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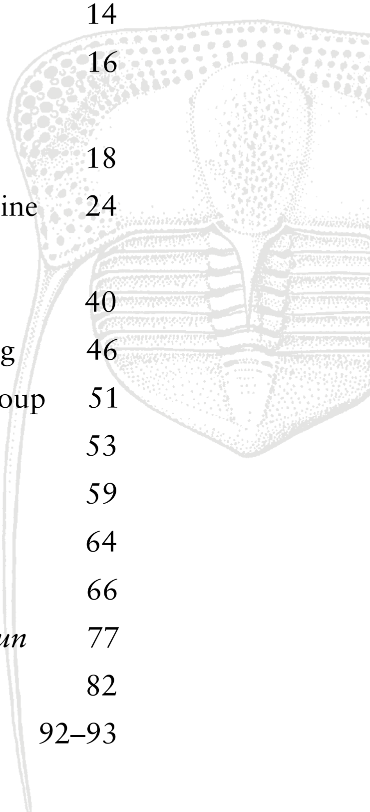
The Palaeontology Newsletter



Contents

Reminder: The deadline for copy for Issue no 74 is 14th June 2010.

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

ISSN: 0954-9900

Association Business

Annual Meeting 2010

Notification of the 2010 Annual Meeting, Annual General Meeting and Annual Address

The 2010 Annual Meeting of the Palaeontological Association will be held at Ghent University in Belgium on 17–20 December, organised by members of the Department of Geology of Ghent University in collaboration with the Department Géosystèmes of the University of Lille 1 (France), the Royal Belgian Institute of Natural Sciences (KBIN – Brussels, Belgium) and Kunsthal St-Pietersabdij (Ghent, Belgium).

Nominations for Council – AGM 2010

At the AGM in December 2010, the following vacancies will occur on Council:

- President
- Vice President
- Two Editor Trustees
- Publicity Officer
- Webmaster
- Four Ordinary Members

Nominations are now invited for these posts. Please note that each candidate must be proposed by at least two members of the Association and that any individual may not propose more than two candidates. Nomination must be accompanied by the candidate's written agreement to stand for election and a single sentence describing their interests.

All potential Council Members are asked to consider that:

> "Each Council Member needs to be aware that, since the Palaeontological Association is a Registered Charity, in the eyes of the law he/she becomes a Trustee of that Charity. Under the terms of the Charities Act 1992, legal responsibility for the proper management of the Palaeontological Association lies with each Member of Council."
> Responsibilities of Trustees can be obtained from <**secretary@palass.org**>.

The closing date for nominations is 1st October 2010. They should be sent to the Secretary: Dr Howard A. Armstrong, Department of Earth Sciences, University of Durham, Durham DH1 3LE; email <**h.a.armstrong@durham.ac.uk**> or via <**secretary@palass.org**>.

The following nomination has already been received:

President: Prof. Jane Francis (nominated by Council)

Awards and grants

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 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; they are 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 resume (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 will reserve the right not necessarily to make an award in any one year. Details and nomination forms are available on the Association Website and with the *Newsletter*. Deadline is **1st May**. The Medal is presented at the Annual Meeting.

President's Medal

Council is instigating a mid-career award for a palaeontologist in recognition of outstanding contributions in his/her 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 will reserve the right not necessarily to make an award in any one year. Details and nomination forms are available on the Association Website and with 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 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 on the online application form. Such requests will be considered by Council at the March and October Council Meetings each year. Enquiries may be made to <**secretary@palass.org**>, and requests should be sent by **1st March**.

Lapworth Medal: Prof. B. Runnegar

Runnegar has been one of the most innovative researchers of his generation, and a testament to the visionary nature of his research is its endurance. Of course, taxonomic works in palaeontology have a long 'half-life', but review papers tend to burn brightly and quickly. Runnegar has published his fair share of taxonomic studies, elucidating the early evolutionary history of molluscs. However, he also has an enviable back-catalogue of reviews and opinion pieces that were not merely of the moment, but remain as relevant and inspirational today as when they were published, many of them decades ago, and they continue to accrue citations as a result.

Runnegar's 1982 *Geol Soc Australia* article codified the conundrum of the Cambrian Explosion – whether it should it be interpreted as an explosion of animal diversity, or merely of fossils (Runnegar, 1982b). He made the first serious attempts to tackle this problem, by employing the molecular clock, long before it became fashionable among molecular biologists (for whom it is now an industry), in trying to obtain an independent timescale for animal evolution (Runnegar, 1982a). To my knowledge, he is the person who first codified the concept of disparity (Runnegar, 1987) used by Gould as the centrepiece of his thesis in *Wonderful Life*. Furthermore, Runnegar had reconciled the 'weird wonders' of *Wonderful Life* as stem members of extant animal phyla soon after its publication, but it took almost a decade for the debate to catch up (*e.g.* Budd and Jensen, 2000).

Runnegar's vision was ultimately distilled in the written account of his 1985 address to the Palaeontological Association in which he argued that palaeontology is a discipline concerned with fundamental questions, that the most appropriate dataset to answer these questions is not always to be found in lumps of rock, and that all relevant data and methods should be brought to bear in attempts to resolve these questions. I think that this perspective is held generally among palaeontologists, and he has a flourishing following of disciples, but no one has fulfilled the promise of this integrative vision as has Runnegar, evidenced, not least, by his appointments as Director of the UCLA Astrobiology Center, and of the NASA Astrobiology Institute.

BUDD, G. E. and JENSEN, S. 2000. A critical reappraisal of the fossil record of the bilaterian phyla. *Biological Reviews*, **75**, 253–295.

RUNNEGAR, B. 1982a. A molecular-clock date for the origin of the animal phyla. *Lethaia*, **15**, 199–205.

RUNNEGAR, B. 1982b. The Cambrian Explosion – animals or fossils. *Journal of the Geological Society of Australia*, **29**, 395–411.

RUNNEGAR, B. 1987. *Rates modes of evolution and in the Mollusca* In: K.S.W. Campbell and M.S. Day (eds), *Rates of Evolution*, pp.39–60, Allen and Unwin, London.

President's Prize – Dr K. Peterson

Kevin is an inspirational scientist who, in focusing on the big questions of palaeontology rather than on a particular group of fossils on which he may tackle such questions, is an example to all palaeontologists – not merely those who wish to follow his personal example of marshalling molecular and developmental biological data to solve these problems. His example shows us that palaeontological science is more than the sum of the fossil record, forcing us to reconsider the limits of the ambition we have for our discipline.

After a pre-medical degree, Kevin enrolled as a graduate student in the palaeontology programme at UCLA because he wanted to address some of the big questions in animal evolution. His PhD, supervised by Bruce Runnegar and Charles Marshall, focused on the calcichordate problem. He was the first to recognise that it could not be solved until the interrelationships of extant deuterostome phyla were resolved. He was also the first to integrate classical anatomical data with new molecular phylogenetic hypotheses on deuterostome relationships, effecting a test of Jefferies' calcichordate hypothesis from which it has never recovered.

Kevin's subsequent career is more commonly known. With characteristic modesty, he wanted to solve the Cambrian explosion problem and dove straight into a postdoc with Eric Davidson, a multi-Nobel-nominated molecular biologist, who has been arguing since the 1960s that the divergence of animal phyla could be explained by studying the evolution of development of their larval stages. Kevin obtained bench training in molecular biology, then immersed himself completely in this ideology, effecting test after test after test of its basis assumptions. Kevin was completely right until he was completely wrong – ultimately, his tests of Hox expression in larval versus adult development demonstrated that larvae must be a derived not primitive feature of animal development, his molecular clock analyses demonstrated shallow, not deep origins of animal phyla, and his developmental genetic experiments revealed that the principal features of larval anatomy are contingent on the interaction of different regulatory genes in different animal phyla –

demonstrating that the larval stage has evolved convergently, rather than through common descent in each of these clades. This is an astonishing achievement, overturning over a century of dogma extending back to Haeckel in the late nineteenth century, disembowelling Davidson's set-aside theory; he has been attempting to erect a new timescale and mechanism of animal diversification ever since.

Kevin's most recent agenda is the architecture of animal phylogeny. He has been pursuing this on two threads – on the basis of molecular phylogenetic analysis of gene-coding DNA loci, and on the basis of miRNAs. The latter have also led Kevin to explore the ultimate basis of evolutionary emergence of animal complexity, to which miRNAs are thought germane because these non-coding regulatory RNA molecules are responsible for refining cell fate, mitotic activity and, as a result, tissue and organ development – the basis of anatomical complexity. miRNAs are an extraordinarily well funded and fast moving object of scientific enquiry, with many competing groups, but Kevin has carved out world leadership in the investigation of their pattern of evolution among animals, and the implications of this pattern for understanding the evolution of organismal complexity.

Hodson Award – Dr Emily J. Rayfield

Emily is a world-leading expert in the application of Finite Element Analysis (FEA) to palaeontological material. FEA is a technique developed by engineers to analyse stress/strain distributions in complex 2-D and 3-D structures and has been used widely in medicine and engineering. During the course of her PhD studies at the University of Cambridge, Emily was one of the first to successfully apply this technique to fossil vertebrate material, analysing the 3-D mechanical performance of a theropod dinosaur skull (Allosaurus), establishing the bite force of this animal and the response of the skull to various stress and strain regimes. She was able to demonstrate that the skull was not optimally designed for high bite forces (as is usually assumed for all large carnivores), but showed that it was well-adapted for resisting various torsional stresses that would have enabled specialised feeding mechanisms. This work (her first paper) was published in *Nature* and has been widely cited.

This work has been followed by more detailed investigations into theropod dinosaur functional evolution using 2-D and 3-D FEA. In addition, Emily has gone on to use FEA for studies of skull function in numerous other extinct amniotes in collaboration with various PhD students of her own (encompassing dicynodonts, crocodilians and ornithischian dinosaurs). Her position at the cutting edge of vertebrate biomechanics has been consolidated by a solid body of work in this field, culminating in prestigious invited reviews on this topic (*Annual Review of Earth and Planetary Sciences*) and dinosaur feeding (*Trends in Ecology and Evolution*), and numerous invitations to speak at specialist symposia. Emily's work crosses the boundary between palaeo- and neontology: her palaeontology projects are grounded in empirical data from living animals and she is also in the process of validating her palaeontological work with new experimental work on living animals (for example, her collaboration on feeding in the extant Komodo dragon, published in *Journal of Anatomy*). Emily has wide interests in other areas of vertebrate biomechanics (particularly flight), and has also gone beyond the realm of vertebrates to apply FEA to foraminifera in what is likely to be a ground-breaking study. FEA is only one of the techniques used by Emily – she also uses morphometrics and was instrumental in the early application of Geographic Information Systems to palaeontological problems.

During the course of her career, Emily has held postdocs at the University of Cambridge, the University of Oxford and the Natural History Museum, before taking a permanent post as Lecturer in Palaeobiology at the University of Bristol, where she heads a large and active research group that includes PhD and Master's candidates. Indeed, she has already successfully steered several students through their PhDs, most of whom are now in postdoctoral positions in the UK, USA and South Africa. She has had notable success with UK research councils (as a Principal or Co-Investigator on several NERC Small, New Investigator and Standard grants) and EU funding, and contributes to the wider palaeontological community via her involvement with the Palaeontological Association (Council Member), the Society of Vertebrate Paleontology (Programme Committee Member and Host Committee Co-Chair for 2009 meeting in Bristol) and International Congress of Vertebrate Morphology. Finally, her work has formed an excellent conduit for the public communication of science and has been featured heavily in numerous international documentaries.

Emily is recognised to be at the cutting-edge of the subject and future work is only likely to consolidate this position. She is certainly one of the most gifted vertebrate palaeontologists of her cohort worldwide and is likely to be world-leader in this area in the years to come.

Mary Anning Award – Magne Hoyberget

Magne is an avid fossil collector with a unique ability and insight in palaeontology. He is 46 years old and a teacher by profession. Growing up in the Mjøsa area of Norway, he has had a keen interest in fossils most of his life. Magne is also extremely skilled in preparing fossils. During the past two decades he has studied Cambrian fossils extensively, particularly trilobites, and developed an almost unsurpassed insight into the Cambrian of Norway.

Since 2002 this has resulted in four professional papers with co-authors:

- *The Ordovician trilobite Megistaspis (Rhinoferus) hyorrhina (Leuchtenberg 1843) (Trilobita) in Norway, with notes on its autecology*(Ole A. Hoel & Magne Høyberget, 2002).
- *A reconstruction of Telephina bicuspis, a pelagic trilobite from the Middle Ordovician of the Oslo Region, Norway* (Bruton and Høyberget, 2006).
- *Redescription of Holmia Inusitata (Trilobita) from the Lower Cambrian of Scandinavia* (Ebbestad, Ahlberg, Høyberget, 2003).
- *Middle Cambrian trilobites of the suborders Agnostina and Eodiscina from the Oslo Region, Norway* (Bruton and Høyberget, 2008).

In addition Magne has written several popular articles about fossils in local papers and the amateur magazine “Stein”. For almost ten years he has acted as the secretary for the Friends of the Paleontological museum (PalVenn) associated with the Natural History Museum (NHM) in Oslo. Magne has participated actively in the Spitsbergen expeditions to excavate Jurassic marine reptiles arranged by the NHM in Oslo and led by Dr Jørn Hurum. Magne is by natural disposition friendly and careful, and with calm, engaging enthusiasm for fossils. He is highly knowledgeable in the field of Scandinavian invertebrate and vertebrate palaeontology, and actively promotes collaboration between private collectors and professionals.

H. A. Armstrong
Secretary

ASSOCIATION MEETINGS

Progressive Palaeontology
Department of Earth Sciences, University of Bristol *26 – 28 May 2010*

Progressive Palaeontology is the annual conference for postgraduates who wish to present their results at any stage of their research. Presentations on all aspects of palaeontology are welcome. The meeting includes oral and poster presentations, the annual dinner and a field trip.

There are full details at <**http://www.palass.org/modules.php?name=propal&page=57**>.

International Palaeontological Congress IPC3
Imperial College & Natural History Museum, London *28 June – 3 July 2010*

IPC is a major international meeting held once every four years under the auspices of the International Palaeontological Association. The meeting provides a showcase for all that is exciting and new in the fields of palaeontology and palaeobiology. IPC3 in 2010 is hosted by the Palaeontological Association and partner organizations the Natural History Museum, the Palaeontographical Society and the Micropalaeontological Society. It will be based in Imperial College and the Natural History Museum in the heart of London's 'Albertopolis'.

The programme will comprise field trips, plenary lectures, workshops, contributed talks and posters, and thematic symposia, including:

- Comparing the geological and fossil records, and the implications for biodiversity studies
- Macroevolution and the Modern Synthesis
- The micropalaeontological record of global change
- The Great Ordovician Biodiversity Event
- Geomicrobiology at critical periods of Earth history
- Palynology and the Palaeozoic Earth system
- Biotic recovery after mass extinctions
- Microfossil contributions to understanding the tree of life
- Modelling the climate of Palaeozoic Earth
- Rates of morphological evolution in fossil lineages
- Molecular palaeobiology

The conference dinner will be held in the Central Hall of the Natural History Museum

For full details see the IPC3 website at <**http://www.ipc3.org/**>.

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

The 54th Annual Meeting of the Palaeontological Association will be held at Ghent University in Belgium, organised by members of the Department of Geology of Ghent University, in collaboration with the Department Géosystèmes of the University of Lille 1 (France), the Royal Belgian Institute of Natural Sciences (KBIN – Brussels, Belgium) and Kunsthal St-Pietersabdij (Ghent, Belgium).

The meeting will begin with a symposium on Friday 17th December entitled "Biological proxies in climate modelling" and followed by a drinks reception. The conference proper will commence on Saturday 18th December with a full day of talks and posters, the Association AGM and the Association Annual Address. In the evening there will be a drinks reception followed by the Annual Dinner. Sunday 19th will be a full day of talks and poster sessions. The time allocated to each talk will be 15 minutes; if too many abstracts of sufficient quality are submitted, shorter ten-minute slots are envisaged to avoid parallel sessions. A dedicated poster session will be scheduled. The meeting will conclude on Monday 20th December with a field excursion to the Mons Basin in South Belgium and a museum visit to the Royal Belgian Institute of Natural Sciences in Brussels (with the famous Iguanodons of Bernissart, collected from the area visited earlier).

Venue and travel

The conference will take place at two of Ghent University's conference venues (<**http://www.ugent.be/**>), right in the historical city centre of Ghent (<**http://www.gent.be/**>): the 'Aula' and 'Het Pand'. The 'Aula' is the University's official hall, and will be the venue for the Palaeoclimate thematic symposium and reception on Friday. The second venue, 'Het Pand', is the University's official conference centre, housed in a converted medieval Dominican monastery, and will be the site for the scientific sessions on Saturday and Sunday.

Transport into Ghent is easy, quick and affordable when booked early: travel times by train from London St. Pancras to Brussels South Station are now advertised as 1 hour and 51 minutes (weather permitting); Paris Nord to Brussels South is 1 hour and 22 minutes. Ghent station is a less than 30 minutes' direct train ride away from Brussels South station. Early booked return tickets from St. Pancras to Ghent are from €80 (or £55; current Eurostar fares). In addition, many (European) airlines fly directly into Brussels Airport, which is easily reached by train from Ghent Station (allow one hour). The city of Ghent has a good public transport network, allowing you to get to the hotels and conference venues very quickly and easily. Hotels in the historic city centre typically are within walking distance of these venues.

Ghent is an enchanting and vibrant city, which is often referred to as one of the most beautiful historic cities in Europe. From St Michael's bridge, literally two minutes away from the main meeting venue, there is a breathtaking view of the skyline of Ghent with the three impressive towers of St. Nicholas' Church, the Belfry with its bell tower and St. Bavo's cathedral, which houses the world famous painting 'The Adoration of the Mystic Lamb' by Jan van Eyck (1426–1432). Traces of the Middle Ages run through the city. The old port with its guild halls on the Graslei and Korenlei is merely one example of the beautiful sights this town has to offer. Not far from the Graslei arises the Castle of the Counts, once the medieval fortress of the Counts of Flanders. Nowadays it is a major tourist attraction. The Annual Dinner will be held in St. Pieters Abbey (Saint Peter's), one of Ghent's finer and better preserved historical buildings, housing the tombs of the first counts of Flanders.

Accommodation

Rooms in a variety of hotels at a range of different prices can be reserved through the usual channels. Most of them are in close proximity to the conference venues. The city also has a number of cheaper hotels and hostels. More information on these and alternative accommodation will be provided on the website in due course.

Registration and booking

Registration and booking (including abstract submission) will commence in June 2010. Abstract submission will close on Monday 6th September; abstracts submitted after this date will not be considered. Registration will incur an additional administration charge of approximately £20, with the final deadline of Friday 19th November 2010. The main conference lecture hall has a capacity of 350; the Annual Dinner venue holds c. 200 persons and the number of registrants will be capped at this figure, even within the registration deadline if necessary. Registrations and bookings will be taken on a strictly first come first served basis. No refunds will be available after the final deadline.

Registration, abstract submission, booking and payment (by credit card) will be through online forms available on the Palaeontological Association website (<**http://www.palass.org/**>) from June 2010. Accommodation must be booked separately and details will be placed on the website.

Programme

Friday 17th December 2010

- 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 (Kunsthal St. Pietersabdij)

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

The Palaeontological Association runs a programme of travel grants to assist student members (doctoral and earlier) to attend the Annual Meeting in order to present a talk or poster. For the Ghent meeting, grants of less than £100 (or the € equivalent) will be available to student presenters who are travelling from outside Belgium. The actual amount payable depends on the number of applicants and the distance travelled. Payment of these awards is given as a disbursement at the meeting, not as an advance payment. Students interested in applying for a PalAss travel grant should contact the Executive Officer, Dr Tim Palmer (<**palass@palass.org**>) once the organisers have confirmed that their presentation is accepted, and before 1st December 2010. Entitle the e-mail “Travel Grant Request”. No awards can be made to those who have not followed this procedure.

University of BRISTOL

PROGRESSIVE PALAEONTOLOGY

BRISTOL 2010

26th - 28th May 2010

Department of Earth Sciences, University of Bristol

Registration deadline: 14th May
Abstract submission deadlines: 30th April (Oral), 14th May (Poster)

The itinerary incudes an icebreaker, a day of oral and poster presentations, the annual dinner in the scenic Bristol harbourside and a field trip to Triassic fissure fills of South Gloucestershire, including the site of the famous Bristol Dinosaur, *Thecodontosaurus.*

Online registration, abstract submission and further information can be found at **<http://www.palass.org/>.** Contact the organisers at **<progpal@palass.org>**

The Bristol 2010 organising committee are: Aude Caromel, Roger Close, Alex Dunhill, Jenny Greenwood, Duncan Murdock and Rachel Warnock

news

Submit an article to Deposits *magazine:*

UKGE is a company based in Suffolk that has been expanding recently, and which sells kit for geologists as well as publications about fossils. It is one of our best outlets for the Association's 'Field Guides to Fossils' series.

In the last couple of years UKGE has been producing a full-colour magazine for collectors and enthusiasts called 'Deposits', which can be seen at <**www.depositsmag.com**>. It is produced quarterly and is starting to receive subscriptions from abroad. UKGE is eager to receive short articles on any palaeontological subject, and invites PalAss members to submit illustrated text to them. The contact is <**roybullard@ukge.co.uk**>.

TREATISE

on Invertebrate Paleontology

An important announcement to Palaeontological Association members from the Paleontological Institute

All Palaeontological Association members are eligible for a **20% discount** on any number of copies of the *Treatise on Invertebrate Paleontology*. In order to get this, members *must* go through the Palaeontological Association website and sign on in the Members Area. There, in addition to the Wiley Interscience and other links, there is a new link directly to the Paleontological Institute Treatise discount page for Palaeontological Association members. *Note:* Members cannot access this page directly through the Paleontological Institute website, but must go through the Palaeontological Association members page.

Paleontological Contributions

The Paleontological Institute announces the launch of a new online palaeontological journal

Paleontological Contributions succeeds the *University of Kansas Paleontological Contributions, new series*, which consolidated into one format the three series that were published previously: Monographs, Articles, and Papers.

Paleontological Contributions is an online-only, open-access, rapid publication journal, available free of charge to anyone with Internet access. *Paleontological Contributions* invites submissions that deal with all aspects of palaeontology or related biological disciplines. Original research articles and monographs are welcome. Systematic treatments, including descriptions of new taxa, are welcome, and *Paleontological Contributions* complies with the requirements of ICBN and ICZN for publication of valid nomenclature. Hard copies of each article are archived at libraries throughout the world. All articles are peer reviewed by at least two external referees, and reviews are assessed by Associate Editors, who make recommendations to the Editor. Reviews remain anonymous except where reviewers choose to identify themselves. Accepted manuscripts are published online via the Paleontological Institute website as Adobe Acrobat (PDF) files and are open access. Authors may make use of colour in their illustrations. There is no page limit for articles. Authors will be billed $30 per final PDF page, and offprints are available at cost price.

Please go to our web page at <**www.paleo.ku.edu/contributions**> for further information about the journal and submission guidelines and procedures.

