, Cambridge University Press, 2009. ISBN 978-0521715126 (paperback) and 978-0521887151 (hardback), £29.99 and £70, respectively.

This volume focuses on palaeobotany, but also is a useful introduction to the study of fossils in general. It is a relatively modestly sized volume but provides a superb wealth of detail. The style and content are reminiscent of *Paleobotany* by Taylor, Taylor and Krings (Academic Press), but the present volume is much more succinct and therefore rather more portable for taking into the field, if required. The style is clear and easily readable. The content includes a general introduction to fossils and palaeobotany, the history of palaeobotany, methods employed in the study of fossil plants, and several detailed chapters presenting information on the major phylogenetic groups from early land plants through to angiosperms.



The introductory chapter leads the reader thoughtfully into the subject. It details the obvious, 'What is a plant', clearly explains types of fossils, their occurrence and formation, bias in the fossil record and importantly, 'Why do we study plant fossils?' The answer to this last question is, not just for their beauty, but for their value, at a minimum, to the study of evolution, geology and climatology, encompassing key issues of the modern day.

The historical viewpoint presented in Chapter 2 describes several renowned pioneers of the field, including a nice selection of period photographs. This chapter concludes with a short and optimistic speculation on the future of the study of palaeobotany, highlighting the wealth of new discoveries to be made, for example from newly discovered sites, and the prospects of applying knowledge to understand evolutionary trends in the land plants to an even greater depth.

The bulk of the volume comprises a systematic examination of the major groups of (fossil) plants, with a chapter devoted each to early land plants, lycophytes, sphenophytes, ferns, early and modern gymnosperms, and angiosperms. Individually these are not comprehensive in coverage, but are well-illustrated overviews, which will provide the background and basic knowledge to facilitate access to more specialist volumes or field guides. For example, I have not previously come across such an excellent introduction to angiosperm fossils.

A final chapter takes a contrasting viewpoint, detailing the history of land vegetation by epoch, from the Silurian to the modern age, and discussing how climatic factors have influenced the ecological and vegetation types in the various periods. Reconstructed visualizations of landscapes, modern landscapes and several clear continental maps are included.

The volume is well illustrated with a huge number of black and white photographs and line drawings, basically with a picture on every page, and in many cases several. Every illustration is thoughtfully captioned with a wealth of detail. The specimen photographs are coupled with clear and annotated line diagrams. Terminology and nomenclature of plant parts and forms is exceptionally well dealt with. No prior knowledge, other than basic botany, is presumed. Both the diagrams and text are presented in a clear and straightforward style, substantially facilitating understanding. I particularly liked the juxtaposition of fossils and living plants, which as well as highlighting the phylogeny, also demonstrates evolutionary trends within groups. In addition to the excellent example specimen photographs, there are several whole plant reconstructions, particularly appropriate for the large lycophytes.

Multiple boxes of key information highlight key points. All chapters include recommended reading, and a full list of the complete references is in a section at the back of the book. A more general list of recommended reading would have been a nice supplement. A good index completes the volume.

As the authors and publishers promise, this is an excellent introduction to the field. This extremely accessible book is recommended for amateurs, non-specialists and students of palaeontology in general and palaeobotany specifically, as it provides a general and extensive introduction to the subject. The price of the paperback should encourage widespread adoption and I fully recommend purchase.

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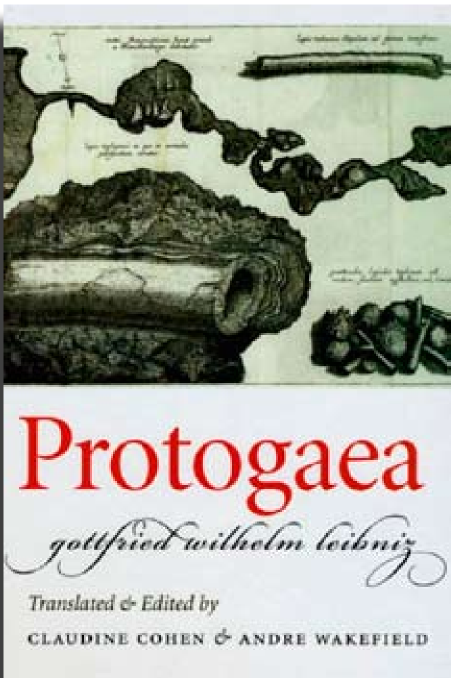
Protogaea

Gottfried Wilhelm Leibniz, translated and edited by Claudine Cohen and Andre Wakefield. 2008. University of Chicago Press. 204 pp. ISBN 978-0226112961.



Protogaea opens with *'Even a slight notion of great things is of value'*, a humble beginning that belies the tremendous significance of Leibniz's contribution to scientific thought in the 18th Century.

Although most famous for his works on mathematics, philosophy and metaphysics, Leibniz was also deeply interested in more tangible matters. His polymathic abilities are evident from the variety of spheres that he influenced and, apart from the themes already mentioned, Leibniz was employed variously as an alchemist, diplomat, historian, librarian and mining engineer. It is this last employment that may interest the reader most, providing inspiration for his posthumously published *Protogaea*.