The first article published in *Paleontological Contributions*:

PERRICHOT, V. 2009. Long-tailed wasps (Hymenoptera: Megalyridae) from Cretaceous and Paleogene European amber. *Paleontological Contributions* **1**, 1–35.

news

——OBITUARY——

Barrie Rickards
12 June 1938 – 5 November 2009

Barrie Rickards was a world-renowned palaeontologist; an expert on the palaeobiology of graptolites and their biostratigraphic use. He was even better known as an angler and influential fishing writer.

Barrie was born in 1938 on the eastern outskirts of Leeds. He went to primary school there and then in Hook, east Yorkshire. A boyhood freedom to roam over the Yorkshire countryside nourished a talent for observing, documenting and interpreting the natural world. Indeed, he was more interested in this outdoor education than in formal study, both at primary school and then at Goole Grammar School. He was more distinguished as a cross country runner and footballer, although he did show enough aptitude for chemistry to gain entry to Hull University. Here he chose to do Geology, getting his BSc in 1960. An undergraduate mapping project across the Dent Fault and Howgill Fells stimulated his interest in Early Palaeozoic fossils. This led to a PhD at Hull in 1963, for a meticulous revision of Silurian graptolites and their biostratigraphy. As his academic reputation grew, Barrie held short appointments at University College London, the University of Cambridge, the Natural History Museum, and Trinity College Dublin. He particularly impressed Oliver Bulman, the graptolite expert and Woodwardian Professor in Cambridge, who lured him back there in 1969.

Barrie spent most of his career in Cambridge, as successively Lecturer, Reader and then Professor in Palaeontology and Biostratigraphy. His work was recognised by the Geological Society with the award of the Murchison Fund (1982) and the Lyell Medal (1997), and by the Yorkshire Geological Society with the John Phillips Medal (1988). Barrie was Curator of the Sedgwick Museum from 1969 to 2000, and a Fellow of Emmanuel College from 1978. He had two spells on the Council of the Geological Society, and served also the Yorkshire Geological Society, the Palaeontological Association, the Ludlow Research Group, and the British and Irish Graptolite Group.

Rickards' internationally renowned geological research, published in over 275 papers and five books, focused on the palaeobiology of graptolites, collected by him in areas from Australia to Argentina and from Canada to Russia. He had a legendary ability to find distinctive fragments of these fossils in the field, even in unpromising rocks. He used their rapid evolution to accurately date and correlate Ordovician and Silurian strata. He used new technologies to shed light on the behaviour of graptolites. Working with doctoral students and young research fellows, Barrie used scanning electron microscopy to show that their skeletons were actively constructed by the colony of animals that inhabited them, meaning that they were more like floating beehives than typical shelly fossils. His collaborations on their hydrodynamics started with simple models in the Emmanuel College swimming pool before progressing to wind tunnels and computer modelling. His study of the enigmatic fossil *Promissum pulchrum* with Dick Aldridge and Johannes Theron found that, rather than being the oldest land plant as was previously considered, this organism was an exceptionally preserved conodont, consequently revealing the complete anatomy of this primitive vertebrate. Barrie taught geology with the same quiet enthusiasm that he researched it, being particularly influential with the many supervision students who passed through his care in Emmanuel, Christ's and Girton Colleges. He also set up the Cambridge geological mapping course in the Howgills Fells, and taught it for over 35 years, training over 1,500 students.

Barrie's activities as an angler even eclipsed those as a geologist. He wrote more than 800 fishing articles and about 30 books. Through his guides to fishing technique he taught a generation of anglers with the same skill that characterised his geological teaching. The two subjects also came together in his campaigning on environmental issues, particularly over drainage policy. He was an expert on fisheries management, and managed a succession of lakes and rivers. He was a scientific adviser to the Anglian region of the Environment Agency in the 1990s.

Barrie was by birth and character a Yorkshireman, though never a parody of one. He was generous to others but thrifty in spending on himself: he used the same trusted rucksack and Barbour jacket for over thirty years. He liked proven technology, preferring his Morris Minor to other cars, and the pen to the computer keyboard. He could be confident and forthright, but was more naturally gentle and shy. His friends will remember him for his integrity, honesty, and an infectious sense of humour, there till the end. Barrie's only son Jeremy died in 2000. He is survived by his partner Mandy Lyne, step-daughters Rebecca and Louisa, and granddaughters Fern and Alice.

Nigel Woodcock and Alex Page

From our Correspondents

Of Barrie and Barrande

They are probably the best palaeontological meetings in the world (a subjective view, most assuredly, and thus assuredly correct). The cast is not, emphatically, of thousands. Between three and fifteen, generally, not counting animals and children. There is never a registration fee. None of those little plastic-covered badges are ever given out at the desk. There is, in fact, no desk, but even if there was a desk, badges would still not be given out – ever – on grounds of principle. There is no book of abstracts, to be filed away afterwards in the perpetual darkness of the never-to-be-opened-again box file. There has never been a keynote speaker – though there have been many invited speakers. Indeed, everyone is invited to speak, at the drop of a hat.

There is no protocol, no procedure. The agenda is typically improvised, and occasionally followed. There are assorted hangers-on and family to bulk up the numbers (and if aged eleven-and-three-quarters or so, to power up a computer or projector that a century's accumulated wisdom has found itself powerless in front of). There is also Lunch, which is treated with suitable seriousness, and which often has provided its own inspiration. As when, say, Adam Urbanek arrived one year from Warsaw bearing bottles of vodka to wash down the bread rolls and cheese; it would have been discourteous to refuse, naturally, for this meeting has traditionally been imbued with a quite unusual amount of inter-cultural tact. Or when Noel Dilly hosted it, at St. George's Medical Hospital, and provided a case of wine to encourage the fiery muse – that then dutifully, if unsteadily, ascended to the brightest heaven of invention.

This is, of course, Big G, aka BIG G or sometimes BIGG – the synonymy follows its own several logics – that stand for (uniquely, you will be relieved to hear) the British and Irish Graptolite Group, a bi-yearly gathering of the palaeontologists who study, for their pains and occasionally their pleasure but with undiminished fascination, this enigma of the palaeo-plankton. It is, of course, a thoroughly practical acronym, conveying the united-but-separate character of these islands. But it has also, typically, the most delicate tinge of *double entendre*, hinting perhaps at the generous *embonpoint* of that redoubtable graptolite worker Gertie Elles in her later years, as can be seen in the succession of photographs of the denizens of the Sedgwick Museum, Cambridge, as they trace through the middle part of the last century.

It has been something of a slowly diminishing gathering of graptolithologists, has BIG G, for while the palaeontology of the Remarkable Specimen and of the Grand Idea has been going from strength to strength, that of the humble study of the Ordinary Fossil, and of what it should be called *exactly*, and of *precisely* when it lived, has been in something of a gentle decline. And now it is grievously diminished, for no more will here be the genial presence of Barrie Rickards, who started this micro-community, and who kept it going year after year, who chaired the Big G – though the word chairing does not quite precisely convey the alchemy by which Barrie steered (no, not quite), directed (certainly not!) encouraged (closer) or perhaps *nudged* the ensuing discussions.

Big G is (one must now fight off the impulse to say 'was') a community that strove – no, not quite the right word, but one might try 'had a fancy' – to punch above its weight, which was and is a featherweight, always, as far as numbers went. In its history it plotted, and produced, something that might be regarded by most impartial observers as that most clear contradiction in terms (like the bumblebee that shouldn't fly but does): a popular book on graptolites (Palmer and Rickards, 1991). Retailing at the king's ransom, then, of £39.95 for a handsome hardback, it somehow sold out (almost: the last unsold copy remains in the BIG G vaults). And there was more of this quixotry. A teaching pack on graptolites, say, in the pre-electronic format of 35mm slides and ring-bound notes. A plan to redraw all of the type specimens of graptolite species, which like all Big G plans is evolving with the same almost imperceptible rhythm (in real time, year by year) as did the graptolites themselves (or rather, the more sluggardly of them, truth be told); this is, naturally, reality taxonomy for the modern age, a form of minimalist performance art. For there's more to the meetings, also, than science (or indeed, than lunch), with the artist Paul Rosenbloom being a recent stalwart attendee; his paintings of graptolites have been exhibited – he's justifiably proud of this – alongside Da Vinci, Dürer and Turner.

Big G, or BIG G or BIGG, of course, is hopelessly out of kilter with the modern scientific ethos – but that then was a measure of the man, and all the more reason why his passing (all too soon; he was 71) is to be mourned. He was justifiably proud of his academic oeuvre, not least because he had thought through so many aspects of graptolites that when we tyros, young and green, thought we had come up with some amazing new Hypothesis or other, he would gently direct you to Rickards 1979c (say), published in the *Proceedings of the Yorkshire Geological Society* where that very point had already been identified, mused upon, and chewed through. And of course it likely was in the *Yorkshire* or some such, because he regarded those as serious and solid journals where one had the space to write a proper description and provide a full illustration of a new species (and spoke somewhat disparagingly of *Nature*, for instance, seeming to regard it as a flashy fly-by-night organ whose fashionable content mostly wouldn't last). And he regarded the Gadarene rush of academics towards high-impact-factor journals with something approaching horror, for, of course, this is killing off the local, non-prestigious journals that form the bedrock of the science.

And here, of course, objective memory gets fatally tangled with personal prejudice, with my own suspicion that this whole impact factor business, and all that surrounds it, is deeply corrosive, long-term, to the science. It is squeezing out the smaller and regional journals, for one, and arguably these form the essential foundations to the upmarket end of the science. And it is encouraging the ever-greater use of hyperbole, the squeezing of every last drop of significance from what might be, at heart, the usual motley and variously-behaved accumulation of data, with all the ambiguity that comes hand-in-glove with the imperfectly preserved remnants of an unimaginably long and ferociously complicated Earthly past.

At times it seems that, driven by the exigencies of the latest Research Assessment Exercise, some of the tales – scientific hypotheses, that is – that we spin are encouraged to stretch just as high as (and sometimes just a little higher than) the evidence will bear. The tales are stretched, too, into global reaches (heaven forbid that their significance be only local). The foundation on which these hypotheses are spun, meanwhile – of stratigraphy, of taxonomy – becomes a little more tattered and threadbare each year. And it is harder, today, to justify simply going into the hills to put together the basic information on which all such tales must be supported – and put it together *for its own sake*. The devil lies in the detail always (the sound of a squadron of grandmothers energetically sucking eggs will now, hopefully, be becoming deafening). Hence, one must forever go back to the rocks, extract the fossils from them in quantity, and interrogate them as much for the stories that they inherently contain, as for those that we had fixed in our crania at the outset.

Barrie squared this particular circle by regarding the latter as possessing four right-angle corners from the beginning, and apologised not at all for doing so. He was simply interested in graptolites for their own sake: in their evolution, their biology, their taxonomy, their stratigraphy, their ultrastructure. It's a particular way of doing things, of going about the science of palaeontology. There's no side to it, no calculation, no strategic calculation of imputed (or trumpeted) social relevance, or any wish to Think Big as regards the Really Really Important Scientific Questions. Barrie was interested in graptolites, and got to know them better, I think, than any other person of his generation. Narrow, perhaps? If so, it's a narrowness that one could do with more of, these days.

He was a field man – another trait that is becoming progressively more old-fashioned. His trajectory in this was a little differently shaped to that of most geologists (we are talking about the days when fieldwork was still routinely part of geology, mind), where the svelte and wiry youngster slowly mutates into comfortable beery rotundity. Barrie, when I first got to know him three decades back, was a field man, but a generously proportioned one – and then he took to – or rather went back to – running (to the level of a sub-three-hour marathon). Well into his retirement, he could, on field trips, comfortably outpace the average undergraduate across the Sedbergh hillsides. And, of course, he could find graptolites. His approach was splendidly direct. If there were some Early Palaeozoic marine strata that hadn't yet yielded graptolites – well, that was because nobody had properly looked before. Barrie *could* look properly, and had both skill and patience with the hammer. A fine example was his campaign, a few years ago, on the type Ashgill rocks of the Lake District (Rickards 2002): these had been known since the early days of geology as the repositories of a fine assortment of shelly fossils – trilobites, brachiopods and suchlike. And of course shelly strata are not supposed to contain much in the way of graptolites. Barrie's campaign on these rocks, though, turned up hundreds of specimens and dozens of species; his analysis and correlation of these newly liberated graptolites at the time seemed a little quirky (that Yorkshire element, perhaps); but as time passes it seems to be holding up remarkably well.

Barrie went into graptolite studies – and indeed into academia – entirely by accident, it seems. His schooldays, I understand, were unsullied by an excess of formal academic striving or achievement (a 'distracted pupil' of Goole Grammar School, as his *Times* obituary put it), being devoted to exploring the local countryside and to fishing. He was kept on at sixth form because he was good at running, developed an aptitude for chemistry, and somehow, at Hull University, that evolved into a PhD on graptolites, a passion that from that time ran parallel (though was often secondary, depending on the season) to that for fishing.

It is the end of an era, not least at Cambridge, where graptolite studies spanned a century or more from Gertie Elles through to Bulman and then Barrie. It is a chain that is now broken. It's a moot point whether the leading research strategists of our times regard this as being at all important. But there's a longer chain present here too, though; one that spans, if not the world, at least the Europe (*sensu lato*) of the last couple of centuries. It's one that creates a touch of assonance – entirely coincidental and without a shred of deeper significance, one must emphasize – in any potted history of graptolite studies. And it's just an excuse, naturally, to meet an ancestor among the practitioners of one's science. And to ponder on the quirks of coincidence.

For there was Barrie, an accidental gift, as it were, to graptolite studies. And then there was Barrande, near the other end of the temporal chain of this science. It's not quite at the other end, for there was Linnaeus arguably occupying that position, coining the name *Graptolithus*, one that he ascribed to markings on the rock that looked like fossils but were not; the start, perhaps, of the bad press that these unfortunate hemichordates have received ever since.

Joachim Barrande helped found the science in Bohemia, and this was another chance by-product of historical happenstance, albeit on a rather greater scale. It was French politics, at the highest and sharpest levels, that shaped his career in palaeontology. Barrande was one of the great names of this discipline, and a set of (broadly) biographical discussions were published following a meeting dedicated to him on the 170th anniversary of his birth, with various accounts of his life and work by the likes of Boucek, Regnell, Bout, Plas and Whittington (though the meeting itself was interrupted by the events of the Prague Spring in 1968). I happened on these reminiscences (a personal copy of Peter Sylvester-Bradley's that turned up during a departmental spring clean, of *Casopis pro mineralogii a geologii*, vol. 15, part 1, written in a beguiling mixture of Czech, French and English, and with a cover of shocking yellow) from which the following account is largely plundered. Happenstance once again, you see.

Barrande was born in 1799 in the village of Saugues in the Haute-Loire of France (now a village with some local fame, boasting the fourth largest sheep market in France). He seems to have been assiduous from the beginning, studied in Paris, became a civil engineer, came to the notice of the royal family, and was appointed as the personal teacher of Henry of Artois, the Comte de Chambord and grandson of Charles X.

Association with royalty can be a mixed blessing, then as now. In 1830 came trouble in the form of the July Revolution, and the king was overthrown. Charles X had the initial disadvantage of being a hereditary monarch of the old school, when the events of 1789 had definitively changed the relationship between the French people and the aristocracy. On top of that he seemed to have a singular knack, even in his five-year reign, of alienating public opinion. He introduced the death penalty for profaning the Catholic host, for instance, and proposed laws to provide financial indemnity to those who were on the losing side in 1789. His popularity dropped like a stone, among both the people and the sizeable left-wing section of the Chamber of Deputies. He saw this, and in the time-honoured style of a beleaguered monarch, lit the blue touch-paper by setting out the decrees of the July Ordinances – suspending press liberty, dissolving that troublesome Chamber of Deputies, and so on.

Before a week was out he was gone. The first day after the Ordinances were published there were (now illegal) radical newspapers streaming out, and an uprising that soldiers tried to quell, with 21 civilian deaths. The riots lasted well into the night (helped by previous municipal thoughtfulness, the new invention of street lamps, though these were ultimately smashed in the melee too). The second day, there were edgy and inconclusive talks between Charles' representatives and protestors; Charles himself was away from the action, in the relative security of Orleans. The third day, there were some 4,000 barricades in Paris, revolutionary tricolour flags flying above. The Louvre fell to the crowds (who nevertheless protected the paintings and sculptures in them from looting and vandalism), then the Tuileries, the Palaces of Justice, the Hôtel de Ville (not a hotel, but the administrative centre). Hours later, liberal politicians came in on the shirt-tails of the uprising, and established a new government. Charles was replaced by his cousin Louis-Philippe – but in a monarchy that was now constitutional, not hereditary. Charles and his family went into exile. The faithful Barrande went with them, first to England, then Scotland, then to Prague.

Barrande remained faithful to the monarchy all his life, but in Prague lost his position as personal teacher to the family. He was a victim of court intrigue, being accused of being too liberal and progressive to have entrusted to him the education of the (ex-) king's nephew (quite unjustly too, for Barrande was a royalist to his boots and remained one all his life). The aristocracy's loss was palaeontology's gain, for Barrande went back to being an engineer, and in particular on the railway system as it was constructed around Prague. But he never lost the trust of (or ceased to support) the ex-king Charles.

He found some trilobites that intrigued him and … well, that pretty well decided the course of the rest of his life. The discovery fell on prepared ground. In Paris, he had gone to lectures by Cuvier, d'Orbigny, Brongniart and others. In Prague he had got to know Sternberg, founder of the National Museum and other savants. He knew his fossils to be 'Silurian' (of Murchison, that is, and now Ordovician to us). They were worth further study, he thought. And so they were.

This further study used up all of his spare time, and resources (austere and self-disciplined in daily life, he never took a wife, marrying palaeontology instead, and he stayed faithful to this lovely if stony-hearted mistress for the rest of his life). He approached his new passion with military organisation, hiring a network of collectors to augment his own collecting. By the end of his life there had appeared the fruits of his labours (and mostly funded from his own resources) – 22 volumes of the *Silurian System of Bohemia*– with 6,000 pages and 1,160 plates, describing trilobites, cephalopods, brachiopods, graptolites and others (and after his death his will provided for further volumes dealing with gastropods, echinoderms, corals, bryozoan). The productivity was extraordinary, even in a profession where assiduity is the norm. To study the development of just one species, the trilobite *Aulacopleura konincki*, Barrande obtained some 6,000 specimens of this species (and to similarly pin down *Sao hirsuta* he employed up to four workmen for several years. But his first monograph, a small one by his standards, was his *Graptolites de Bohême*.

So, Barrande was a determined man, to an extreme degree, obstinate in pursuit of his goals, and obstinate as regards the wider scientific context of his work. He was comfortable with facts, and collected them hugely ('C'est ce que j'ai vu' was what he wrote at the front of his great work), while theories were 'in the sphere of the imagination'. His two great influences were Cuvier and Brongniart. Faithful to Cuvier (and perhaps also partly because of his strong religious faith), he resisted Darwin's revolutionary ideas to the end, saying that he could find 'no trace' of evolution among his beloved Silurian fossils (though Darwin cited Barrande several times in the *Origin of Species*, saying of him that 'a higher authority could not be named').

In place of dangerous theory, he had 'observed facts' – one such being Cuvier's catastrophes. Another of these was one of his very own confection, a particular idea largely involving what were, in truth, bit players on Barrande's vast palaeontological stage, the graptolites. This was his idea of 'colonies'. This was not the interpretation of fossils themselves as colonial. Rather it was his view that assemblages of fossils could become locally extinct in a region as a result of some catastrophe (Cuvier's influence, again), to be replaced by another – only to return once more when conditions changed again. Not a daft idea, at all, and originally supported by the likes of Lyell, Murchison and Suess. Alas, in this case it was wrong, and demonstrably wrong. Others came to look at the field evidence, and suggested (much as Lapworth was doing in Scotland) that the reason for this interleaving of fossil assemblages was tectonic, with repetition of them by faulting or folding.

Barrande would have none of this. As stubborn in his attachment to his colonies as he was in organising his vast collecting campaigns, he wrote – was provoked into writing – several volumes that he titled *Défense de Colonies*. He was not a man who willingly let opponents emerge unscathed, and pounded them mercilessly and scathingly if any of them made a mistake. Not a good man to cross, therefore – though that is not at all to say that he did not possess many good (and human) qualities. Collectors who worked for him reminisced fondly of him. Barrande was not altogether insensitive to the fair sex – one collector remembered how he spoke about "nice girls met on their strolls when out looking for 'crayfish'"; and he named fossils such as *Mila delicatula* ('the delicate fair lady') and *Panenka amabilis* ('the affectionate girl', not to mention *Nevesta vendita*, a direct reference to Smetana's opera *The Bartered Bride*). He did not put on airs and graces, either – and indeed refused official honour (such as the freedom of Prague) towards the end of his life. He could be generous and hospitable to a fault. He liked his adopted country to the extent that, for all that he was a confirmed royalist, during the 1848 insurrections he put his fossil-boxes at the disposal of his neighbours as barricade-material.

But the 'colonies' (that he never renounced) dogged him all his life. In 1879, the 22-year-old John Marr, fired up by the work of Lapworth, visited the 'Barradeum' of Bohemia to see the famous rocks first-hand, and called on Barrande himself, now an old man in his eighties. In the field he was guided by Barrande's secretary – and made observations that fatally wounded the theory of colonies. Barrande afterwards wrote of Marr's 'deplorable pleasure trip' and of 'a … fabrication unworthy of a respectable geologist'.

Barrande lived well out of my time. I prefer that my time overlapped with Barrie. They were both field men, but Barrie was the more … *singular*. He did all his field work himself, not having a small army of collectors to call on (although the Sedgwick Club could occasionally be cajoled into a mass graptolite-collecting exercise), so he got to know the rocks at first hand. My last memory of him is of his last BIG G meeting, in Cambridge. Now in a wheelchair, and having for quite a while spent more time in hospital than out of it, he was nevertheless full of plans and ideas. What is more, he had, over those past few months, done more work on graptolites than the rest of us put together. Characteristically he had been following a personal and deeply unfashionable enthusiasm, for the benthic dendroid graptolites. Useless, morphologically nondescript things? Well, here was Barrie pointing out quite new thecal morphologies, convincing-looking stratigraphic lineages, rescuing these hemichordate orphans from long obscurity. He worked to the end, and in a style quite his own.

And – perhaps most important, even these days – his considerable measure of achievement came together with a great deal of likeability. Barrie could take to an academic disagreement with as much vim as the next person, but there was also a feeling of the limits to which this might extend. For instance, the views he had on how graptolites lived mostly did not chime with those of the remarkable Nancy Kirk, who certainly could express herself forcefully in print (I bear a few scars myself). But when he was assembling the world's only popular book on graptolites, the dedication was to … Nancy. There's more to life than monographs, indeed.

Jan Zalasiewicz

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PalaeoMath 101
Shape Models II: the Thin Plate Spline

In the last column we developed a simple method for expressing the results of complex, multivariate, geometric morphometric ordinations as form and/or shape models. These were configurations of landmark points that exist at discrete coordinate locations in the multivariate linear spaces we typically use in geometric morphometrics to portray similarities and differences in the form and/or shape of a sample of specimens. In this column we're going to develop a more mathematically sophisticated way to do the same thing that, at least on a superficial level, makes connection with the 'deformation grid' approach to shape modelling developed by D'Arcy Thompson in his classic treatise *On Growth and Form* (1917, 1942). But before we get into the mathematics of this, now conventional, approach to expressing the results of a comparison between forms/shapes, and to avoid later confusion regarding the degree to which this convention realizes the Thompsonian ideal, it's worth taking a moment to review what Thompsonian transformation grids are and why they were developed.

In his original (1917), and in the later, expanded (1942) edition, Thompson's goal was to "correlate with mathematical statement and physical law certain of the simpler outward phenomena of organic growth and structure or form while all the while regarding the fabric of the organism, *ex hypothesi*, as a material and mechanical configuration" (Thompson 1917, p. 17). In other words, Thompson sought to "see how, in some cases at least, the forms of living things, and of parts of living things, can be explained by physical considerations and to realize that in general no organic forms exist save such as are in conformity with physical and mathematical laws" (*ibid*, p. 15). Thompson was, of course, aware of evolutionary theory and agreed that natural selection operated to sort mechanically efficient from inefficient forms in the manner Darwin had suggested. But he bridled at the idea that every aspect of a form is now, and always has been, under direct adaptive scrutiny, preferring to believe that some aspects of form owe their origin to the physical forces with which they must contend.[1] Thompson saw organic form as a 'diagram of forces' from which inferences can be made regarding the nature of the forces that act upon it now or that have acted upon it in the past. Using this force metaphor, Thompson saw the mathematical comparison of forms as a way of deducing how these fields of forces changed during both ontogenetic and evolutionary history.

Thompson's proposed method of force-field analysis was to take two simple line drawings of species' bodies or some corresponding structural element therefrom (*e.g.*, copepod, ungulate cannon bone, leaf). For convenience we'll label one form as the 'reference' and the other as the 'target'. In order to better visualize the nature of the geometric transformation Thompson superimposed a rectilinear grid on the reference form. He then worked out simple sets of mathematical transformations that would map point location coordinates of the reference into topologically corresponding locations on the target. Applying those same mathematical transformations to the coordinate locations of the grid vertices Thompson obtained a striking image-based summary of the implied geometric transformation (Fig. 1).

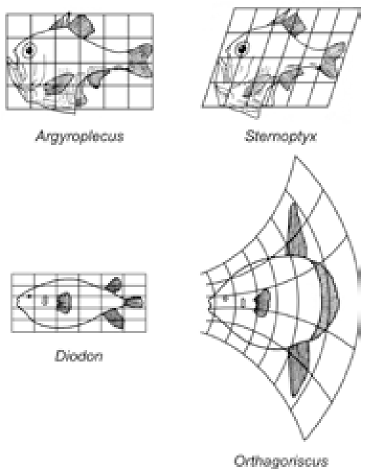

Figure 1. Example Thompsonian transformation grids specifying uniform (upper) and non-uniform (lower) transformation functions. For each comparison the reference form is located on the left and the target form on the right. Redrawn from Thompson 1917.

It is clear from Thompson's many statements throughout the last chapter of *On Growth and Form* that he regarded the mathematical transformation as pertaining to, and being constrained by, all mathematical points comprising the line drawing and that he respected the principle that biological homology pertained to structures, but not necessarily individual point locations on structures. Rather, it was the configuration of the entire ensemble of mathematical points—

[1] In this view Thompson perhaps reflects the same level of discomfort with hyperadaptationist arguments criticized more recently by Gould and Lewontin (1979), among others.

represented diagrammatically by the superimposed grid—that he looked to in judging whether he had devised biologically reasonable formulae for a particular form transformation. Similarly, it is clear the only purpose served by the mathematical grid was to passively express the overall geometry of the transformation in the manner of a deformed, map-like coordinate system.

As illustrated in Figure 1, Thompson used his approach to provide examples of both linear (uniform) and non-linear (non-uniform) transformation modes. Like the later 'relative growth' studies of Otto Snell, Julian Huxley and Georges Teissier (see below), the thing that impressed morphologists about Thompson's transformation grids was the fact that seemingly complex form changes appeared to be able to be described accurately by simple mathematical transformations applied consistently to all point locations over a form. This suggested to many at the time that the underlying principles and/or determinants of morphological changes might be simple when expressed in, or studied using, the language of mathematics.

While Thompson's transformation-grid approach resulted in the creation of compelling diagrams—so much so that both his original set of drawings and many subsequent variations of them have been reproduced in countless books on biology and evolution, despite the fact that the physical-force theory these drawings represent is almost never discussed in those same texts—his geometric approach to the analysis of form never caught on during his lifetime. Thompson himself provided some guidance regarding how to operationalize his transformation grids, which he thought of as a visual tool akin to a modern-day spatial morphing algorithm. Those algorithms subdivide an image into a set of points and then smoothly map a subset of these between a reference and a target form with their difference displacements informing the displacement of intermediate points via simple linear interpolation. For example, it is this linear interpolation approach to transformation grid analysis that Thompson used to create his morph-like model of the complex geometric transition between *Hyracotherium* and modern-day *Equus* (Fig. 2).

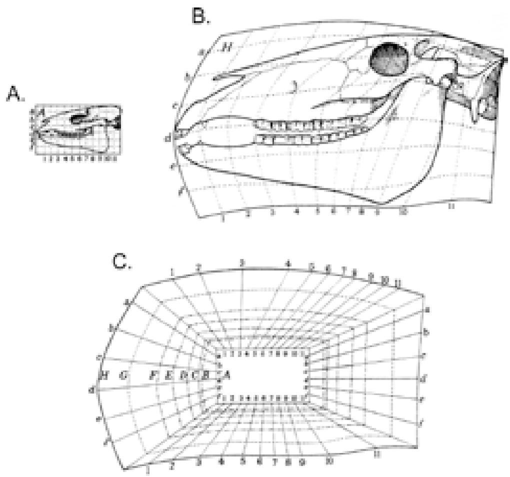

Figure 2. Thompson's transformation grid analysis for the transition from the Eocene Hyracotherium *skull form (A) to the modern* Equus *skull form (B). Note the representation of hypothetical intermediate stages of the transformation via linear interpolation (C). From Thompson 1917.*

Although Thompson's original, interpolation-based approach to the realization of transformation grids was fine if all you wanted to do was map one form into another, it was not well suited to the summarization of geometric information across a larger sample of data. Arguably Huxley (1924) and Teissier (1929, see also Snell 1892 and Huxley 1932) were more successful in developing an analytic approach to the general problem of form variation than was Thompson. But the logistic regression equations used by students of relative growth—or allometry in modern parlance—were not used to create graphic models of form change with anything like the visual impact of Thompson's grids.

Curiously, this failure to capitalize on the modelling capabilities of regression-based methods when treating morphological data remained in place for a half-century during which time Huxley and Teissier's bivariate regression-based approach to form analysis was extended to the multivariate case (*via* PCA, see Jolicouer and Mosimann 1960), and holistic modelling approaches were developed for other aspects of morphological analysis (see Olson and Miller 1958). As we have seen in the last column, all the mathematical machinery for implementing at least some aspects of useful geometric shape modelling was in place by the 1960s. Yet, no new developments in this area took hold until the 1980s despite a few attempts to formulate an explicitly Thompsonian modelling approach in the form of morphological trend surfaces (Sneath 1967) and biorthogonal grids (Bookstein 1978).

In retrospect there appear to be two reasons for this. The first was that the largest school of morphometrics (multivariate morphometrics) tended to look to the communities of statisticians and psychometricians for methodological guidance, neither of which were particularly interested in creating morphological models. The second was that, ever since the 1930s, the tradition in bivariate and multivariate morphological studies was to analyze pairs or sets of distances between landmark locations rather than configurations of Cartesian coordinate locations scattered over a sample of forms. Once the power of shape coordinates had been established by Bookstein (1986) and the outlines of shape theory had begun to emerge (see Kendall 1984), the stage was set to renew the search for an analytic method that could combine the intuitive appeal of Thompson's transformation grids with the equally popular, and far more powerful, tools of multivariate morphometrics. The key insight that allowed this new approach to shape modelling to be realized was specification of a new spatial metaphor for shape similarity.

In traditional multivariate analysis the similarity between two objects is quantified by calculating the distance between them across all variables. This is fine for a quick-and-dirty summary of form differences, but lacks the ability to track varying patterns of size/shape similarity and difference in different regions of the forms. In the days when morphometricians characterized forms using sets of linear distances between landmarks, this distance-based metaphor seemed both natural and practical. After all, distances are simply magnitudes. There is no information about geometry in a list of distance values. Since geometry can't be reconstructed precisely from a table of distance values there wasn't any point in worrying about shape models. But with the move to characterizing forms using the coordinate values of the landmarks themselves—and especially the transformation of landmark coordinate values to *Procrustes* shape coordinate values via standardization for position, scale, and rotation—it became possible to represent the form and shape similarities or differences between any two objects precisely in a manner that retained the fundamental geometry of the landmark configurations.

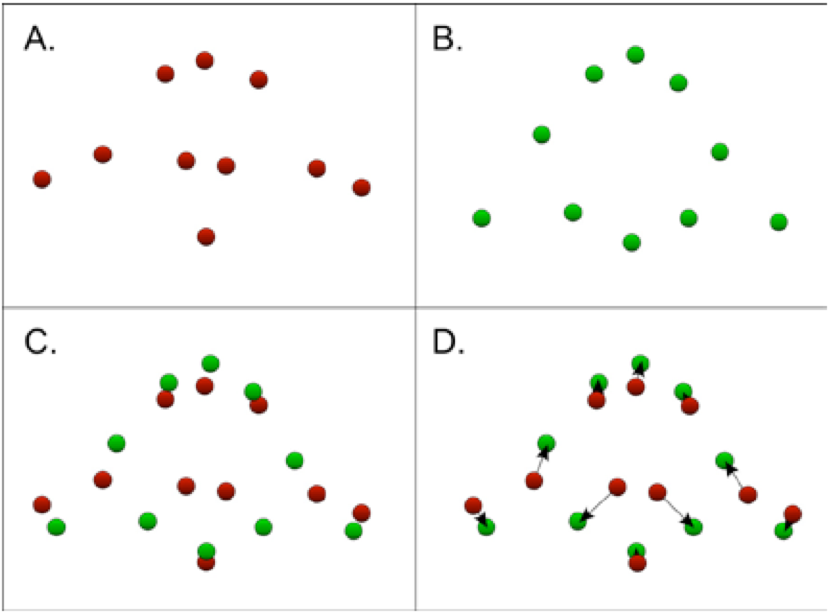

Figure 3. Stages in the landmark-based comparison between shapes. (A) Cranidial landmark configuration for the trilobite genus Acaste. (B) Cranidial landmark configuration for the trilobite genus Calymene. *(C)* Procrustes *superposition of the* Acaste *(red) and* Calymene *(green) shape coordinates. (D) Shape difference vectors between corresponding reference (red) and target (green) shape coordinate locations. See text for discussion.*

Imagine two forms defined by corresponding sets of landmark coordinates. As above, we'll call one the reference form and the other the target (Fig. 3A-B). *Procrustes* superposition of these landmark sets transforms the forms into shapes and brings corresponding landmarks into positions of maximal correspondence (= minimal sum of squared deviations, Fig. 3C). The differences between the reference and target shapes can be visualized as a set of difference vectors between the reference and target shapes at each coordinate location (Fig. 3D). Now, rather than summing these differences up to produce a statistical estimate of shape-difference as we'd do in traditional multivariate morphometrics, let's select the reference shape and express the difference between it and the target shape as a set of vectors with the same displacement as in Fig. 3D, but rotated such that the difference vectors are parallel to the *z*-axis of a three-dimensional coordinate system. In this system the *z*-axis expresses the shape difference between the reference and the target. The resulting figure (Fig. 4A) expresses the shape difference as a set of stalks at each landmark location. Either the reference or the target shape can be used as the basal shape for constructing this sort of shape-difference diagram. Note that the geometry of the landmark configuration is retained in this graphic expression of shape difference and that we can easily identify which regions of the two shapes are more similar to, or more different from, one another.

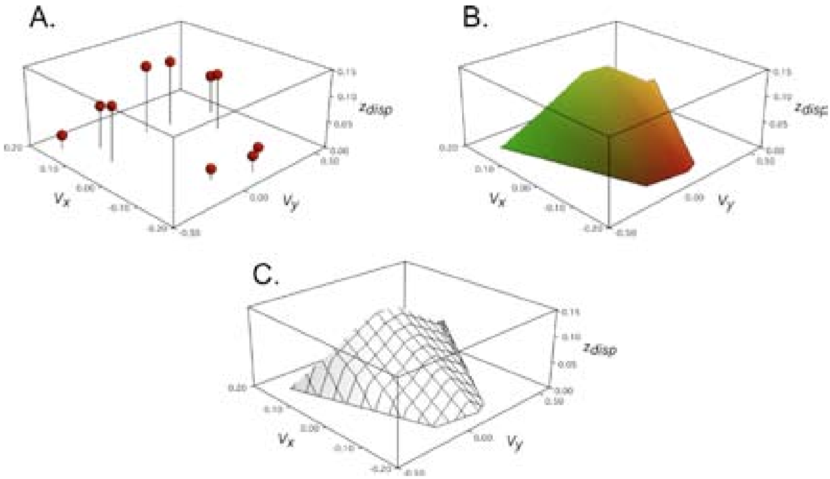

Figure 4. Shape-difference diagrams between the Acaste *(reference) and* Calymene *(target) cranidial landmark configurations. (A) Rotation of the reference-to-target shape-difference vectors shown in Fig. 3D to the z-axis to form a three-dimensional representation of shape difference. (B) Spline-estimated surface of the shape-displacement data with colours representing regions of differential curvature. (C) Same spline surface as in B, but this time with the surface represented as a deformed rectilinear grid. In all three diagrams the reference configuration was used as the basis for the shape-difference graphic.*

Although the only information about shape similarity and difference present in the diagram is located at the landmark locations, we can nevertheless summarize the general character of the shape transformation by fitting a mathematical surface to the ends of the difference vectors. Because the differences between the shapes are not the same in all parts of the form constrained by landmarks, this surface usually (but not always) has the character of a set of folds or warps, the tightness or looseness of which typically vary over the landmark set (Fig. 4B). These days, through the magic of computer graphics, we can characterize the geometry of these folds in many different ways using contour lines or various shading schemes. But in simpler, less technology drenched times, the standard way of representing a contorted mathematical surface was as a deformed rectilinear grid (Fig. 4C). The resulting diagram summarizes the differences between the shapes of any two shapes in a manner that bears a strong, but superficial, resemblance to a Thompsonian transformation grid.

The surfaces shown in Figures 4B and 4C are standard parametric cubic splines. These aren't terribly useful for summarizing shape difference because they specify elastic deformations in which the shape of the underlying mesh, when viewed from the direction of the shape-displacement (*z*) axis, is held constant. This amounts to an isomorphic projection of the 3D mesh onto the *x,y* plane. Instead, the surface interpolation method of choice among morphometricians is an advanced type of polyharmonic spline called a thin plate spline (TPS, see Duchon 1976, 1977). The TPS attempts to mimic the behaviour of a defect-free, uniform, and infinitely thin metal plate that is bent in the *z*-direction to conform to the geometry of the shape-displacement vectors. This metal-plate metaphor is important because, unlike elastic surfaces, metal plates bend in ways that minimize the energy required to achieve the bend in all directions over the entire plate. In applying this physical metaphor to shape analysis, the TPS represents the surface of minimal bending energy implied by the transformation of one shape into another.

Before we get into the equations for calculating a TPS surface let's understand what we mean by deformation. There are two broad classes of possible geometric deformations. These go by various names. Uniform deformations (also called affine or linear) include all modes of deformation in which lines that are parallel prior to the deformation remain parallel after the deformation. There are six types of uniform deformations (Fig. 5).

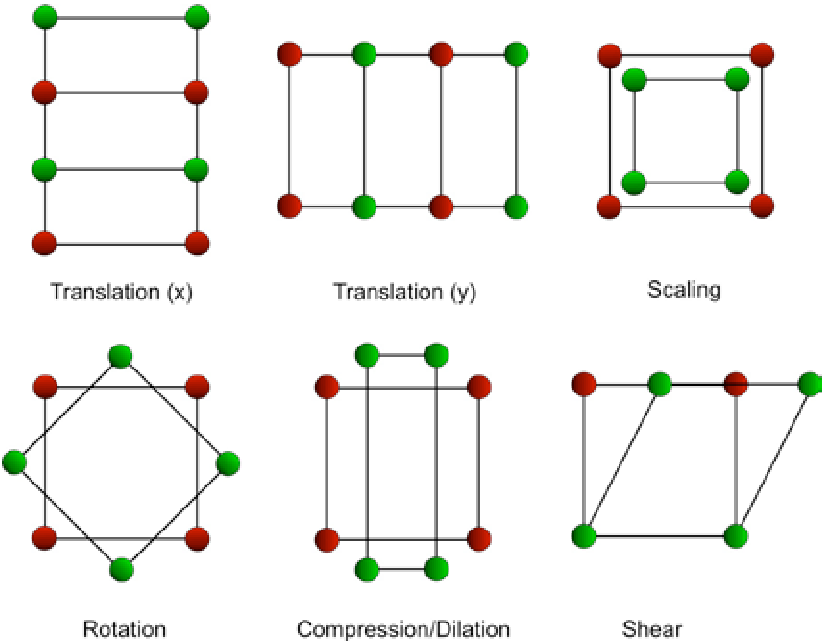

Figure 5. Alternative modes of uniform shape deformation.

Among these you'll recognise the deformation modes that are corrected during *Procrustes* superposition. Nevertheless, the compression/dilation and shear modes can be used, or combined, to describe aspects of genuine shape change.

As for the 'other' category, it's usually referred to as a non-uniform deformation in the morphometric literature, but can also be termed a non-affine or non-linear deformation. These are deformations in which lines that are parallel prior to the deformation are not parallel after the deformation. Examples are numerous, but the simplest is the so-called 'square to kite' deformation (Fig. 6).

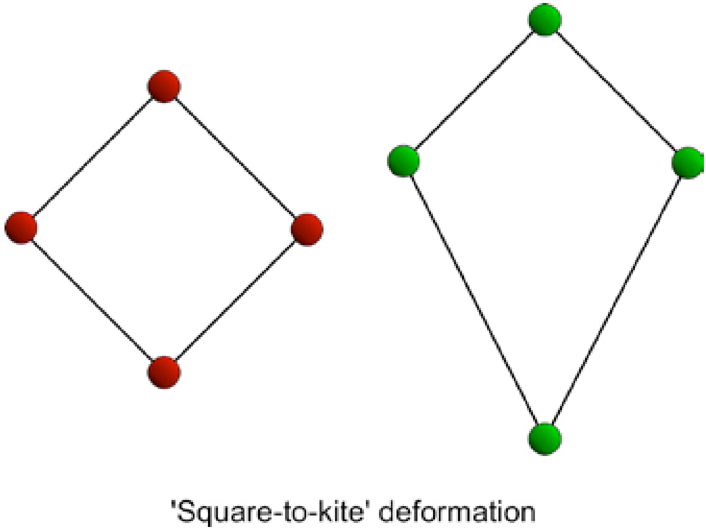

Figure 6. One simple example of a non-uniform shape deformation.

Most 'real-world' geometric deformations are combinations of uniform and non-uniform deformation modes. This is certainly the case for the deformation implied by the *Acaste* and *Calymene* shape coordinate sets shown in figures 3 and 4.

With our goal of representing shape transformation as a thin plate spline in mind, and with an appreciation of the fact that this spline is (likely) going to be composed of both uniform and non-uniform deformation modes, we're now in a position to begin a (very generalized) discussion of TPS mathematics. Since we're going to be minimizing the hypothetical bending energy in the specification of our shape transformation surface, we're going to need to calculate an index of bending energy at each landmark location. The first step toward this is achieved by the following equation.

$$U\left(r_{ij}\right) = r_{ij}^2 \ln r_{ij}^2 \tag{19.1}$$

Here the value r^2_{ij} is the square of the distance between landmarks i and j in the set of shape coordinates for the reference configuration and $\ln$ is the natural logarithm function (base e). This calculation quantifies the relative amount of 'energy' required to achieve a bend between all pairs of landmarks. The spacing of landmarks represents an important constraint on the spline because it is more difficult (= requires more energy) to achieve a bend between closely spaced landmarks than between landmarks located at a distance from one another. This distinction will have important implications when we discuss principal warps a bit later in this essay series.

Returning to the problem of determining the TPS surface, the various possible modes of bending across a set of landmarks are specified by a partitioned matrix (L) whose structure is summarized as follows.

$$L = \begin{bmatrix} P & Q \\ Q^t & 0 \end{bmatrix} \tag{19.2}$$

The P matrix partition summarizes the distances between landmarks using the U function (equation 19.1).

$$P = \begin{bmatrix} 0 & U_{12} & U_{13} & \cdots & U_{1p} \\ U_{21} & 0 & U_{23} & \cdots & U_{2p} \\ U_{31} & U_{32} & 0 & \cdots & U_{21} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ U_{p1} & U_{p2} & U_{p3} & \cdots & 0 \end{bmatrix} \tag{19.3}$$

Note here the subscript p refers to the total number of landmarks specified in the reference (and target) configuration(s). The diagonal of this matrix is occupied by zeros because the distance between any landmark and itself is zero. The off-diagonal U values are calculated using equation 19.1. Note that the P matrix is both square and symmetrical about its diagonal.

The Q matrix summarizes the coordinates of the reference landmark configuration.

$$Q = \begin{bmatrix} 1 & x_1 & y_1 \\ 1 & x_2 & y_2 \\ \vdots & \vdots & \vdots \\ 1 & x_p & y_p \end{bmatrix} \tag{19.4}$$

The Q^t matrix is the transpose of the Q matrix. Finally, the 0 matrix is a 3 x 3 matrix of zeros.

$$0 = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \tag{19.5}$$

Arranging these matrices in the manner indicated by equation 19.2 produces a composite p+3 x p+3 square, symmetrical matrix whose diagonal elements are all zeros. Once this matrix has been assembled its inverse is calculated (L^{-1}). The L^{-1} matrix represents the energy required to achieve a displacement of the landmarks of the reference configuration (= bending of the implied reference TPS surface) in any combination and by any amount.

The overall TPS surface is calculated from the L^{-1} matrix by padding out the matrix of x and y shape coordinate values for the target configuration (X_t) with a 3 x 2 matrix of zeros (X_{t+}) to give it the same number of rows as the L^{-1} matrix, then multiplying these two matrices together as follows.

$$W = L^{-1}X_{t+} \tag{19.6}$$

This creates the weight matrix (W). We'll use the W matrix more in our discussion of partial warps and relative warps. But for now all we need to know is that the W matrix can be partitioned into two sections. The first p rows represent the weights assigned to the non-uniform modes of shape variation and the remaining three rows represent weights assigned to the uniform modes of shape variation.