Written between 1691 and 1693, *Protogaea* is the product of Leibniz's engagement by Duke Ernst August of the House of Brunswick to provide silver mines in the Hartz region of Northern Germany with the water essential for mechanisation. However, the use of novel windmill technology ultimately proved unsuccessful due to a lack of wind, exacerbated no doubt by a local resistance to outside technological ideas;

the project failed and Leibniz was forced to abandon his efforts in 1686. Although attracted, in all likelihood, by the glamour of the Hartz mines and the wealth of silver produced there, Leibniz was gripped by an interest in the wider questions posed by his experiences in the mines, such as the formation of minerals, the origin of the stratigraphy that the miners described, and the mechanisms and processes of hydrogeology. On the desertion of the mine engineering project, Duke Ernst August commissioned Leibniz to write a history of the Guelf family, including the House of Brunswick to which the Duke belonged, stipulating that it was to begin with the 'earliest times'. Perhaps using this as an opportunity to articulate the discoveries and theories of his last six years in the Hartz mines, Leibniz took this literally, and began his history with *Protogaea*. Eventually running to 11 volumes, the history of the Guelf family exceeded the expectations of the commission, possibly explaining why *Protogaea*, the most peripheral of these volumes, was not published until after Leibniz's death in 1716.

Protogaea deals with a range of natural phenomena and ideas familiar to 17th Century natural scientists, including geological processes, hydrogeology, tectonic forces, natural and laboratory chemistry, fossils, landforms and stratigraphy; although these do not, and were never meant to, provide a strictly comprehensive narrative of earth history.

The import of *Protogaea* becomes apparent as Leibniz approaches each idea with a progressive and open mind. He is obviously influenced by his predecessors and contempories such as Agricola, Bernier, Descartes and particularly Steno, who he calls '*a learned man*' or '*that eminent man*' in his arguments in order to avoid naming him repeatedly. However, Leibniz is not afraid to disagree with these academic heavyweights or with current thinking, and his statements are based largely on first-hand observations of events or objects, describing his field observations thoroughly. This 'grass roots' science results in verifying statements such as the slightly prosaic chapter entitled '*The forms of fish imprinted on slate come from real fish, and are not games of nature*'. The manner in which subjects are essayed varies as Leibniz makes a unique and scientifically invaluable move; using his own observations together with the miners' descriptions of the geology of the Hartz region, he infers details of the earth's history in that region and then, significantly, attempts to infer broader earth history. He leads up from the more trivial statements and questions to veritable enigmas of the time, encountered in chapters entitled '*The first formation of the earth through fire*' and '*The origin of mountains and hills explained through waters, winds, and earthquakes*'. The influence of his brief stint as an alchemist is clear in his preponderance towards fire as a major natural agent of, amongst other things, fossilisation; in his trust of chemical analyses, such as those performed on amber, and in his reliance on comparisons between natural forms and products of human artifice. Leibniz clearly trusts and wishes for the advancement of technology, expressing resentment at the slow spread of the newly manufactured microscope; he is equally sensitive to the idea of ideological advancement and often, after taking the conclusion as far as possible, will admit ignorance and outline the work that must be undertaken by the next generation of scientists to develop the theory.

Originally published in Latin, the translation of Claudine Cohen and Andre Wakefield is sensitive and maintains eloquence throughout the text, making *Protogaea* an easy and pleasurable read. The split text provided in this edition allows the reader to revert to Leibniz's original words. The historical setting and implications of *Protogaea* are discussed in a comprehensive introduction which, far from boring the reader with unnecessary background minutiae, enables a full appreciation of the courage of Leibniz in his postulations, writing at a time when explanations of natural phenomena had to address the tenets of religion, Aristotelism, and pure superstition. Leibniz does not make a clean break from the doctrines of religion, but instead takes the next step, applying mechanisms to ideas put forth by Descartes in the early 17th Century. This is not science as we know it today, isolated almost completely from religion, but rather one vital step in the extrication of observable mechanisms and processes from the miasma of theological and folkloric explanations of the natural world.

The illustrations included by Cohen and Wakefield provide a valuable point of interest and reference for the reader, whilst also allowing a glimpse of Leibniz's original accompanying sketches. We can see that in describing the form of mineral veins in mines, Leibniz uses a 3D cone that is instantly, and delightfully, recognisable to any student of geology as a stereonet. In fact, the germ of modern earth sciences can be detected in the majority of Leibniz's discussions, from his use of stratigraphic descriptions of well cores and mines to infer palaeoenvironment to his attempts to recreate theoretical petrogenic conditions in the laboratory. *Protogaea*, in essence, documents the uneasy birth of modern scientific practices and thought during the turn of the 18th century, a gradual and mosaic epiphany which has culminated in the strict scientific directive of modern earth science.

Kelly Richards
University of Cambridge

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- *Carnivoran Evolution: New Views on Phylogeny, Form and Function*, edited by Anjali Goswami and Anthony Friscia
- *The Paleontology of Gran Barranca: Evolution and Environmental Change through the Middle Cenozoic of Patagonia*, edited by Richard H. Madden, Alfredo A. Carlini, Maria Guiomar Vucetich, and Richard F. Kay
- *Geobiology: Microbial Mats in Sandy Deposits from the Archaean Era to Today*, by Nora Noffke
- *Introducing Geology: A Guide to the World of Rocks (2nd edition)*, by Graham Park
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- *New Perspectives on Horned Dinosaurs: The Royal Tyrrell Museum Ceratopsian Symposium*, edited by Michael Ryan, Brenda Chinnery-Allgeier and David A. Eberth
- *Fossils Alive: New Walks in an Old Field*, by Nigel Trewin
- *Introducing Palaeontology: A guide to Ancient Life*, by Patrick Wyse Jackson

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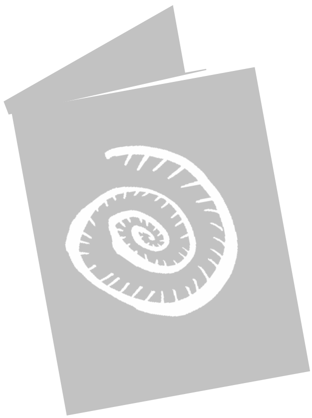

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