In order to calculate the 2D representation of the 3D TPS surface the following equations are used.

$$z_y(x,y) = W_{p+1,2} + W_{p+2,2}x + W_{p+3,2}y + \sum_{i=1}^{p} W_{i,2}U\left(\sqrt{\left(r_{i,1}-x_{i,1}\right)^2+\left(r_{i,2}-x_{i,2}\right)^2}\right) \tag{19.7}$$

$$z_x(x,y) = W_{p+1,1} + W_{p+2,1}x + W_{p+3,1}y + \sum_{i=1}^{p} W_{i,1}U\left(\sqrt{\left(r_{i,1}-x_{i,1}\right)^2+\left(r_{i,2}-x_{i,2}\right)^2}\right) \tag{19.8}$$

The values input into these equations (x,y) are the coordinate positions of vertices of a grid centred over the target shape. The dimensions of this grid, the number of grid cells used in its construction, and the amount by which the grid extends around the periphery of the target shape landmarks all are under the analyst's control. Once the positions of the TPS vertices have been established, the grid is constructed by drawing straight lines between adjacent grid vertices to create a deformed, rectilinear grid pattern. By convention, the shape coordinate values of the target shape landmarks are usually plotted along with the grid graphic itself as an aid to interpretation of the TPS surface.

The bending energy matrix is the upper-left p x p block of L^{-1} matrix (= L_p^{-1}). This partition is used to calculate the non-uniform component of the transformation between the reference configuration and target configuration in the *Procrustes* space. The equation that yields the coefficients of the non-uniform aspect of the TPS surface is simply the p x 2 matrix product of the target object's shape-displacement values (X_c) and the p x p bending energy matrix (L_p^{-1}).

$$TPS_{non-uniform} = X_c L_p^{-1} \tag{19.9}$$

This manner of calculating the non-uniform aspect of shape transformation was originally published by Bookstein (1989) and has remained stable since then. Unfortunately, the uniform component of the shape transformation has had a more tortured history. It is beyond the scope of an introductory essay such as this to review that history in detail. The method for estimating the uniform component of shape transformation I will present here is taken from Rohlf (1993) because it is simple and has been used most often in TPS calculations to date. However, there are other methods (see Bookstein 1991, Bookstein 1996, Rohlf and Bookstein 2003, Zelditch *et al.* 2004).

Under Rohlf's (1993) approach, and drawing on analogy with the calculation of the bending energy matrix, the uniform component of shape transformation is encoded in the upper right p x 3 block of L^{-1}. This block is referred to by the subscript q, again drawing on analogy with the Q matrix in equation 19.4. Thus, the L_q^{-1} partition of the L^{-1} matrix is used to calculate the uniform aspect of the TPS as follows.

$$TPS_{uniform} = X_c L_q^{-1} \tag{19.10}$$

Now, let's run the *Acaste* and *Calymene* data through these equations and take a look at their TPS surfaces. Figure 7 summarizes the contrast between the *Acaste* (Fig. 7A) and *Calymene* (Fig. 7B) specimens in terms of the ten landmarks used to quantify cranidial morphology. Both of the possible TPS representations are shown, *Calymene* to *Acaste* (Fig. 7C) and *Acaste* to *Calymene* (Fig. 7D). As per morphometric convention, the configuration of the target specimen is plotted along with the spline. Note the geometrically reciprocal character of two splines.

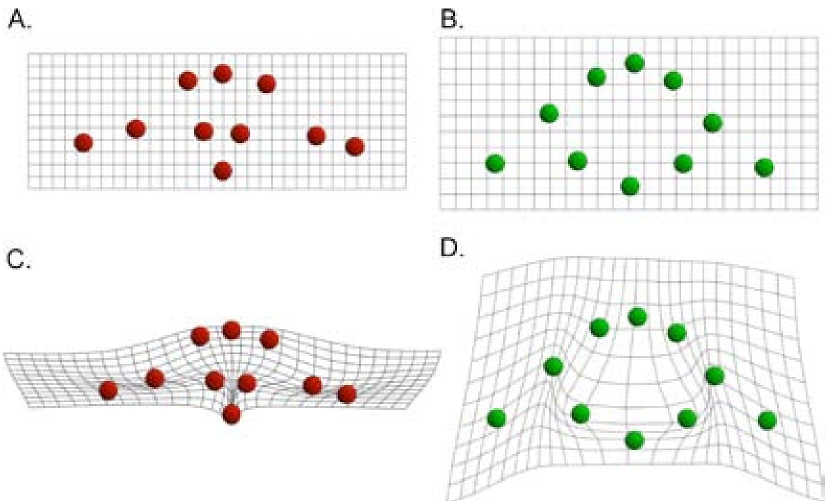

Figure 7. Total TPS spline surfaces for the geometric transformation between Acaste *(red) and* Calymene *(green). (A) Basal (non-deformed) grid for* Acaste *landmark configuration. (B) Basal (non-deformed) grid for* Calymene *landmark configuration. (C) Thin plate spline surface for the* Calymene-Acaste *transformation. (D) Thin plate spline surface for the* Acaste-Calymene *transformation.*

By way of an example, the *Acaste-Calymene* TPS surface can be further decomposed into uniform and non-uniform deformation modes, as shown in Figure 8.

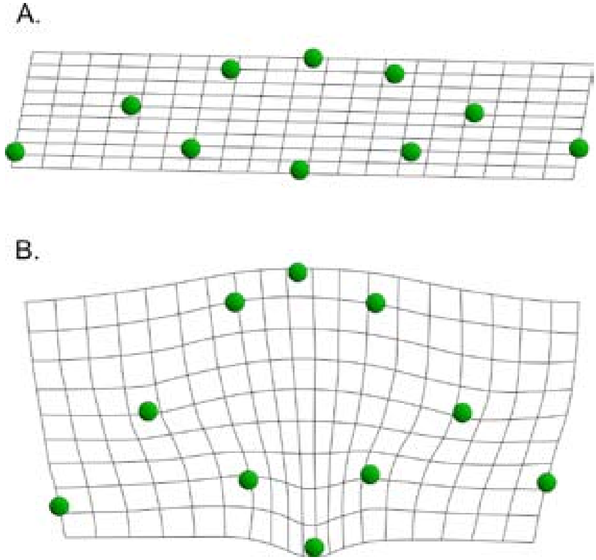

Figure 8. Deformational modes of the Acaste-Calymene *geometric transformation. (A) Uniform (affine) TPS surface. (B) Non-uniform (non-affine) TPS surface.*

Accordingly, the deformation shown in Figure 7D can be described as a combination of a uniform deformation that combines aspects of a clockwise shear, strong anterio-posterior compression, and clockwise rotation (Fig. 8A). To this is added a pronounced non-uniform deformation centred in the glabella involving a strong element of asymmetrical latero-posterior compression with movement of the three anterior landmarks strongly forward relative to the remaining landmarks. This relative movement results in elongation of the glabella and anterior of the cranidium, lateral migration of the eyes, and latero-posterior migration of the intersection between the cranidium's posterior lateral projection and the posterior lateral margin of the glabella (Fig, 8B; see MacLeod 2009, Fig. 5 for landmark definitions).

Thin plate splines for the entire trilobite dataset for which these ten landmarks can be located are shown in Figure 9. In these analyses the sample mean shape was used as the reference shape. Also provided is the value of the total bending energy specified by each spline surface. This number is analogous to the total shape variance and can be used to identify the shapes that deviate more (or less) from the reference (= mean) shape than others.

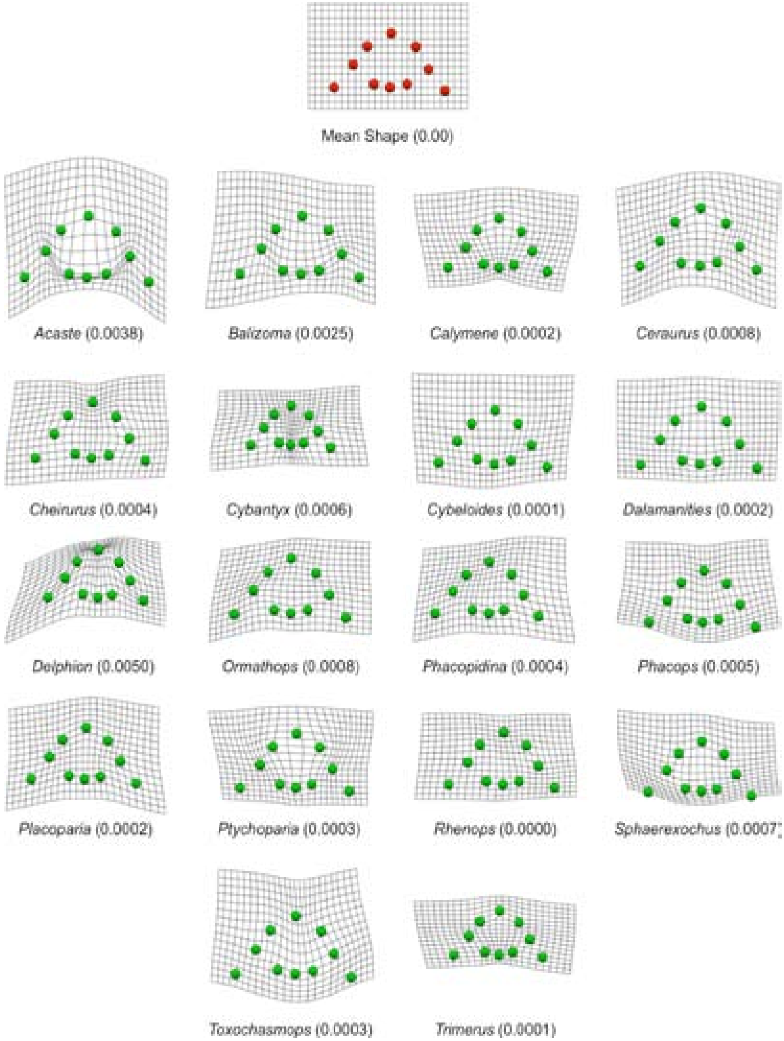

Figure 9. Total TPS surfaces for the comparisons between the trilobite sample mean shape (red) and the landmark shape configuration for 18 genera from the trilobite dataset. Numbers in parentheses beside each genus name are the total bending energies associated with that shape configuration relative to the sample mean shape. This value is analogous to the shape variance.

I hope this brief explanation and demonstration of thin plate splines has demystified the topic for you, at least a bit. Thin plate splines are a very attractive way of graphically depicting shape changes and, because of that, they are also very seductive. They should be used more widely than they are, but they need to be used with caution.

Because these splines are depicted as surfaces that encompass the landmarks themselves, the areas between the landmarks, and even areas outside the region covered by the landmark set, there is a tendency to make more of the details of the spline's configuration than is actually warranted. It should be remembered that, except for the areas immediately surrounding the landmark locations, all other aspects of the spline are artificial interpolations. While the geometry of the spline between the landmarks can identify regions of potential interest (see Bookstein's 2002 method of TPS creases), interpretations involving these inter-landmark regions should be made with caution. Ideally once inter-landmark regions of interest have been identified, landmarks should (if at all possible) be placed at or near their location and the analysis repeated.

The issue of the robustness of TPS surfaces to changes in the experimental design should also be mentioned. As in any multivariate analysis, any TPS result is only valid for the specimens used to calculate it, the landmark set used to quantify morphological variation, and the reference form used as a basis for the spline. Variation in any one of these parameters will likely result in substantial changes to the spline's geometry. In other words, the results of a TPS analysis are simply mathematical descriptions of the shape comparison the analyst has chosen to make between two or more forms; nothing more and nothing less. These descriptions are not generalizable in and of themselves. In subsequent columns we'll learn how to use the TPS approach to make general statements about the character of shape variation in a sample. But even with those techniques the instability built into the TPS method of shape representation needs to be appreciated. In particular, the selection of the reference shape is, in most cases, a critical decision.

Is the thin plate spline the long-sought realization of the Thompsonian transformation grid concept? In some ways it is and in some ways it isn't. I suspect Thompson himself would have absolutely loved thin plate splines. D'Arcy Thompson was a great believer in the constraints that materials and physical processes place on morphological arrangements. The idea that the TPS algorithm involves a metaphorical concept of bending energy which is required to be minimized by the resulting geometry would have spoken to one of his most deeply held beliefs about the organic world. However, no data or morphological patterns have come to light in the 93 years that have elapsed since *On Growth and Form*'s publication to lend support to the idea that evolutionary processes operate in such a way as to minimize physical parameters such as bending energy. To be sure, organic design cannot exceed the performance limits imposed by the materials used to execute the design. This represents an absolute limitation. But evolutionary history abounds with examples of structures that are inefficient from a purely mechanical point of view. The reason for this is that mechanical design is only one of the parameters evolutionary processes seek to optimize.

On a more mundane, algorithmic level, the TPS approach also exhibits significant differences with the grids drawn by Thompson and his colleagues, most notably in the sense that Thompson's grids were conceived of as applying to all points on the form, not just those that happen to be located by particular landmarks. While the TPS technique can be used to visualize morphological transformations across an entire form, that transformation is controlled entirely by a relatively small number of point locations. Such a severe abstraction of the overall morphological signal stands in contrast to Thompson's original transformation-grid concept. Rather, that concept was, as we will see later, much closer in spirit and practice to the analysis of a continuous series of point locations that specify the complex, but biologically information-rich geometries of organic forms. Fortunately, the TPS approach can also be applied to these data despite the fact that the application of TPS analysis to these data have been rare so far because alternatives to TPS-based shape modelling have been available.

A final word about computer programs for implementing a TPS representation of shape difference. The industry standard remains Jim Rohlf's tpsSplin and tpsRelw packages (<**http://life.bio.sunysb.edu/morph/soft-tps.html**>). Øvind Hammer's PAST package (<**http://folk.uio.no/ohammer/past/**>) also calculates thin plate splines though his description of the algorithms it employs to do so (Hammer and Harper 2006) appears to differ in many ways from the canonical descriptions provided by Bookstein (1991), Rohlf (1993) and Zelditch *et al.* (2004). Other packages that can be used to perform TPS analyses include Dave Sheets' IMP software (<**http://www3.canisius.edu/~sheets/morphsoft.html**>), Paul O'Higgins' Morphometrika (<**http://sites.google.com/site/hymsfme/downloadmorphologica**>) and Jon Krieger's Morpho-Tools online morphometrics data analysis tools site (<**http://www.morpho-tools.net/**>).

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

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

Meeting REPORTS

Sea Dragons of Avalon and meeting in honour of Arthur Cruickshank

Strode Theatre, Street, Somerset, UK *30 July – 1 August 2009*

Figure 1: The sign at Marshall's Elm lower crossroads – itself a former quarry complex

Tourists driving through the village[2] of Street on their way to Glastonbury might well wonder at the representation of a skeleton on the road sign. Could this perhaps be a warning that this stretch of the A39 is a roadkill hotspot? I (*Stig Walsh, once a local inhabitant*) suspect that the skeleton's true identity may be far from what most outsiders expect of this part of Somerset (and most locals too). Cider, cheddar cheese, sheepskins, sensible shoes and scratched vinyl LPs of 'The Best of the Wurzels' probably rank highly in a top ten list of 'objects found on and around the Somerset Levels'; Mesozoic ichthyosaurs probably wouldn't make the top 40. Street nonetheless has an important place in the history of vertebrate palaeontology, and the PalAss review seminar held in late July was organised to look at what can be said about those fossils today.

The meeting was held in the Strode Theatre, a public theatre attached to Strode College of Further Education, which is oddly enough where I took A-levels in the dim and distant past. Although such a small venue off the academically beaten track might seem unconventional, the organisers (**Mike Taylor**, National Museums Scotland; **Leslie Noè**, Birmingham Science Museum; **David Hill**, South Somerset District Council; **Jeff Liston**, Hunterian Museum, Glasgow; and **Darren Naish**, Portsmouth University) put together something truly unusual and very enjoyable, in large part *because* of this venue. Unlike most technical meetings, *Sea Dragons of Avalon* welcomed scientist and interested lay person alike, providing the meeting with a very different atmosphere, and demonstrating one of the best examples of public outreach I have seen for some time. Unusually for a PalAss event, it was advertised through the theatre's own programme and PR machinery, and with local historical societies, as well as the usual geological groups. It even managed to get near-full-page coverage in the local newspaper.

The title of the seminar stems from the popular legend that nearby Glastonbury was the location of King Arthur's Isle of Avalon. In keeping with the legend, the Somerset Levels were at one time under water for much of the year, only really dry during the Summer, whence the name 'Summerlands' and supposedly the county name too. However, as the presentations illustrated well, the Jurassic Blue Lias rocks in which the fossils were buried were laid down in far deeper waters in a very different West Country. In many respects the talks characterised three main themes: the importance of Street and its fossils due to the time span of the Street sequence apparently encompassing

[2] Street is technically a village despite doing a very passable imitation of a small town.

the Triassic–Jurassic extinction; the geology and taphonomy of the sequence; and the historical contribution of collectors to the science.

The first afternoon of the meeting comprised a half day's talks in celebration of the life and achievements of another Arthur – A. R. I. Cruickshank. Strictly speaking this was not part of the review seminar proper, but kept separate financially. This was partly because of PalAss's charitable aims which (very properly) disallow meetings by invitation, even if it is simply a matter of giving priority to an honorand's friends and colleagues within the limited space available for a sit-down lunch. It was also partly to allow the review seminar programme proper to be tightly focused without the risk of ending up as a disparate Festschrifty grab-bag of papers.

The meeting began in style with a buffet lunch and an informal presentation. The organisers had somehow managed to keep Arthur in the dark until mere hours before he found himself receiving a short speech by Mike Benton and a huge card and a goody bag of presents, including that indispensable gift for any Scotsman in the form of a decent single malt (Ardbeg 10 year old), a couple of model plesiosaurs, and the Haynes Manual for the Avro Lancaster, while Enid his wife was presented with a large bouquet. And at teatime Arthur found himself cutting a cake beautifully decorated in his honour with a scaled-down skeleton of the Natural History Museum (NHM) holotype of the pliosaur *Thalassiodracon hawkinsi*.

Figure 2: Arthur and Thalassiodracon*: two names with strong local connections*

All the day's talks had some connection with Arthur. His work on dicynodonts was reflected in the first talk by **Marcelo Ruta** and **Mike Benton** (University of Bristol) about dicynodont diversity before and after the Late Permian extinction. Despite the magnitude of the extinction, some dicynodonts such as *Lystrosaurus* managed to survive and allowed the group to 'bounce back' in the Triassic. However, the authors' analysis of dicynodont diversity showed that the morphospaces occupied by Permian and Triassic species are distinct, presumably as a result of different adaptations in dicynodont species either side of the boundary. Next, West Country fossil collector **Simon Carpenter** (Frome) gave a glimpse of his extensive history of collecting from various sites in the area. This talk exemplified the flavour of this meeting as a whole; Simon gave a good presentation aided only by good old-fashioned slides – very refreshing in this era of 'presentation innovation = scientific quality'. His description of the 1994 'pliosaur dig' at the Blue Circle quarry in Westbury – previously the source of a pliosaur on which Arthur and Mike Taylor published – was something of a nostalgia trip for me, for a friend and I had tried to visit this very dig 'without invitation' all those years ago. We didn't get very far after being picked up on the CCTV, but the helpful quarry security men gave us a Land-Rover ride to the site.

Continuing the pliosaur theme, **Adam Smith** and **Nigel Monaghan** (NMI Dublin) detailed the history of the sea reptile collections at the National Museum of Ireland, including the holotype of *Rhomaleosaurus cramptoni*. This specimen has recently undergone preparation across the water at the NHM (which has its own cast on display in the fossil reptile hall) after having been packed away for some time. This was part of a project which included Adam's own doctoral work, initiated following advice from Arthur. Arthur's work in South Africa was the link for **David Norman**'s (Sedgwick Museum, Cambridge) look at the various theories of how *Heterodontosaurus* might have masticated its food, and concluded that lower jaw bowing, which he called "wishboning", is the most likely mechanism. If correct, this early ornithischian had a more complex jaw mechanism than later, more derived taxa, and one which has no comparison among living animals.

The second session was opened by **Mike Taylor** and **Jehane Melluish** (Catcott), who gave an entertaining history of the rather colourful character Thomas Hawkins and his importance to reptile collecting in 19th century Street. What with adding parts to fossils, possibly serial marriages, feuds, lawsuits, perjury and (worse) unreadable religious poetry, Hawkins was clearly not someone anyone would want as a neighbour! **Richard Forrest** and **Mark Evans**, Arthur's part-time PhD students at Leicester University, discussed their ongoing work on an exceptional Taunton Museum plesiosaur discovered by local man Nick Collard in the Liassic rocks of the Somerset coast. Preliminary X-ray CT work has given promising results, and there is some possibility that soft tissue is also preserved in what seems most likely some form of rhomaleosaur. Next, **Richard Edmonds** (Jurassic Coast, Dorset County Council) gave a good overview of the difficulty in finding and procuring good material for display in the local museums of the Jurassic Coast. It's rare to hear about situations where funding is available for this kind of endeavour, and it seems a shame that the project (funded by the National Lottery Collecting Cultures fund and Dorset and Devon County Councils) has been criticised for causing inflation in the trade of local fossils; how can museums hope to acquire the best material without paying market value? Moving north, **John Hudson** (University of Leicester) discussed the Eigg plesiosaur and its likely freshwater palaeoenvironment, and proved that neither Powerpoint nor traditional slides are needed to make a talk interesting. John's association with Arthur Cruickshank goes as far back as the late 1950s, almost as far as that of **Tom Kemp** (Oxford

University Museum), who presented the final talk of the session. Tom gave a light-hearted and entertaining 'phylogenetic' investigation of whether there exists a Cambridge School of Palaeontology, in the sense of a 'clade' defined by Rex Parrington 'synapomorphies'. Arthur is of course a shoot of this clade – or first filial (F_1) as Tom put it – and the same question could of course be asked about Arthur's own legacy. I came away wondering to what extent we *all* perpetuate the memes of our supervisors.

The evening saw an impressive turnout, just over half being the general public, for **Ryosuke Motani** (University of California, Davis) and his excellent public lecture, *Street's symbol: The Ichthyosaur – two centuries since its discovery*. Ryosuke gave a well-balanced and visually engaging talk to a well-filled theatre about his work on ichthyosaurs and their palaeobiology, both in the context of Street and in a more international setting. The quality of questions asked after the talk showed that there still exists a healthy public interest in palaeontology.

The review seminar proper began on the Friday, with **Mike Taylor** and **Angela Milner** (Natural History Museum, London) opening the first session with a review of Street's fossil collecting history. They showed that although the location of former quarries is hard to pinpoint exactly because most quarry sites have been built over, meticulous work with old papers, maps of the area, aerial photographs and lots of on-the-ground surveying can provide a good insight into their position and how and why the quarries were worked. However, few of the 'Street' fossils can be exactly provenanced, and some 'Street' fossils may have come from other Somerset localities. This question was taken further in **Dave Martill** (University of Portsmouth) and **Mike Taylor**'s overview of the taphonomy of the Street marine reptiles. The probability of reptiles being preserved in such condition is normally so low that Street's apparent concentration of skeletons can be called a forgotten *Lagerstätte*.

Keith Ambrose (British Geological Survey) opened the second session of the day with a highly detailed and in-depth consideration of new BGS data on the stratigraphy of the Street region, arising in part from a coincidentally very timely resurvey of the Glastonbury sheet. This drew to a conclusion the more geologically-themed first part of the day. **Richard Twitchett** (University of Plymouth) now started the organism-based talks with a look at the invertebrates, or, as he himself put it in the context of the seminar, "the food", either side of the Tr–J boundary and extinction. The invertebrate faunas (especially trace fossils) provide crucial evidence about ecosystem collapse in the Rhaetian and slow recovery during the Hettangian and early Sinemurian, and so act as an important backdrop to the vertebrates discussed throughout the rest of the day. In the first of these, **Mike Benton** dealt with terrestrial tetrapod diversity trends across the P–Tr and Tr–J boundaries. Mike showed that morphospace between the various archosaur clades does not overlap, suggesting a strong degree of specialisation.

After lunch (provided in the registration fee, including a drink up to local ale or cider) **Leslie Noè** (Thinktank, Birmingham Science Museum) opened Session 3 with an overview of the sauropterygian taxa found at Street, which are amongst the earliest known complete plesiosaurs. Leslie suggested that plesiosaurs might have evolved in more open waters where fossilisation is less likely, and only later moved into shallow waters during the Jurassic, explaining their apparent rarity in the Late Triassic and suggesting that a ghost lineage might extend back into the Triassic. The Tr–J boundary was clearly an important period for Sauropterygia, with notable differences between Triassic and

Jurassic forms. Again, the Street sauropterygians are important for understanding plesiosaur evolution due to their completeness and the age of the Street sequence. A difference between 'Triassic' and 'Jurassic' forms has conventionally been noted in ichthyosaurs, but **Ryosuke Motani** demonstrated that many features associated with Jurassic forms are in fact sometimes present in Triassic forms. It now seems that there was no clear morphological turnover at the Tr–J boundary, and new specimens appear to show that Triassic-style, non-fish-like forms survived into the Jurassic. **Peter Forey** (Natural History Museum, London) then discussed what is known of the fish diversity during this period. Except for sharks, fish are not well represented in this part of the sequence. They also show a sort of 'recovery' phase during the Hettangian, before moving to a different fauna in the Sinemurian. Much of the stratigraphy is rich in mud, and Peter suggested the rarity of fishes may have been because of this.

We also had opportunities to examine a range of marine reptiles from Street and elsewhere in Somerset and Dorset. The day was brought to a conclusion by **Mike Benton**, who led a short discussion session. Several interesting and relevant questions were asked, such as why have the Street deposits so far yielded no flying vertebrates? As with most fossil-rich deposits, what gets left out is almost as interesting as what gets discovered. And perhaps most puzzling of all is the apparent dissonance of the benthic invertebrates' and fishes' record with that of the ichthyosaurs and plesiosaurs, which seemed to bounce back so much earlier from the Tr–J extinction. Indeed, their fossils at Street strongly imply that the extinction was rather earlier than the conventional Tr–J boundary, which is defined as the base of the *Psiloceras planorbis* Biozone, and lies bang in the middle of the reptile-bearing beds at Street. Some mistake somewhere, surely.

Stig had to return home on the Saturday, so Mike adds: A field trip to quarries in the Lias near Langport and Somerton and sites in the Polden Hills had been planned on the Saturday following the meeting, but rain and potentially dangerous conditions in the quarries meant that a rethink was in order. Instead **Richard Edmonds** organised a tour of various items of interest in Lyme and Charmouth at short notice: the Charmouth Centre with its displays on local geology and conservation, including some very interesting recent finds by collectors; the workshop of Chris Moore of Old Forge Fossils, with a large but disarticulated plesiosaur on the workbench; the Lyme Regis Museum; another collector's workshop, this time Paddy Howe's; and Richard's guided walk along the new seawall below the museum (covering the new sewage works!), examining current and future coastal defence problems in the area (which may lead to major new temporary excavations in the Lias).

This highlights the importance of the current debate on how to preserve and present the local palaeontology, which has accepted the need for collectors to save the specimens from the sea, and has moved on to discussing how best the finds can be secured in local museums, which are shifting their thinking from making do with old specimens to a much more dynamic acquisition policy to collect new finds. As mentioned above, a consortium of museums working closely with the Jurassic Coast has secured lottery funding to make some purchases, but not enough to meet market values for the range and quality of finds now being made. Some of these are of almost unbelievable novelty given the time over which collectors have already worked the coast. Another factor is that many of the local collectors are not keen to sell their prize finds to distant museums but would rather keep their fossils in Dorset. But they are, at least for now, reluctant to sell locally in the perceived absence of a first rate centre for palaeontology where their finds can be properly

Figure 3: Ryosuke Motani (in blue shirt) contemplating Chris Moore's recent finds while Chris talks to the group (photo © David Hill)

Figure 4: Outside the Lyme Regis Museum. One wing of the Museum (the one behind the traffic cone) is on the site of Mary Anning's house and shop (photo © David Hill).

displayed and stored. One potential centre is, of course, Lyme Regis Museum, which already plans a major extension and improvement to its services, but itself faces obvious challenges of fundraising and of its own exposed and cramped site, which could hardly be closer to the rocks of the shore. This will be a very interesting area to watch in the future, with major implications not only for research but also for the public interpretation and promotion of our science.

Stig Walsh and Mike Taylor
National Museums Scotland

53rd Annual Meeting of The Palaeontological Association
Birmingham *13 – 16 December 2009*

One very cold Sunday in December, 250 palaeontologists gathered at Birmingham University for the 53rd Palaeontological Association Annual Meeting. Registration was in the Lapworth Museum where we collected our conference pack and found out there had been a room change for the seminars (due to a minor fire in one of the buildings, apparently).

The conference started with an afternoon symposium on *Macroecology in Deep Time*. The first half commenced with a talk on palaeobiological macroecology at species level by **Andy Purvis** (Imperial College London) followed by controls on Phanerozoic marine diversification from the Paleobiology Database by **John Alroy** (University of California), and finished with additive diversity partitioning in palaeobiology by **Steven Holland** (University of Georgia). Coffee break in the next room was a welcome chance to catch up with friends and colleagues to discuss the latest research while getting in some welcome caffeine. The posters were going up in the same room as the talks, so many people gravitated to have their first look at what was being presented. We all settled back down in time for the second half of the symposium which started with origins of marine patterns of biodiversity by **James Valentine** (University of California), followed by competitive accommodation and the response of ecological community structure to environmental perturbation by **Thomas Olszewski** (Texas A&M University). This informative and varied symposium was concluded with a final talk at 5pm on Cope's rule, climate change and body size evolution in deep-sea ostracods by **Gene Hunt** (Smithsonian Institution).

The drinks reception was held at the Birmingham Museum and Art Galleries and started at 6pm so it was a mad dash across town from the University to the Museum. With plenty of wine to drink, and socialising to be had, the next few hours went quickly until the wine ran out and it was time for food. A group of us (the last to leave) went on to a restaurant to eat then carried on drinking in the first pub we found to end the night.

The following morning after a relatively late night the main conference started at 9am. Most people stayed in accommodation in the city centre which meant the easiest way to get to the University was a morning commute by train, which was a novel PalAss experience! Session 1 got under way with a talk on what lived on the land before the land plants, by **Charles Wellman** (University of Sheffield), followed by a talk discussing biomarkers and biomats, interpreting Proterozoic molecular fossils by **Maria M. Pawlowska** (University of Cambridge). This was followed by a very interesting talk on why ecosystems collapse by **Jonathan Antcliffe** (University of Oxford) and then early evidence for

Conference reception in the Birmingham Museum and Art Galleries (photo Martha Koot)

metazoan style locomotion in the fossil record by **Alexander Liu** (University of Oxford). The last two of the session discussed modelling the dynamics of Ediacaran communities (**Emily Mitchell**, University of Cambridge) and then the impact of the earliest land plants on the evolution of Cambrian to Devonian alluvial environments (**Neil Davies**, Dalhousie University).

During the well-earned coffee break we finally got our first chance to peruse all the posters and talk to their presenters about their work. Everyone settled back in their seats in time for the second session to start with a talk on key contributions of inter-group variation to macroevolutionary inference by **Thomas Ezard** (Imperial College London). The next two talks were on the Cretaceous period, firstly on using GIS to test dinosaur-plant association by **Paul Barrett** (Natural History Museum, London) and then evolution of photosymbiosis after the end-Cretaceous extinction event by **Heather Birch** (Cardiff University). This was followed by a talk on the Devonian nekton revolution by **Christian Klug** (University of Zurich), then one on the rise of pelagic cephalopods and the emergence of complex food chains during the earliest Ordovician by **Bjorn Kroger** (Humboldt University, Berlin). Finally back to the Cretaceous for an interesting description of a late Cretaceous rocky shore ecosystem by **Anne Mehlin Sorensen** (University of Copenhagen). This ended the first half of the day and everyone moved next door for a well-earned lunch break.

A talk on biomolecular evidence of methanogenesis in herbivores by **Fiona Gill** (University of Bristol) started the third session with somewhat of a bang. This was followed by a talk on experimental insights into carbon isotope fractionation under Phanerozoic conditions using the model plant *Arabidopsis thaliana* by **Barry Lomax** (University of Nottingham), followed by a discussion on preservation of Silurian and Devonian early vertebrate microfossils by **Zivile Zigaite** (Vilnius University). The next two talks were on conodonts, starting with a critical analysis of their use (or not!) as palaeothermometers for ancient oceans by **James Wheeley** (University of Birmingham) and then moving on to using tooth wear and damage to test hypotheses of ecology and function by **David Jones** (University of Leicester). The final talk before the coffee and poster break was a discussion of the dietary ecology of two of the earliest stem mammals by **Emily Rayfield** (University of Bristol).

The final session of the day started off with a very interesting talk entitled *Putting Humpty together again*, which was actually a discussion about the *Bilignea* plant by **Leyla Seyfullah** (University of Birmingham). This was followed by a really different take on Carboniferous cockroaches where XMT-based reconstructions were used by **Russell Garwod** (Imperial College London) to gain a visually amazing three-dimensional look at the fossils. The last two talks of the session started with **Andrew Rees** (University of Birmingham) looking at whether the living fossil *Ginkgo* had changed in 150 million years, by analysing the morphology of preserved seeds, and finished off with a talk on a possible Silurian soft-bodied lophophorate by **Mark Sutton** (Imperial College London).

After the AGM was quickly dealt with, the annual address was given by **Lawrence Witmer** (Ohio University College of Osteopathic Medicine) who gave a very different, fascinating talk about unlocking the riddles of dinosaurs through 3D imaging. Using this, he showed us how to get a visual image of the hard parts encased in the rock and then how to reconstruct soft tissue structures within the skull, which was just amazing. The soft-tissue reconstructions were compared to results from the dissection of extant relatives to track brain evolution, functioning of the inner ear and position of blood vessels to give information on the extinct dinosaur's sensory biology and behaviour. He demonstrated from the images of extinct skulls (which were rotating in front of us to show the full effect of what can be done on Powerpoint!) that the contours of the brain reflect different levels of cognitive and sensory abilities in different dinosaur groups. The talk then moved on to the astounding fact that they can model the inner ear from the fossilised skull and that this provides key information on not just the expected importance of hearing but also on balance and the visual system including the alert posture of the head, which could relate to the evolution of feeding behaviours. This talk was visually amazing and the results of the 3D imaging were fantastic.

The annual dinner was held at the Birmingham Botanical Gardens and a coach was organised for us to be taken there. When the coach finally arrived (having got lost getting to the University…) it picked up half the group, while the rest of us had to wait for it to come back for the second

The lecture theatre where the conference was held (photo Martha Koot)

The Annual Dinner in the Birmingham Botanical Gardens (photo Martha Koot)

pick up (it got lost again…) before we got to the location. We started with a welcome drink in the main bar area after having walked through the spectacular gardens, then moved into the main dining area to sit down for the meal. The meal began with a very strange but nice starter consisting of a small tower of spiced potatoes with salad and two kinds of dip (still not sure exactly what). The main course of roast chicken and vegetables was delicious and the meal finished with a desert of chocolate brownie and caramel sauce. After the meal the awards were given out. **Prof. Bruce Runnegar** was awarded the Lapworth Medal, **Kevin Peterson** was awarded the President's Medal, **Emily Rayfield** received the Hodson Award and **Magne Hoyberget** was awarded the Mary Anning Award. Afterwards, all that was left to do was polish off all the remaining wine…

The next day was another early start and rush for the train, with the first session kicking off with three vertebrate talks. The first one was on how the decay of lampreys and hagfish provides taphonomic constraints on jawless vertebrate evolution by **Robert Sansom** (University of Leicester), the next on skeletal evidence that *Palaeospondylus gunni* is an osteichthyan vertebrate by **Zerina Johnanson** (Natural History Museum, London), and finally back to hagfishes, lampreys and gnathostomes and the nature of the ancestral vertebrate by **Alysha Heimberg** (Dartmouth College, Hanover). The last two talks before coffee were on integrating molecular and palaeontological approaches to telling evolutionary time by **James Tarver** (University of Bristol) and inferring ancestral genome sizes through comparison of cell sizes in living and fossil seed plants by **Richard Bateman** (University of Birmingham).

After coffee, the talks restarted in the second session of the day with the evolution of Cambrian sponges and the calcitic composition of *Protospongia* spicules by **Alex Page** (University of Cambridge). This was followed by **Jakob Vinther**'s (Yale University) molecular palaeobiological perspectives on annelid evolution. Another talk in the session was how soft part relicts in *Metaconularia manni* substantiate the phylogenetic association of Conulariida with scyphozoan-like cnidarians by **Nigel Hughes** (University of California). This session had three further talks based around the Cambrian: ontogeny and phylogeny of stem Rhychonelliform brachiopods by **Lars Holmer** (Uppsala University); the absence of echinoderms in the Chengjiang Lagerstätte, China by **Sebastien Clausen** (University of Lille); and then the morphology of lobopodian eyes and their evolutionary significance by **Xiaoya Ma** (Yunnan University).

The second to last session of the day got under way after lunch by getting beneath the skin of fossil holothurians, courtesy of **Andrew Smith** (Natural History Museum London). This was followed by two talks on trilobites, firstly a history of their body size evolution by **Mark Bell** (University of Bristol), then trilobite diversity in the Silurian by **Andrew Storey** (University of Birmingham). A talk on whether coccolith evolution in the Quaternary was rapid by **Jeremy R. Young** (Natural History Museum London) was followed by **Phil Jardine** (University of Birmingham) who used the fossil plant record as a tool for studying spatial heterogeneity in extinct plant assemblages. The last three of the session started with two on extinction events, firstly latitudinal selectivity of foraminiferal extinction during the late Guadalupian by **David Bond** (University of Leeds), and a discussion of richness, composition and ecological traits in the recovery after the Triassic–Jurassic extinction by **Luis-Felipe Opazo** (University of Plymouth). The session finished with **Tim Smithson** closing Romer's Gap by looking at new tetrapods and arthropods from the basal Carboniferous.

The final session started with a talk on molluscs and high fidelity climate records in the Weddell Sea during a warm interval in the early Pliocene, given by **Mark Williams** (University of Leicester). Then **Jon Poulter** (University of Leeds) moved on to fossil floras of the British Tertiary Volcanic Province, and was by followed by two taphonomy talks: experimental taphonomy of *Artemia* and the role of microbial activity, by **Aodhan Butler** (University of Bristol), and then a description of the unusual taphonomic window on the Cambrian explosion provided by the Sirius Pass fauna, by **David Harper** (University of Copenhagen). The penultimate talk was intriguingly titled *Instant fossilization! Just add hot water*, and the presentation by **Crispin Little** (University of Leeds) didn't disappoint as he described how a variety of biological substrates were deployed in mesh cages at deep sea hydrothermal vent sites to see if fossilisation would occur. It did, but the experiments also demonstrated how mesh cages can be buried when unexpected undersea eruptions occur. Finally, it was left to **Graeme Lloyd** (Natural History Museum London) to give the final talk of the conference on whether deep sea diversity patterns suffer from a rock record bias.

At the end of the conference the best presentation prize and best poster prize were given out. Due to the high quality of the posters at the conference two prizes were awarded, to **Nicholas Crumpton** (University of Bristol) and **Laurent Darras** (University of Leicester), for their work on tooth microwear in, respectively, bats and fish. The prize for the best presentation went to **Russell Garwood** (Imperial) and his 3D Carboniferous cockroach. The following day was the field trip to the south Cotswolds area to view and collect from the Oxford Clay in freshly quarried sections. Overall the conference was a great success with lots of varied and exciting research. We would like to thank the School of Geography, Earth and Environmental Sciences at Birmingham and in particular **Guy Harrington** for organising such a successful event. We would also like to thank all those who presented talks and posters, and **Lawrence Witmer** for giving such an innovative and fascinating annual address. We look forward to seeing you all at the 2010 Palaeontological Association Annual Meeting in Ghent.

Nikita Jacobsen and Martha Koot
University of Plymouth

International Field Workshop on the Vindhyan Supergroup, Central India
Lucknow to Kajuraho, India *20 – 31 January 2010*

Properly, India should play a key role in Precambrian palaeontology, because huge series of unmetamorphosed sediments crop out in a number of cratonic basins. But age constraints are controversial, particularly in the largest one, the Vindhyans: While microfossils have an Ediacaran or even Cambrian aspect, radiometric dates indicate much older ages (Meso- and late Paleoproterozoic up to 1800 my; Azmi *et al.*, 2008). On the other hand, the conspicuous Ediacaran macrofossils, as known from other continents, seem to be absent.

In order to clarify this issue, the Palaeontological Society of India sponsored an international field workshop from 20th to 31st January 2010. It started in the Sahni Institute of Palaeobotany in Lucknow with four lectures and ended in Kajuraho with statements of all participants. The days in between were spent in the bus and on the 31 meticulously selected outcrops, with a review session and general discussion following every evening. Most debatable were sections near Bhandanpur, Chirakoot, and Chorhat. For me, the most lasting impression was a negative one: in spite of spectacular outcrops and beautifully preserved bedding planes we did not find a single macroscopic body or trace fossil other than occasional *Chuaria*, *Tawuia, Grypania*, and stromatolites. Why?

One possible explanation builds on Nick Butterfield's view (2007) that in the absence of metazoans, complex ecosystems, and large body sizes, morphological evolution proceeded at a much slower pace than in Phanerozoic times, from which our traditional biostratigraphic measuring stick has been calibrated. Accordingly, certain microfossils may have had much longer time ranges than expected. Another source of confusion are various *pseudofossils*. Most of these are anactualistic, because they resulted from the unusual behaviour of Precambrian matground sediments. Thus, the tractional gliding of a consistent biomat over its substrate may result in transverse wrinkles (in sand) or sigmoidal microfaults (*Kinneyia* Walcott 1914; in micritic limestones) at the surface and in specific glide marks (*Arumberia* Glaessner & Walter 1975) below the biomat. We also discussed *molar tooth structures*, in which overpressure in a mat-bound mud layer seems to have been released by earthquakes. If sand layers reacted the same way (microbial pudding), this could explain the "*Chorhat worm burrows*" (Seilacher *et al.*, 1998).

In the end, many of the participants got involved in one or other aspect of Vindhyan geology and were eager to return in the context of cooperative projects. Additional information about Proterozoic microfossils, radiometric ages, and geochemistry may be expected from samples that participants were encouraged and helped to take at prospective sites. Organisers hope that all contribute to an edited volume, the timely publication of which will provide a new base for future Vindhyan research.

After having experienced this perfect mix of continuous discussions and observations, one wonders why we do not have more meetings like this, rather than endless series of talks in a stuffy lecture hall without time for discussion? The answer is clear: it requires a lot more preparation. Dr Mukund Sharma and Professor Surendra Kumar have done this in admirable style. Participants were equipped with field bags and name-tags printed on both sides that included a photo ID. Outcrops (no more than five a day, often less) were easily accessible (where necessary by smaller, locally hired vehicles) and had the stop numbers of the field guide visibly and durably painted on the rock. Suitable, sometimes luxurious, hotels had been strategically chosen for accommodation, meals, meetings and a minimum of dislocations – not to forget the lavish lunches under palm trees by invitation of a cement factory and a diamond mine or by an erstwhile Maharaja of Rewa for the celebration of Republic Day of India (26th January 2010). Even the touristic appetite was satisfied by a concluding visit to the temple complex of Khajuraho from the 11th century – a UNESCO World Heritage Site that survived the Moghul time because it became overgrown by jungle.

In summary, the Indian organisers must be praised for an event that sets new standards for the future. The only drawback (that the whole Chinese delegation and R.J. Azmi could not come) was beyond their control.

Adolf Seilacher
Tübingen

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Front Row sitting: *Neil Ryan Mckenzie, Jackob Vincent Bailey, Edwin Stephen Kite, Srikanta Murthy, Shailendra Singh, Bijai Prasad;* ***Standing Row:*** *Ashish Sharma, Dolf Seilacher, Shuhai Xiao, N. J. Butterfield, V. K. Mathur, Mukund Sharma, M. Shanmukhappa, Ravi Chaure, O.P. Pandey, S. Kumar, B. N. Tewari, Arundhati Pathak, Ravi Prakash Srivastava, Santosh K. Pandey (Photo taken on 22nd January at Chitrakoot; Tirohan Limestone of Semri Group is in the background).*

>>*Future* Meetings of Other Bodies

IGCP 572: 2010 Meeting and Field Workshop in South China, International Conference of Geobiology (ICG)
Wuhan, China *4 – 6 June 2010*

IGCP 572 is one of the major sponsors of the ICG and will organise three sessions at the IGC, China University of Geosciences, Wuhan, in Summer 2010: Permian/Triassic (P/Tr) mass extinction; Triassic restoration of marine ecosystems; and Global distribution of Early Triassic microbialites.

The symposium aims to update the studies on the P/Tr mass extinction and possible causes, investigate the mechanisms and processes of marine ecosystem restoration following the P/Tr mass extinction through studies of biostratigraphy, palaeontology, palaeoecology, sedimentology, geochemistry and biogeochemistry, and elucidate the growth mechanisms and environmental significance of the Early Triassic microbialites. Three potential field excursions will be organised before and after the symposium: 1) Meishan-Chaohu: examining the P/Tr mass extinction and its aftermath from platform ramp to basin setting; 2) Guizhou: assessing recovery pattern and processes of palaeo-communities in various facies settings; 3) Southern Tibet: collapse and re-building of marine ecosystems at the margins of Gondwana. Funds are available to help students and presenters to participate in the meeting and field excursions. More information can be found at <**http://geobiology.org.cn/2010meeting**> and <**http://www.igcp572.org/**>.

If you have any questions, please contact organisers Jinnan Tong (<e-mail **jntong@cug.edu.cn**>) or Zhong Qiang Chen (e-mail <**zqchen@cyllene.uwa.edu.au**>).

Third International Palaeontological Congress (IPC3)
London, UK *28 June – 3 July 2010*

IPC is a major international meeting held once every four years under the auspices of the International Palaeontological Association. The meeting provides a showcase for all that is exciting and new in the fields of palaeontology and palaeobiology. IPC3 in 2010 is hosted by the Palaeontological Association and partner organizations, and will be based in Imperial College and the Natural History Museum in the heart of London's 'Albertopolis'. The programme will comprise field trips, plenary lectures, workshops, contributed talks and posters, and thematic symposia. For further details and announcements visit the meeting website at <**http://www.ipc3.org/**>.

8th European Palaeobotany–Palynology Conference
Budapest, Hungary *6 – 10 July 2010*

EPPC conferences usually host a small but enthusiastic group of Quaternary (Pleistocene and Holocene) pollen and plant macrofossil scientists. In accordance with the tradition of EPPC conferences, oral and poster presentations are invited to introduce the latest findings and results of palaeobotanical and palynological research. We are looking forward to receiving presentations focusing on Paleozoic, Mesozoic and Cenozoic taxonomy, palaeofloristics, taphonomy, palaeoecology and palaeoclimate studies. Symposia, poster sessions, and meetings associated with workshops will be included in the scientific programme.

Call for Symposia
We invite proposals from scientists dealing with any field of palaeobotany, palynology and associated sciences to organise symposia and workshops, and we encourage all of you to contribute new ideas, topics and concepts to enhance the scientific quality of the conference and attract more participants. Symposium proposals may address any topic related to palaeobotany and palynology. The preliminary scientific programme includes Palaeozoic, Mesozoic, Cenozoic (Palaeogene–Neogene and Quaternary) palaeobotany and palynology sessions giving the framework for symposia. Please send proposals in electronic format to Boglarka Erdei (email <**paleobot@bot.nhmus.hu**>). The deadline for proposals is 15th November 2009.

For further information on the call for symposia, see <**http://www.eppc2010.org/modules.php?name=scientific**>

Registration
Registration and hotel information are published on the EPPC conference website. Conference registration will open on 1st November 2009.

Social Programmes
You can find detailed information at <**http://www.eppc2010.org/modules.php?name=soc_prog**>

Professional field trips
Various pre- and post-conference field trips will be organised for participants, to ensure that all can select the one that fits their personal interest; see <**http://www.eppc2010.org/modules.php?name=professional**>

If you are interested in EPPC 2010, please contact the conference secretariat via the following link, so that we can keep you informed about the latest news: <**http://www.eppc2010.org/modules.php?name=contact**>.

Join the 8th European Palaeobotany–Palynology Conference and experience Hungarian hospitality!

Flugsaurier 2010: Third International Symposium on Pterosaurs
Beijing, China *5 – 10 August 2010*

Pterosaurs are among the most fascinating and enigmatic of all extinct creatures. Thanks to some spectacular fossil finds in recent years our understanding of the palaeobiology and evolutionary history of these 'flying reptiles' has seen several dramatic advances. Some of the most important discoveries, including the first eggs with embryos, have been made in China, where the Late Jurassic/Early Cretaceous is currently producing new species of pterosaurs at a faster rate than anywhere else in the world. In recognition of this the Third International Symposium on Pterosaurs, 'Flugsaurier 2010', will be held in China in August 2010. This will be the third international pterosaur symposium and follows successful meetings in France in 2001 and Germany in 2007.

The meeting will be organised by the Geological Survey of China, sponsored by the Institute of Geology, Chinese Academy of Geological Sciences, and co-sponsored by the Bureau of Fossil Protection, Liaoning Provincial Department of National Land Resources, and the People's Government of Yixian.

The meeting is planned for 5–10 August 2010. Talks, posters, at least one open discussion session and (subject to availability) examination of specimens, are planned for the first three days of the meeting. This will be followed by an optional three-day field excursion to view exposures of the Jehol Group and exhibitions/collections of fossils from this sequence which has yielded more than 100 specimens of pterosaurs in the last ten years. All those interested in pterosaurs and the communities and environments in which they lived are encouraged to attend.

1. Meeting aims:

As in previous symposia this meeting is intended to cover all aspects of pterosaur palaeobiology and the world in which they lived:

(a) The origin and evolution of pterosaurs
(b) Taxonomy, systematics and phylogeny
(c) Palaeobiology including anatomy, functional morphology and ontogeny
(d) Taphonomy, sedimentology and environments of preservation
(e) Ecosystems and contemporaneous fauna and flora

2. Meeting Programme:

(a) Academic sessions (three days): Oral presentations: These will consist of key-note lectures (45 minutes) and talks (30 minutes). These times include at least five minutes for discussion. Posters: There will be at least one poster session (further details will be given in the second circular). Language: English.

(b) Field excursion (three days): North-east China. This will include visits to field sites, exhibitions and collections primarily in Liaoning Province.

3. Abstracts and Symposium Volumes:

An abstract volume will be prepared for distribution at the meeting. The abstract submission deadline is 31st March 2010. No abstracts will be accepted after this date. Abstracts of up to two printed pages (A4) are preferred, but longer abstracts will be considered. Preferred formats are 'Word' for text files and 'JPG' for figures. A symposium volume is planned for publication in 2011 and will be available to both attendees and non-attendees. The manuscript deadline will be 31st December 2010 (further details will be given in the second circular).

4. Expressions of interest/information:

If you are interested in attending this meeting please send us an expression of interest indicating your plans to attend the academic session and the field trip, possible talk/poster title(s) and likelihood that you will be accompanied.

All correspondence (e-mail preferred) should be sent to Lü Junchang and Dave Unwin:

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The 5th International Conference on Fossil Insects, Arthropods and Amber
Beijing, China *20 – 25 August 2010*

The 5th International Conference on Fossil Insects, Arthropods and Amber will be held at Capital Normal University in Beijing, China from 20th to 25th August, 2010. A series of scientific sessions including plenary and special sessions, and special group meetings, in addition to mid-conference and post-conference field excursions will be organized, along with social events and programmes.

PRELIMINARY SCHEDULE

20 August: Registration and welcome reception
21 August: Opening Ceremony and group photo, Conference symposia and general sessions
22 August: Conference symposia and general sessions; Congress Banquet
23 August: Mid-social programme and conference excursion
24 August: Conference symposia and general sessions
25 August: Conference symposia and general sessions, workshops, Closing Ceremony, Post-Congress Excursion preparations
26–28 August: Post-conference field excursions

CALL FOR ABSTRACTS

All abstracts should be submitted by e-mail before 1st May 2010, and must include:

Author's name
Author's affiliation
Title of the presentation
Abstract (500 words or less)
E-mail address
Postal address
Presentation preference (oral or poster)

PROPOSED FIELD EXCURSIONS

1. Mid-Conference social programme (23rd August):
Great Wall and Ming Tombs: One day, about 80 km from CNU campus. including hotel pick-up and drop-off, air-conditioned coach, English-speaking guide, lunch, all admission tickets.

2. Post-conference Excursion (26–28 August):
The Jurassic–Cretaceous Biota of Northern China: Insects, Feathered Dinosaurs, Basal Birds, Mammals and Angiosperms

Contents: In recent years, the study of the Jurassic–Cretaceous Biota has been progressing rapidly in Western Liaoning of China. A lot of very significant fossils have been found in this area. Up to now, about 23 kinds of fossils in the Jehol and Yanliao Biota have been reported from Western Liaoning, including insects, dinosaurs, lizards, choristoderes, pterosaurs, birds, mammals, turtles, amphibians (anurans and salamanders), fishes, conchostracans, ostracods, bivalves, gastropods, shrimps, limuloids, spiders, ferns, gymnosperm, angiosperm, algae, pores and pollens.

Western Liaoning of China is really a rare treasury of Mesozoic fossils and a magnificent place to study the origin and evolution of insects, birds, eutherian mammals and angiosperms. This trip begins and ends in Beijing, including two localities in Beipiao City, one locality in Chaoyang City and one locality in Lingyuan City of Western Liaoning.

REGISTRATION

Professional participant: 350US$
Student: 200US$
Accompanying person: 200US$

The registration fees cover the cost of the meeting's resources and support, congress publication (congress special issues, abstract volume and programme, not provided for accompanying members), conference bag, T-shirt, tea and coffee breaks, and all lunches and dinners from 20th to 25th August, and the Mid-Conference social programme to the Great Wall and Ming Tombs on 23rd August. The Congress Banquet in the evening of 22nd August will be available for regular registrants without additional charge.

Note:
1. Registration fees are subject to modification depending on the exchange rate between the Chinese Yuan RMB and US$. The exchange rate on 23rd January was 100US$ = 680.37RMB Yuan.)
2. Payment: A down-payment for the meeting and field trips is requested in this Second Circular. The balance will be due at the time of the meeting, payable in US$.
3. Outstanding students and distinguished retired palaeoentomologists may apply for limited financial support (free of charge for Registration Fees and Accommodation from 20th to 26th August). All applicants should give an oral presentation and contribute an original manuscript to the Proceedings for evaluation by the Organizing Committee.

Methods of Payment:

The registration fees and field excursion costs may be paid in either of the following ways:

1) Bank Transfer to the bank account designated for FossilX3 CNU 2010:
Name of Account: GAO TAI PING
Bank Account Number: 4022000-0188-009752-2
Name of Bank: Bank of China, Beijing Xisanhuanbeilu Sub-Branch
Address of Bank: B1-Floor, No.72 xisanhuan North Road, Haidian District, Beijing China
Swift address code: BKCHCNBJ110

Note: Please inform us by e-mail (<rendong@mail.cnu.edu.cn>) the detailed information (such as name, how much registration fees and how much field excursion fees) when you complete your payment by bank transfer. The invoice will be given to you upon check-in at the conference.

2) On-site Payment in Cash:
If you can't pay by bank transfer, you can pay all fees in cash when you check-in at the Registration Desk at the Conference.

Cancellation and Refunds:

Cancellations for registration and field excursion fees must be in writing and addressed to the Secretary Office of FossilX3 CNU 2010.

Cancellations received in writing before 1st August 2010 will be accepted and fees will be refunded in full except for RMB 200 Yuan banking service charge. The requested refund will be sent to the registrant after the Congress. Cancellations received after 1st August 2010 will not be refunded.

All persons interested in receiving the Second Circular with programme outline, registration and abstract forms and the application for accommodations, should contact the Conference Organizing Committee at the following address.

CONTACT DETAILS

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Cell: 0086-13661048193

8th International Symposium, Cephalopods – Present and Past (8ISCPP)
Dijon, France *31 August – 3 September 2010*

The 'International Symposium, Cephalopods Present and Past' – ISCPP – brings together all scientists 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. We are proud to host the 8th ISCPP at the University of Burgundy, Dijon, France from 31st August to 3rd September 2010. It will be a unique opportunity for sharing research ideas and recent findings on all aspects of cephalopod biology and evolution. We strongly encourage young scientists to attend this symposium. Studies using cutting-edge techniques and original approaches are particularly welcome. Dijon is located 310 km (186 miles) from Paris and it takes only about 90 minutes to get there by train. Two fieldtrips will follow the symposium: a one-day fieldtrip in Burgundy, and a four-day fieldtrip beginning near Lyons and continuing in the "Réserve Géologique de Haute-Provence" (South of France).

For further details e-mail <**Pascal.Neige@u-bourgogne.fr**>.

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

The Open Dinosaur Project

The ubiquity and increasing respectability of the World Wide Web has dramatically changed the way that science is reported in recent years, especially palaeontology. But so far, it has had much less effect on how it is actually done. While blogs and mailing lists provide increasingly important vehicles for discussing published research, public participation in the scientific process is still mostly after the event: discussing and interpreting (and often disagreeing with) results that have been arrived at by the same rather closed methods that have been in use for many years. Initiatives such as the Audubon Society's Christmas Bird Count, SETI@home (analysing astronomical data for signs of extraterrestrial intelligence) and Folding@home (simulation of protein folding) go some way towards allowing laymen to contribute to scientific endeavours in other fields, but there is nothing analogous in palaeontology; and these projects are in any case very circumscribed in what contribution they allow people to make: provision of raw data and CPU cycles.

Encouraged by the high level of contribution in the comments of our blogs *Sauropod Vertebra Picture of the Week* (<**http://svpow.wordpress.com/**>) and *The Open Source Paleontologist* (<**http://openpaleo.blogspot.com/**>), we felt that the time was right to try to change that. In other fields, the technique of "crowdsourcing" – inviting contributions to a project from anyone who feels inclined to pitch in – has been very successful. The most visible example is perhaps the rise of Wikipedia (<**http://wikipedia.com/**>): that an encyclopedia written and maintained by volunteers exists at all is astonishing enough; but, more than that, its increasing maturity over the last few years has resulted in its becoming a surprisingly reliable resource that is now unquestionably the Internet's primary reference site for most purposes (its coverage of dinosaurs is excellent). But other examples are not hard to find. When the *Guardian* acquired half a million pages of official documents relating to MPs' expenses in June last year, it invited volunteers to review them in search of irregularities, and very quickly uncovered much information that its own journalists would never have had time to sift out (<**http://mps-expenses.guardian.co.uk/**>). Achievements like these show that the part-time efforts of many untrained people can sometimes be more fruitful than the concentrated focus of a few specialists.

Could such techniques be applied to palaeontological research? Not at such a scale, obviously: far fewer people are seriously interested in dinosaur science than are provoked about being defrauded by their supposed representatives. Still, we had seen enough interest in our blogs, and on mailing lists, to feel that there was a significant body of interested laymen out there who would make a real contribution if the mechanism existed for them to do so. And one evening in Southern California – after a few beers, naturally – Andy and Matt thrashed out a basic structure for such a project, and invited Mike on board the next day. We're interested in how ornithischian dinosaurs evolved from the primitive state of bipedality to quadrupedality – a transition that occurred independently in at least three different lineages (thyreophorans, ceratopsians and ornithopods). To comprehensively study how that happened, and whether it happened in the same way each time, involves analysing measurements of thousands of bones from hundreds of specimens. Much of that information is published but inaccessible, as it is scattered across innumerable papers in various languages; other measurements have never been published in any form. Gathering and collating these measurements seemed like an ideal pilot project for the idea of crowdsourcing science, with the possibility of running further projects in future if the first is successful. And so was born the Open Dinosaur Project, or ODP for short (<**http://opendino.wordpress.com/**>).

Openness

Our explicit goal is to open up every aspect of the process of producing a formal peer-reviewed publication: to allow anyone who wishes to contribute where appropriate, and at least to be able to see every step of the process. That goal is expressed in the following aspects:

- Most immediately, the project is open to contributions of data – ornithischian limb-bone measurements – whether harvested from published accounts or personally measured. (See below for more detail on how we handle these contributions.)
- Contributors are working on a unified, formatted bibliography and master list of museum abbreviations.
- We are open to suggestions on how to analyse the collated data, and have already benefited greatly from the insights of contributors with more background in statistical methods than we ourselves have. We expect project members to run some of the analyses and prepare figures illustrating trends.
- Although the three of us will prepare the manuscript, we plan to open it to all contributors for pre-submission review, and fully expect the eventual submission to be much the stronger for having gone through this process.
- Crucially, the project will be open to the world, in that the resulting paper will be published in an open-access venue: at present, we expect to submit to *PLoS ONE*, in part because PLoS journals will allow unlimited colour figures and appendices.
- The database being assembled is already freely available, and the snapshot that we perform the analyses on will be included as supplementary information in the published paper. We invite other workers to start using the data as soon as they wish, and request only that they not publish work based on that data before the ODP's own paper comes out, and that they acknowledge the Project for providing the data.
- Finally, the process of assembling the paper is open through blogging (and through the comments that project participants leave on the blog entries). At each stage, we explain what we are doing, why we are doing it that way, and what we expect to do next; and we solicit comments on the future plans. When the paper is published, the ODP blog will be a unique "paper-trail" documenting how it came about.

So far as possible, we want the project to have no secrets from the world.

About the data

Data for the ornithischian gait project comes from two main sources: personal measurements, and published information. While in general members of the public do not have access to the former, it is increasingly possible for anyone who is interested to read the literature. This is partly because of the swing towards open-access publishing, and partly because of digitisation projects that are making older publications freely available – either formal projects, as in the AMNH's digital library (<**http://digitallibrary.amnh.org/**>), or ad-hoc collections such as the O. C. Marsh papers (<**http://sauroposeidon.net/marsh.html**>). One of the most encouraging fringe-benefits of the ODP so far has been seeing how possible it has now become for an enthusiast with no formal affiliation to access the primary literature.

We are alert to the potential for incorrect transcriptions to reduce the quality of the database. Accordingly, we require each measurement to be contributed by two different people before it is accepted into the database. Measurements are publicly released only after having been verified in this way, so as to avoid inadvertently influencing verifiers by allowing them to see the initial contributed value. Measurements that have been submitted only once are noted in the public data as having been submitted, but the values are not given.

Raw data is on the level of individual specimens, and is recorded separately for left and right elements: sternal plate, scapulocoracoid, humerus, ulna, radius, metacarpals, manual phalanges, femur, tibia, fibula, metatarsals and pedal phalanges. For some elements, only the length is taken; for others, more measurements are recorded: for example, femur measurements include length, minimum circumference, midshaft mediolateral width and midshaft anteroposterior width. Of course, most specimens do not include enough preserved material to allow measurements to be made for all relevant elements, so the measurement matrix is very sparse. At the time of writing, one of the most active topics of discussion on the blog is how best to cope with missing data in the various analyses that we intend to run: in this, as in many other matters, the involvement of our contributors puts us in a much better position to apply optimal techniques than we would otherwise be.

At the time of writing, the database contains measurements for 1,659 specimens, of which 507 were personally measured by contributors and the other 1,152 taken from the literature. Of the latter, all but three have been independently verified, and 346 of them double-checked. Aside from personal measurements, the remainder have been harvested from 220 publications. These vary from data-rich papers such as Tumarkin-Deratzian (2009), which contains measurements for 126 specimens, Carrano (2006) (94 measurements) and Maidment *et al.* (2008) (84 measurements), all the way down to the 102 papers that contain measurements for only a single specimen each. It is encouraging to find that the papers that include the most measurements are largely recent ones.

The impressive tally of 1,659 specimens is not quite an accurate representation of the data: some specimens have multiple entries for different bones – for example, because the different bones were described in different publications; in other cases, specimens that have been renumbered or transferred to different collections appear under more than one specimen number. Deduplication is currently under way. Also in progress is the combination of multiple specimens into whole-species records by averaging measurements taken from adult specimens: some analyses will use the per-specimen data and some the aggregated per-species data.

About the contributors

At the time of writing, the data collection phase of the project is essentially complete. Contributions to the database have been made by 46 separate people, all of whom will be given the option to be listed as co-authors on the paper. (Although this is an unusually long authorship list in palaeontology, it is dwarfed by some papers in other sciences: King (2007) showed that the number of papers with 50, 100 and 200 authors is on the increase, with 131 papers published in 2005 having more than 500 authors.) Contributors have widely differing backgrounds, though mostly with some science component: among the most active are professional palaeontologists like Andy Farke and Matt Carrano, but also a database manager for a health-care IT company, a biology student specialising in feather development, a librarian specialising in geology and chemistry, and a camera salesman who also sculpts dinosaur models for museums. (Interviews with some of these people are available on the ODP website.)

On the negative side, nearly half of the participants have provided measurements for fewer than ten specimens. It's not clear what we could or should have done to encourage more wholehearted participation. We might have established a threshold number of contributions necessary to earn an authorship, but that would seem to go against the principle of openness: all contributions are valuable, after all. If the long tail were longer, then numerous contributors providing just one or two sets of measurements each could be very important on aggregate; as it is, 90% of the data was provided by just the top 13 contributors. A more positive perspective is that these 13 are mostly people who would otherwise not be involved in palaeontology, for whom the ODP presents a unique opportunity.

Into the future

The ODP is not the last word in crowdsourcing palaeontology. In fact, to the best of our knowledge, it is the first that is open to the general public; and our fondest hope is that it will catalyse other efforts that greatly surpass its achievements. Once the paper is published, we will sit down and post-mortem the project: figure out what we did right, what we got wrong, how we might have communicated better or made better use of our volunteers. It's too early to do that at this stage, with the analyses yet to be run and the paper yet to be written, but we do have some sense of what we hope to see happening in the wake of this initial open dinosaur project:

- First, of course, we hope to discover new and interesting insights into the bipedal-quadrupedal transitions within Ornithischia, write them up and illustrate them clearly, and get the paper through peer-review and published.
- We hope that we will find other useful ways to use the limb-bone measurement database, and that other workers will find yet further uses for it beyond those that we have envisioned ourselves.
- If there is appetite for it, we may well follow up the ornithischian gait project with further projects under the ODP banner: perhaps expanding the limb-measurement database to other clades, perhaps tackling completely different problems; hopefully making use again of our existing contributors, and also bringing new people into the fold.
- We want the blog that is being written throughout this project, and the accumulated data-files, to serve as a publicly accessible example of how science happens, what scientists actually do – how data is gathered, collated, analysed and interpreted.
- We hope that non-professional palaeontologists who have dipped their toes into our world by participating in the ODP have learned enough on the journey, and become confident enough, to progress to other projects outside the ODP fold.
- Best of all, we would like to see other palaeontologists learning from our mistakes and successes, and using crowdsourcing in their own work – so that in a few years what we're doing with the ODP will no longer look unusual.

Conclusion

When we launched the Open Dinosaur Project, we did it rather tentatively, not sure how it would be received. We expected pessimism, derision or even hostility from among the ranks of professional palaeontologists, but have been pleasantly surprised at the complete absence of such attitudes. Far from opposing this opening up of science, many professionals have enthusiastically joined in with the data-gathering exercise, and others have offered guidance and good wishes. To be honest, we still do not know for sure that this is going to work; and because everything has been done in the open, we are set up to fail very publicly if we do fail. Still, it seems like a risk worth taking. The ODP is important to us: it's not just about recruiting additional effort into a project, it's about opening up what has traditionally been a rather secretive science, breaking out of the cloisters (Farke *et al.*, 2009). We don't want to work quietly in a dark corner, only to emerge after a few years with findings that we publish in pay-for-access journals that the general public can't read: we want to engage and involve anyone and everyone who cares about science, to bring them into the process and let them share the results.

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MYSTERY FOSSIL 18

The latest Mystery Fossil was sent in by **Jan Ove Ebbestad**, of the Museum of Evolution, Uppsala University. The images below were sent to Jan Ove by the owner of the fossil with a request for identification. Apparently the images have been circulated to 'a number of colleagues' but to date 'no one has come up with a satisfactory suggestion'.

Apart from the images below, all that is known is that the specimen was found loose on the path about 1km southeast of the town of Ferres, which is north west of Nice, France. The lithology appears to be limestone, and the locality in the Alpes Maritimes would perhaps suggest a Jurassic age for the specimen. Apart from that, the only other piece of information we have is that the matchbox in the images is about 6cm long.

As usual, all suggestions will be gratefully received and should be directed to <**newsletter@palass.org**>.

Richard Twitchett


SOLSTICKAN

Sylvester-Bradley REPORTS

Evolution of gigantic tortoises from the Neogene of Europe

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The evolution of gigantism in tortoises (Testudinidae) is often linked to geographical isolation and "island effects", where selection for larger individuals occurs in response to an absence of predators and ecologically limiting factors such as the availability of food resources (Arnold, 1979). Paradoxically, however, the fossil record has shown that peak body sizes were historically more pronounced in mainland continental taxa and coincided with the Miocene–Pliocene transition when the onset of cooler, dryer climates radically altered vegetational regimes throughout key testudinid distributional ranges in Europe, Africa and Asia (Suc *et al.*, 1999).

The European record in particular has yielded numerous examples of spectacularly colossal tortoises – skulls, isolated postcranial elements and at least one near complete skeleton indicating individuals with carapace lengths of up to and exceeding two metres! Because these remains are very well-preserved this project employed them as a model for elucidating the phylogenetic and palaeoecological implications of maximal body-size development in Afro-Eurasian testudinids.

The distribution of European gigantic tortoise fossils extends from the Upper Eocene–Upper Pliocene in France, Greece, and Spain, with all of the present material referred to a single genus, *Cheirogaster* (comprising up to 11 species). Comparisons of postcranial anatomy (see Lapparent de Broin, 2002) have traditionally suggested a close sister taxon relationship with the African giant tortoise *Centrochelys* (occasionally referred to the polyphyletic *Geochelone* complex: see Le *et al.*, 2006), implying dispersal of a common ancestor into Europe some time prior to the late Eocene (the oldest occurrence of *Cheirogaster*) and a long period of subsequent diversification culminating in a speciation maximum during the Miocene (seven recognised taxa). Significantly, this evolutionary scenario contrasts with palaeogeographical reconstructions and recent molecular analyses of modern European testudonans (*Testudo*+*Eurotestudo*), which suggest the absence of an Arabian–Anatolian land bridge until the early Miocene (Rögi, 1999) and thus a probable Palearctic/Asian origin for European fossil tortoise taxa prior to the influx of testudonans from Africa <10 million years ago (Late Miocene: Le *et al.*, 2006).

Testing these hypotheses was in part facilitated by the Sylvester-Bradley Award, which supported travel to Paris, Vienna and Athens to examine the most complete available remains (Figure 1).

Detailed reassessment of these specimens reinforced the traditional view of congeneric homology between *Cheirogaster* spp., but indicated probable species-level differentiation between coeval populations from the eastern versus western Mediterranean. Phylogenetic analysis incorporating both cranial-postcranial data from fossils (based on the pre-existing character matrix of Takahashi *et al.*, 2003) and a nuclear/Mt DNA molecular scaffold for the extant taxa (derived from the comprehensive published phylogeny of Le *et al.*, 2006) placed *Cheirogaster* as a basal taxon (related to *Manouria* and *Gopherus*) within Testudinidae. This result not only confirms a Palearctic/Asian radiation of *Cheirogaster* but also demonstrates that gigantism (defined as body size increase beyond ~one metre) is not lineage specific (*i.e.* phylogenetically controlled *sensu* Lapparent de Broin, 2002); rather it might constitute a more immediate adaptational response to local environmental constraints and/or larger-scale change. Indeed, simultaneous appearance of the most massive *Cheirogaster* specimens (carapace length ~two metres) with other equally gigantic tortoises in Africa and the near East (India: Lapparent de Broin, 2002) could have been prompted by the onset of widespread climatic cooling during the late Miocene–late Pliocene; increased body-size conferring an advantage for maintaining higher metabolic activity (through inertial homeothermy) and/or reflecting a dietary shift towards greater consumption of C_4 vegetation (necessitating a voluminous fermentative gut), which dominated the concomitantly spreading savannah grasslands throughout Mediterranean Europe and beyond.

Acknowledgements
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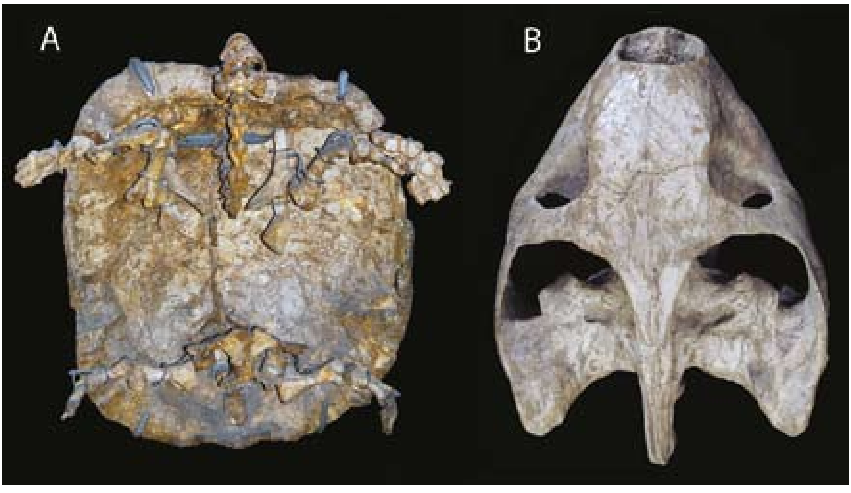

Figure 1. The near complete skeleton of Cheirogaster perpiniana *(A) found near Perpignan in southern France (the carapace is 114 cm long); (B) the massive skull of* Cheirogaster schafferi *(nearly 30 cm long) from Samos, Greece.*

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Myology and biomechanics of the hindlimb and pelvis of Poposaurus gracilis *(Archosauria: Suchia)*

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During the Summer of 2003, a team from Yale University discovered a largely complete articulated postcranial skeleton of *Poposaurus gracilis* (YPM 57100) (Fig. 1) in Late Triassic sediments in the Chinle Formation of southern Utah. This animal represents the most complete poposaur skeleton known to date, and possibly the most complete bipedal suchian archosaur yet discovered (Joyce & Gauthier, 2006). Suchian archosaurs were the largest terrestrial carnivores during the Late Triassic period, and are generally accepted as close relatives of Crocodylomorpha (*e.g.* Brochu, 2001); however, due to the paucity of complete specimens, their relationships, anatomy and biology remain the most ambiguous and poorly understood of all of the basal archosaurs (*e.g.* Gower & Nesbitt, 2006).

Bipedalism is often considered an essential prerequisite to the evolution of nonlocomotor behaviours such as flight or tool use, and thus is one of the more significant changes to occur during the evolutionary history of certain vertebrate groups (Hutchinson & Gatesy, 2001). Changes associated with a shift from quadrupedal to bipedal locomotion can be seen through forelimb reduction, modifications in the pelvic and limb muscles supporting the leg, and changes in the anatomy of the hip, knee and ankle joints allowing for placement of the limbs beneath the pelvis of the animal as opposed to alongside the trunk (Hutchinson & Gatesy, 2001). The release of the forelimbs from terrestrial locomotion may have contributed to the great success of modern birds, and as a result the evolution of bipedalism in the dinosaur-bird lineage has received considerable attention (*e.g.* Hutchinson, 2001). Interestingly, there was at least one other independent evolution of bipedalism within reptiles by suchian archosaurs that is not represented in their extant descendants, the crocodilians. The variation in pelvic and hindlimb anatomy associated with this postural change in suchian archosaurs has largely been neglected due to the lack of quality specimens. The new specimen of *P. gracilis* confirms previous hypotheses of obligate bipedalism for this animal (Mehl, 1915), and the complete nature of the postcranial skeleton allows for the detailed analysis of posture.

The aims of this study were (1) to create a 3D digital model of the postcranial skeleton of *P. gracilis*; (2) to reconstruct and map the pelvic and hindlimb musculature onto the skeletal model, (3) to use the model to establish how the hindlimb muscle moment arms of *P. gracilis* change depending upon the position of the limb (*e.g.* flexed, extended, crouched); and (4) to compare the predicted moment arms for each muscle with that predicted for the homologous muscles of *Tyrannosaurus rex* (Hutchinson *et al*., 2005) and other phylogenetically relevant taxa.

The Sylvester-Bradley Award supported my travel in September of 2009 to the University of Manchester to work with Dr Phil Manning, Dr Bill Sellers and Karl Bates to complete the modelling portion of this study, and to map the muscles of *P. gracilis* onto the 3D musculoskeletal model. A hand-held (Polhemus) laser scanner was used to generate the 3D digital scans of each of the hind limb and pelvic bones. The individual scans were then merged and aligned with the software packages RiSCAN PRO, and MAYA (<**www.autodesk.com/maya**>). The pelvic and hindlimb muscles of *P. gracilis* were reconstructed following the Extant Phylogenetic Bracketing (EPB) methodology of Witmer (1995), which facilitates the assessment of the anatomical composition of soft tissues present in extinct taxa, by analyzing the structure and placement of homologous muscles present in closely related outgroup taxa. The skeletal morphology of *P. gracilis* was used to avoid restoring features that vary greatly from those found in extant relatives (Rowe, 1986), resulting in a model that can be continuously modified as more specimens are unearthed for further study. The muscles were mapped onto the digital model using MAYA, from which we extracted x, y and z coordinates of the origin, insertion and various via points for each of the different muscles. All of the data points were then used to build a 3D biomechanical musculoskeletal model of *P. gracilis* using Gaitsym (<**www.animalsimulation.org**>), a software program written by Dr Bill Sellers. A full manuscript on the results from this research will be produced as a part of my PhD thesis and submitted in the Spring of 2010.

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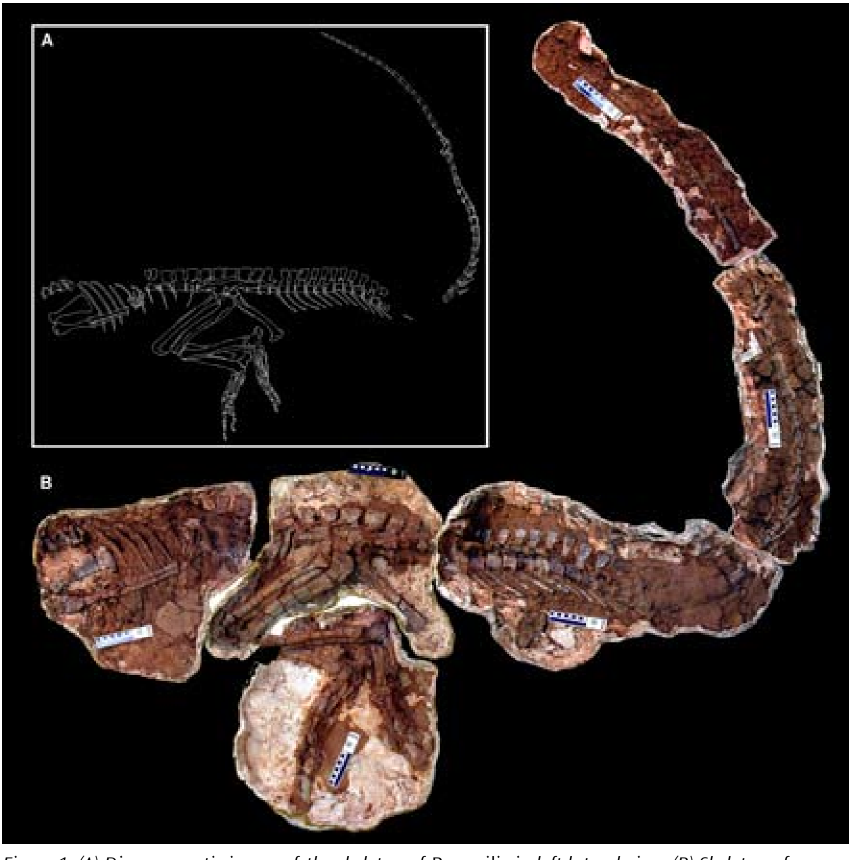

Figure 1. (A) Diagrammatic image of the skeleton of P. gracilis *in left lateral view. (B) Skeleton of* P. gracilis *in original field jackets. Scale bar = 10cm.*

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3D digital documentation of the Paluxy River Dinosaur tracksites (Glen Rose, Texas, USA)

Karl T. Bates

If you want to study dinosaur tracks then there is no better place than the bed of the Paluxy River, Glen Rose (Texas, USA). The site contains of a huge abundance of arguably the best preserved tracks and trackways in the world, including the first definitive sauropod tracks ever recognized (Farlow, 1993). That fact alone has given the tracks significant historical importance, and they attract thousands of visitors to Glen Rose every year. The site was first brought to the attention of the scientific community through the expeditions of Roland T. Bird in the late 1930s and 1940s. The most infamous of Bird's discoveries remains his supposed theropod–sauropod chase sequence. Excavated from Glen Rose in 1940, the parallel trackways are now housed in two separate blocks at the American Museum of Natural History (AMNH) and Texas Memorial Museum (TMM) in Austin. Funding from the Palaeontological Association's Sylvester-Bradley Award allowed me to visit the Paluxy River outcrops and both the AMNH and TMM track blocks in the Summer of 2008.

The aim of the work supported by the Sylvester-Bradley Award was to produce a digital record of the Glen Rose trackways that could be used not only for my own research on dinosaur locomotion, but also to help in the conservation, management and promotion of the sites. The impact of the tracksite as a scientific and public resource has been limited by submergence of the track surface beneath the Paluxy River for much of the year. Data collected will also support a larger collaborative project with Indiana-Purdue University and others in Texas. The long-term goal is to produce an easily accessible palaeontological database, in which historic track site information is integrated with contemporary digital spatial data on existing trackways using modern geographical information systems (*e.g.* ArcGIS). Such a computer archive of maps, photographs, measurements, 3D Digital Outcrop Models (DOMs) and GIS information about the tracksites would enable park managers to document long-term changes in the palaeontological resource. This would facilitate proper planning for preservation and interpretation of the tracks, which constitute one of the prime attractions of Dinosaur Valley State Park (Glen Rose, Texas), and receive more than 165,000 visitors a year. 3D photo-realistic DOMs represent a powerful visualization tool. They may be used for on-site interactive education aids and animations produced for websites and CD-ROMs, and hence would contribute significantly to this scheme.

The Summer of 2008 represented a fairly unique and short-lived window to study the Glen Rose important tracks, as surfaces exposed during the Summer drought were to be cleaned by a team from Indiana-Purdue University led by Professor James Farlow. So, in addition to the logistical opportunity, this window of time also offered the chance to work at Paluxy under the guidance of Jim Farlow, one of the world's leading experts in vertebrate ichnology and a man with some twenty years experience battling the Paluxy River. I was to be ably assisted in scanning by fellow PhD student Peter Falkingham. Having recently been described by NERC's Planet Earth magazine as 'a new breed of palaeontologist', who better than Peter to assist me carrying half a ton of scanning equipment. With the budget tight, timing on this trip was everything. I decided the best approach was to spend several days scanning in Texas, followed by a 'short' trip to the AMNH to scan the second block in the Bird chase sequence. Short was the operative word … three hours to be precise. With no money in the budget for this leg of the trip, the only way to fit in the AMNH was to allow enough time between connecting flights at Newark to dash into New York City (NYC), carry out the scanning and return to the airport in time for the return flight to the UK. Easy … or so we thought.

The first warning sign that this trip was to be less than straightforward came on the outbound trip to Newark. A major low pressure system over the US eastern seaboard forced our plane to land somewhere in Connecticut, where we spent several hours on the tarmac. Eventually we were airborne again and arrived at Newark for our connection to Dallas. The storm, however, had disrupted flights across the US and Newark Airport resembled something of cross between a Brazilian street carnival and a Brooklyn riot. After several laps around the airport, we finally checked in and settled in front of the departure lounge television to pass the time before our flight. CNN reported record breaking temperatures in Texas, with the heat causing people to faint in the streets and even at the wheels of their cars. Temperatures were forecast to increase further in the coming days, peaking at 110˚F. Now, I'm not averse to a little heat and I relish a change from the typically grey and cloudy Manchester ambience. However, scanning equipment is generally not nearly as flexible and the long range laser scanner we were carrying has an automatic switch off at temperatures exceeding 100˚F. We can report to the manufacturer that this automatic switch off works perfectly! After Jim Farlow gave us a short tour around the sites on our first day at Glen Rose, it was mid-day when we set up and far too hot for our long range scanner. Fortunately, we had brought a back up; a short range, hand-held laser scanner, which we'd tested earlier that Summer at the Red Gulch Dinosaur Tracksite in Wyoming (Fig. 1a). Although designed for indoor applications, with a little modification and high-tech environmental controls (Fig. 1a) the unit works really well in the field and produces very tidy high resolution scans of track surfaces (Fig. 1b-c). But to image the sites in their entirety we needed the long range scanner, complete with camera for full photographic coverage. So to beat the Texan heat we were in the field shortly after sunrise the next day to fit in as many hours scanning as possible before the mid-day peak in temperature. These hours of modest heat allowed us to scan two sites at Glen Rose, including the main tracksite (Fig. 2).

On our final working day in Texas we drove south to Austin to TMM to scan the first of the two chase sequence slabs excavated by Bird's team in the 1940s. Unfortunately, the nature of the slab (size, weight, *etc.*) has made it difficult to manage and conserve the trackway. This has meant its potential as a scientific and educational resource has not been met. The tracks at TMM were excavated as part of a 9 m × 3.65 m fragmented limestone slab and were reconstructed on the earthen ground outside the main museum and subsequently enclosed within a single-storey building. Deterioration of the TMM trackway was first reported in 1988. The deterioration, resulting in a loss of surface detail, has several sources. Moisture and soluble salts evaporating up from underlying soil were trapped by a coating of paint that was applied to the track surface during its consolidation in the

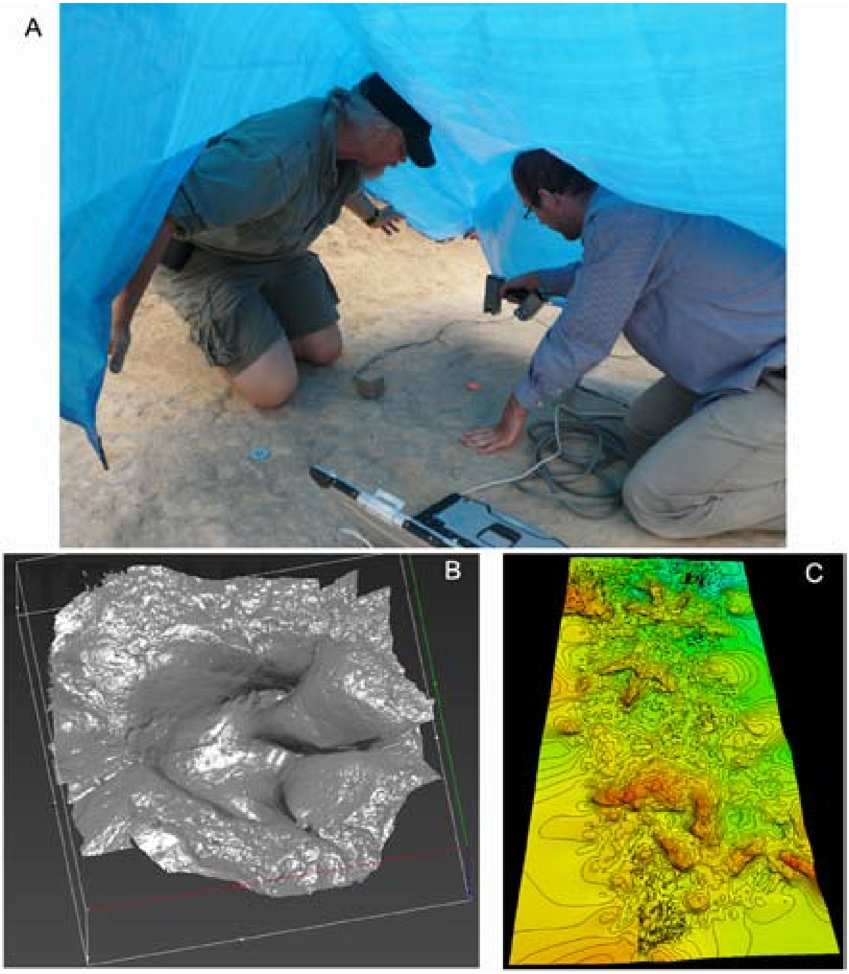

Figure 1. (a) Scanning dinosaur tracks using the hand-held Polhemus laser scanner. (b) Surfaced scan of a large tridactyl track from the bed of the Paluxy River. (c) Surface model of tridactyl tracks colour-coded and contoured according to depth.

building. The salts broke down the stone from the inside out and the trapped moisture eventually lifted off the paint and the limestone attached to it. A leaking roof, windows and inadequate ventilation creates a humid environment ideal for the growth of stone damaging moulds. As of November 2008, a stone conservation specialist has been contracted to test the condition of the tracks and a report is due in 2009. Given that the public has never really seen or understood the significance of the tracks there was little public pressure to improve their conservation. If the conservation of the blocks at TMM is not successful, then the scans we collected (Fig. 3) will serve as the only 3D record of these important tracks. Given that the Paluxy tracks represent the best-preserved sauropod tracks in the world and have type status for the trace fossil *Brontopodus birdi* it is important that they are accurately recorded. Whilst it is important that the tracks are maintained for reference and comparative purposes, it is also essential they be preserved so that the scientific information they hold can be re-evaluated as new methods and analytical techniques become available.

Having scanned the TMM block, then came the daring part of our trip – the dash to the AMNH. Things began promisingly as our flight from Dallas departed on time and favourable weather meant a slightly early landing in Newark. With six hours between our arrival at Newark and the departure of the homeward flight to Manchester we calculated (or rather guessed) that we had around three hours for our New York escapade. Our equipment appeared timely on the conveyer belt and we headed hastily for a taxi outside the airport terminal. Minutes later we were speeding towards NYC.

Figure 2. LiDAR scan of the main tracksite at Glen Rose. The image shows raw point cloud data, in which points have been colour-coded using images from the integrated digital camera.

Then came a question from our taxi driver: 'Where exactly in NYC is the AMNH?' Stunned silence. Our limited local knowledge ('it's next to Central Park') did not impress the driver and his tolerance for two ignorant Brits became clear as he dropped us 'around the corner' from where he believed the AMNH to be. We were 12 blocks away. A second taxi got us and our half ton of scanning equipment to the Museum. Five hours until our homeward flight departure time, two hours to make check-in at Newark on time. We fought our way through the Summer crowds (and Museum security) to the saurischian dinosaur gallery and the chase sequence slab, on display beneath the *Apatosaurus* skeleton. Scanning took a mere half hour, a relieving anti-climax, leaving us time to answer questions from bemused on-lookers. Scrambling back into a taxi we returned to the airport with all the data in the bag and time to spare. Mission accomplished!

To date, the data has been used mainly as an educational and conservation resource (Bates *et al*. 2009b). In particular, scans of the TMM chase sequence slab have proven particularly useful. It has formed part of a petition to TMM and the State of Texas to invest funds to restore, conserve and re-house the trackway before its deterioration becomes irrevocable. The chase sequence data has also been used in recent public engagement events, using the in-house software Virtual Reality Geological Studio (VRGS). VRGS was written to provide a platform for the integration and manipulation of quantitative digital outcrop data (*e.g.* LIDAR) and conventional field-work approaches (*e.g.* facies analysis and logging). The VRGS toolkit also includes a variety of functions specifically designed for rapid interrogation of digital models of vertebrate tracks and trackways, such as automated functions like the calculation of trackmaker speed from track length and stride length (Alexander, 1976). Displayed in VRGS, the digital model of Bird's chase sequence has replaced a roll-out paper trackway display formerly used to demonstrate to the public the kind of information that can be extracted about dinosaurs from their tracks. Whilst successful in the past, the old paper display required a significant amount of space and had to be regularly replaced after being torn by over-enthusiastic members of the public keen to walk in the footsteps of the trackmaker. This allows the Museum visitor to go through a process of scientific discovery, literally step-by-step, learning how fast the predator may have been chasing its prey. The display is currently not stand-alone as VRGS requires operational guidance which at this time is not commercially available. However, the long term goal is a stand-alone display communicating the new data generated about these unique tracks and the fascinating animals that made them.

Future work on the trackway data will largely focus on dinosaur locomotion, with specific emphasis on theropod trackways. Large tridactyl tracks from Glen Rose have been attributed to *Acrocanthosaurus atokensis* (Dinosauria: Theropoda). Detailed morphometric analyses have

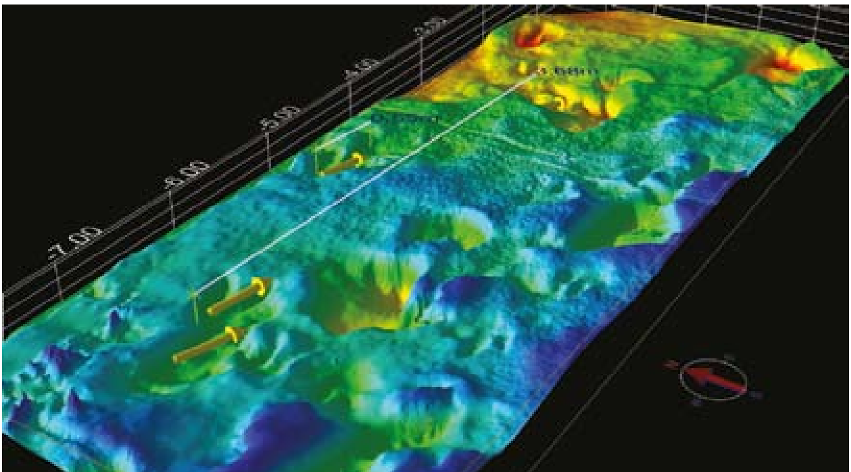

Figure 3. LiDAR scans of the Texas Memorial portion of Bird's theropod-sauropod chase sequence, with selected foot length and stride length measurements shown. In VRGS the model's surface can be presented in a variety of formats to highlight various features in the tracks. Shown here colour-coded according to depth (from Bates et al.*, 2009b).*

shown a clear correlation between Paluxy theropod tracks and the pedal phalangeal proportions of *Acrocanthosaurus* (Farlow, 2001), supporting earlier interpretations of this animal as the track-maker based on qualitative morphological observations and the close stratigraphic occurrence of body fossils (Langston, 1974; Pittmann, 1989). The number and quality of large theropod tracks preserved at Paluxy River provides a unique opportunity to investigate the locomotor dynamics of *Acrocanthosaurus*, one of the largest theropods known from near-complete skeletal remains (Currie and Carpenter, 2000; Bates *et al*., 2009a). To complement the study of the Glen Rose trackways, I have constructed a 3D musculoskeletal model of *Acrocanthosaurus*, which includes all body segment mass and inertial properties necessary to produce a forward dynamics physics simulation (Bates *et al*. 2009a). Gait predictions from biomechanical modelling (*e.g.* speed, stride length, cost of locomotion) will be compared to predictions from trackways, providing important new information on the locomotion dynamics of large theropod dinosaurs.

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Nothing new under *The Sun*

A new year, a new newsletter, a new newsletter reporter. I can't promise anything especially new in the forthcoming missives, but I'll begin with the novelty of being a newcomer to Newfoundland. Even after a year, I've not quite gotten my head around a place that – palaeontologically, geomorphologically and culturally – is both fish-n-chips familiar and whale-watchingly weird. To visit Mistaken Point for the first time was merely to view a more dramatic version of my home haunts of Charnwood, yet also the most exhilarating thing I'd done in years. Its fractal fossils reverted me to over-excited schoolboy mode and even met the approval of my generally unimpressable father, but to find ceramic models of *Bradgatia linfordensis* on sale in the visitor centre shop was just bizarre. Despite their type locality, such things cannot be purchased at the Bradgate Park visitor centre in Newtown Linford. I was only jolted out of my confused reverie back in St John's, when I noticed the Ediacaran fossil display in the Memorial University Department of Earth Sciences claiming that *Charnia masoni* was originally from Nuneaton. That bastion of British prehistory Mary Whitehouse was from Nuneaton; perhaps there had been some confusion.

Elsewhere in the Avalon Peninsula, hunting Welsh trilobites – *Paradoxides davidis* and other Cambrians – on the wrong side of the Atlantic was certainly new, especially when wind chill dropped the temperature to -20. Out on Newfoundland's west coast, meanwhile, trying to pin-point the Cambro–Ordovician boundary in the carbonate breccias of Cow Head was not only new but futile. Thankfully the Carboniferous cold seep fossils of Aguathuna were more readily locatable.

A few months in, I gained a new office mate, a fellow palaeontologist and fellow Brit. Uncertainly, I recalled him winning the Poster Prize at an Annual Meeting; a vague memory of documenting the event in a newsletter meeting report. A consultation of the PalAss online archives to check, and I discovered, yes, I had described his success. Mystifyingly, however, the paragraph preceding his prize-giving had me describing a talk on 'pyritized polecats'. Even by the standards of my usual gibberish, this was strange. Was I being clever and cryptical, alluding to something that made sense at the time, but which has long since escaped my brain? Was I confused by biogeochemistry, just one of many scientific disciplines I don't comprehend to anything beyond a basic level? Or was something else at work? [*Clearly not the Editor – Ed*]

I sat in bafflement. Pyritized *polecats*? It wasn't even part of an obviously jokey sentence. Whatever could I have meant? I was an utter, utter idiot. Then suddenly I figured it out. It was the work of the devil. It was the work of … Microsoft Word spell-check.

I refuse to use the thing now, believing my own ability in ordering letters correctly to be superior to that of an animatronic paper-clip, but I've had my moments. The first salutory lesson of its dangers came from a hydrogeological PhD colleague at Birmingham. Not trusting his English language skills, he set Word to replace automatically any text it didn't like. Thus he submitted a manuscript to his supervisors in which all the boreholes of Birmingham had been replaced by brothels. Elsewhere among the geology postgraduates, ostracods became postcards, which was only understandable if they'd been found at the seaside, and terrigenous muds daydreamed themselves into erogenous moods. As I type now, the spell-checker still wants to make this transformation.

Postdoctorally, my marking of student work brought up some further beauties; the Comley Sandstone of Shropshire was regularly comely; marble and gneiss often metaphoric. There were never any pyritized polecats, though.

Pyritization of soft tissues is rare; environmental conditions need to be high in iron and low in organic matter, and the presence of iron-rich pore waters will allow decay-generated sulphide to be trapped efficiently within a carcass (Briggs *et al*., 1996). As Una Farrell explained in that fateful talk, this process can be invoked for a number of exceptionally preserved polychaetes. Whatever Bill Gates' word-processing programs might want us to believe, it has yet to be demonstrated in mustelids.

Automated computerized alteration of palaeontology is one thing, though. What about when the confusion is caused solely by humans? The media (mis)representation of fossils is something that has graced the pages of this august pamphlet many times previously, but I haven't been made Newsletter Reporter for my incisive originality (or at least I hope I haven't). And anyway, recycling is the future, so this article is at the forefront of green thinking, especially if you don't bother printing a hard copy.

Having taken on responsibility for updating the 'Palaeontology in the News' section of the PalAss website, I am keeping closer tabs on the topic than I've ever done before. So what fossils have been popping up on the media radar?

The online version of the *Chicago Tribune* offered up a gallery recently, documenting 'What's New In Fossils'. This turned out to be: a new Triassic dinosaur; a group of fossilized reptiles known apparently as 'DogCrocs, DuckCroc and BoarCroc'; a new tyrannosaur; a new South African dinosaur; a new small dinosaur; the hominid *Ardipithecus;* a baby mammoth; a Wyoming specimen of *Archaeopteryx;* a new Chinese dinosaur site; a new flying Jurassic reptile; and a new Pleistocene mammal bed in Los Angeles. All fascinating and illuminating, but exclusively chordate. Was nothing new, interesting and backbone-free unearthed anywhere in 2009? Or are invertebrates regarded as simply too difficult to explain to a general audience?

If the latter has any truth in it, this year has already begun inauspiciously. The description by Liu *et al*. (2010) of the earliest evidence for animal locomotion, discovered at Mistaken Point, was exciting, not least from a Newfoundland perspective, and attracted a fair bit of attention. In the *Daily Telegraph* report, however, Ediacarans were described as 'huge ferns that are much less likely to be animal life than the recent discovery'. Not just inelegantly written, but palaeobiologically perplexing to boot. What would the tabloids have done to the story if they'd covered it?

This set me thinking more broadly. Why *hadn't* the tabloids covered the story? What does it take for Britain's most-read newspapers to cover such topics? Broadsheet-reading academics like me never seem to pay the red tops much attention, but they have a much larger audience. If palaeontology is reaching them, in what way is it being presented?

I started with *The Sun*, and was quite surprised to see how often palaeontology gets coverage (type 'fossils' or 'dinosaurs' into their website search engine and you'll see what I mean). Yes, it's generally a bit trite – dinosaurs dominate, palaeontologists are referred to invariably as 'boffins' – but humour comes into it too: the giant fossilized snake *Titanoboa* (the biggest in hissssstory) appeared under the headline "Rocky Bal-Boa!" More encouragingly, *The Sun*'s website offers a few glimmers of scientific hope. 'Hold Ye Front Page' is their online history of the world, and includes some fairly sensible articles about the birth of geology (Hutton Report Leaked), Darwin's theory of evolution (Monkey Nutter), and the first appearance of life on Earth (Ooze That In The Swamp?). Yes there are plenty of mistakes (ammonites in the Cambrian, for example) and I don't know how many *Sun* readers will ever access the articles, but it felt encouraging that someone within the Rupert Murdoch media stable was at least trying to explain Earth history.

Across the Atlantic, Fox News' explanation of a study into elevated incidences of lung cancer in non-smoking females in Chinese coal towns was rather less heart-warming. 'Cataclysm That Killed Dinos Still Taking Lives Today', the online article bellowed, declaring that 'Earth's largest mass extinction … killed more than 70 percent of plants and dinosaurs walking the planet 250 million years ago' and that silica-rich coal being used to heat homes in Yunnan province was 'formed by the same 250-million-year-old giant volcanic eruption … that was responsible for the extinction of the dinosaurs.' Ignoring the suggestion of locomotory plants in the late Permian, I was frankly stunned by the misunderstanding of geological time, the idea that coal was volcanogenic, and the mass death of organisms that didn't yet exist. Numerous others felt the same way, and the comments page was inundated by readers highlighting the glaring factual errors, but nothing was amended.

It reminded me of being in Stockholm when the tomographic microscopy of Cambrian embryos (Donoghue *et al*., 2006) made the news. The website of one local media organization illustrated their version of the story with an image of a dinosaur inside an egg, precipitating urgent phone calls from the Swedish Museum of Natural History. It was quickly removed, but the message was clear: we don't know how to present palaeontology if it doesn't include dinosaurs.

I found myself imagining a new geological time scale. Rather than having the Palaeozoic, Mesozoic and Cainozoic, and further subdividing them into problematical concepts like Cambrian, Permian or Neogene (a recent Canadian news article on meandering rivers and the evolution of land plants placed Devonian in inverted commas, as though it were a debatable noun that only a handful of mavericks ever used), the media would soon be employing this simple tripartite scheme:

> Precambrian and Palaeozoic = The Pre-Dinosaur Period;
> Mesozoic = The Syn-Dinosaur Period (or perhaps just the Dinosaur Period);
> Cainozoic to the present day = The Post-Dinosaur Period.

With this new system, journalists, baffled as to how to crowbar toothsome reptiles into their report, would be able to write, "these fossils, from the Pre-Dinosaur Period of geological time, were probably proto-dinosaurs, even though they lived in the sea and didn't have scales, teeth, claws, legs or even eyes."

As is often the case, I'm being both flippant and pedantic, but it seems apparent that we palaeontologists aren't explaining ourselves very well. We probably pay too much attention to palaeo-coverage in high-impact science journals, broadsheet newspapers and major news websites. This is undoubtedly informative, but it gives a rather skewed perspective. Looking at the circulation figures for British newspapers (ABC, 2010), for example, there are ten times as many people buying the *Sun* (c. 3m) as the *Guardian* (c. 0.3m). *Daily Mail*, *Daily Mirror* and *Metro* readers number in the millions; *Independent* and *New Scientist* readers do not. Regardless of its scientific impact, a palaeontological paper in *Nature* does not bring fossils to a wide audience. Palaeontologists of all kinds need to embrace media of all kinds, including mass-market tabloids, and then harass them into corrections if they get the message wrong.

Easily accessible and easily updated, palaeo-blogs are part of this story, if we can get Average Joe to read and enjoy them. 'Palaeontology, and especially dinosaurs, is quite blatantly the easiest subject to blog about in the world ever' states The Ethical Palaeontologist (2008) and, along with other bloggers like DinoChick, she demonstrates how well it can be done. Maybe what we need next are further well-written, amusing, scientifically accurate blogs, but ones that are produced (or endorsed) by established organizations such as ours. We'll be preaching to the converted to begin with, but perhaps in the long term it will enable us to establish a widely read resource and bypass the confusion filter applied by the non-scientific press.

It must also be worth pursuing the way palaeontology is presented to children, especially on television. A friend of mine with a sedimentology Ph.D. now works at Children's BBC, trying to get earth sciences onto the small screen. 'Humour is at the root of everything we do,' he tells me. 'No matter how dry the subject, if you can make it funny, then you can make it entertaining.' Geology, however, is regarded as boring by most people: 'I battle every day to try and sneak it into shows without people realising it. All they remember is uninspiring lessons about rocks and dusty fossils … but TV has a chance to make something dead come back to life. And that I see as the key.'

Whenever I've worked with school groups, the sheer craziness of the fossil record has found plenty of converts, no matter the period or the environment. Such astonishing variety, such improbably weird creatures, such amazing stories, all can be exploited in the name of inspiring enthusiasm in future generations. I've never been much cop at being serious, so this approach suits me fine, though it has to be grounded in scientific rigour. Being daft should be a serious business.

I have plenty of ideas to start the ball rolling, so here are a couple to begin with. Lars Holmer discussed bad-tasting brachiopods a few annual meetings ago, but the phylogeny of flavour remains to be developed fully. Under the umbrella of exploring their relationship to birds, there's clearly scope for research into whether dinosaurs tasted like chicken. And in our size-obsessed world, I was most disappointed to discover that a search on Google for "the most medium-sized dinosaur species" produced no hits at all. I will therefore be carrying out my own statistical analysis and submitting the results to the highest impact periodical that might publish the findings. That'll be *The Sun* then.

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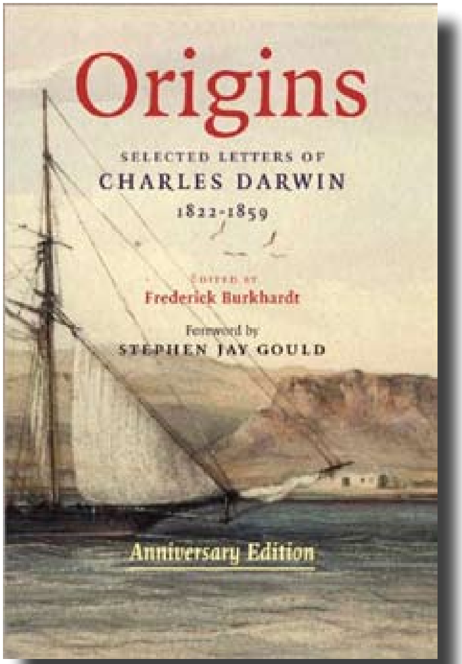
Book Reviews

Origins. Selected letters of Charles Darwin 1822-1859

Anniversary Edition. Edited by Frederick Buckhardt. Foreword by Stephen J. Gould. Cambridge University Press, 2009, 253pp. £18.99. ISBN 978-052189621.



Here is a book that I can recommend for both the Darwin enthusiast and for anyone wanting to know something about his life and thoughts. It contains a very readable and fascinating selection of letters written by Darwin dating from his schoolboy days in Shrewsbury to just after the publication of his *Origin of Species* on 24th November 1859. The letters nearly all come from the first seven volumes of *The Correspondence of Charles Darwin* that were also published by Cambridge University Press (1985–91). Nevertheless this selection offers an insight into Darwin's development from his early insect collecting days into a learned gentleman scientist, his discoveries while voyaging for five years around the world in the Beagle, and his ways of amassing facts for his publications back home in England. The generalities of his travels, his theories and his published work are generally well known but it is still enjoyable to be able to read the letters themselves.

We can see how Darwin came under the influence of the Reverend Professor John Stevens Henslow, who became the catalyst for his scientific work. It is of course generally known that it was Henslow who arranged for Darwin to go with Professor Adam Sedgwick on a geological trip to North Wales where he gained his understanding and enthusiasm for geology. Also that he recommended Darwin to Commander Robert Fitzroy as naturalist and travelling companion for a five year round-the-world trip on the survey ship *HMS Beagle*. It is not surprising therefore to see that many of his letters were addressed to Henslow and it was to Henslow that Darwin sent his collections of specimens from around the world.

Back in England as Darwin began to write his books and papers he started asking an increasing number of people for information – sometimes asking for details that would clearly take the recipients of his letters an enormous amount of effort to gather. Darwin appeared to be obsessed by detail, so there are letters to Charles Lyell about fossils and shells, Henry De la Beche about horse and cattle, John Edward Gray about Cirripedia and animals in domestication, and an increasing number to Joseph Dalton Hooker about plants and their distribution. He bothered his clergyman cousin, William Darwin Fox, for details about a range of subjects and even asked his servant on the *Beagle*, Syms Covington (who was by then living in Australia) for barnacles without knowing if he lived anywhere near the sea. The letters also reveal the increasing friendship between Darwin and Hooker in the way he wrote about his family, his ill health and the death of his baby through scarlet fever. The friendship even survived Hooker's "savage onslaught" in May 1847 when Darwin had through "mental rioting" written to him "be a good boy & make Sigillaria [*an arborescent lycopod*] a submarine seaweed" and by July 1856 even wrote to him "Indeed I do wish I lived at Kew or at least so I could see you more often."

Thomas Henry Huxley and Joseph Hooker were, of course, the defenders of Darwin's *Origin of Species* in the famous debate with the Bishop of Oxford, Samuel Wilberforce, but it is interesting to see that there are very few letters to Huxley in the selection published in this book. Darwin first wrote to Huxley in April 1853 about Ascidiae he had collected in the Falklands and Tierra del Fuego, and later on barnacles. But it was in 1857 that we start to see correspondence on classification and the idea of "natural classification."

As anticipated Alfred Russel Wallace enters the correspondence late on in December 1857 dealing at first with land subsidence and isolation of islands. But then we can read first-hand of the problems Darwin faced in June 1858 in receiving Wallace's manuscript on "Natural Selection". Letters followed in quick succession to Lyell, Huxley and Gray revealing how Darwin was worried about being "forestalled" and "So all my originality, whatever it might amount to, will be smashed" and then his clear pleasure in the outcome when both papers were presented to the same meeting of the Linnean Society writing to Hooker "I am much more than satisfied at what took place at the Linn. Soc^{y}."

The shock of Wallace's manuscript spurred Darwin into finishing his *Origin of Species* and we can read letters sent to Lyell and Hooker about the great length of his "Abstract" and see how he was asking Lyell's opinion on how to go about sorting out the financial terms with the publisher. Then comes his letter to Huxley two days after his book sold out on the day of publication, with 250 orders above the 1,192 available copies, worrying about the Second Edition that the printer wanted immediately. Just imagine having your publisher bothering you for a new edition of your book the day after the first came out – dream on reader.

This selection of letters certainly gives an insight into Darwin's thoughts and actions, and the letters written from the *Beagle* show his enthusiasm and wonderment at what he had seen. But some also reveal much about Darwin's social beliefs, including his loathing of slavery and child labour, and his ideas on educational reform. However, because the letters are merely a small selection of the ones he wrote there were times when I wished there were more about his geological and palaeontological collections and his thoughts on geological processes. Of course the details of such things are in his publications and my frustration at not being able to read the relevant letters must stem from having recently re-read some of his books. The letters read in isolation might confuse a reader not familiar with the details of Darwin's works, but the editor has helped to relieve the problem by supplying notes taken from the original seven volumes. There are also bibliographical notes on Darwin's writings from the years covered by this volume, biographical notes on the correspondents and most people mentioned in the letters, and suggested further reading.

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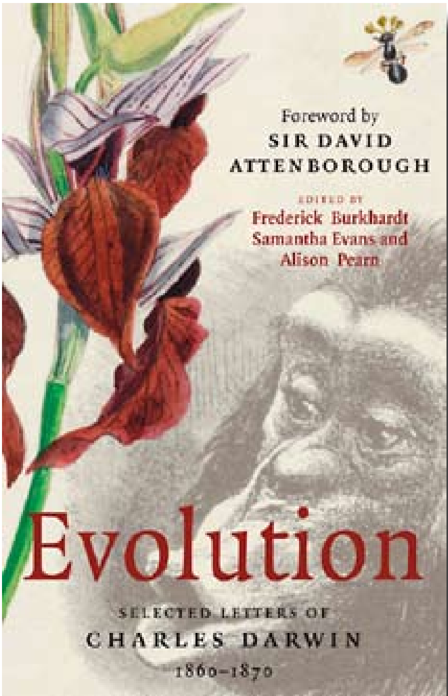
Evolution. Selected letters of Charles Darwin 1860–1870

Edited by Frederick Burkhardt, Samantha Evans and Alison Pearn. 2008. Cambridge University Press. 336 pp. £18.99. ISBN 978-0521874120.



Evolution is a tightly edited volume of correspondence between Darwin and his contemporaries penned immediately following the publication of *On the Origin of Species* up to just before the publication of *The Decent of Man* in 1871, and presents a wholly engaging insight into the machinations of the great man.

Darwin, as Sir David Attenborough reminds us in the anthology's introduction, was an extremely ill man. His poor health and almost absolute inability to travel meant that letters were the primary agents through which he defended his work. The defence of his own ideas, however, is not over-represented in this collection as Darwin's colleagues, including (and especially) T. H. Huxley, took it upon themselves to spread the word, which an embarrassed Darwin was simultaneously delighted and humbled by. But so much is already known. Scarcely six months after *The Origin*'s publication (though two more editions would be rolled out by the end of the year) he was already complaining to Charles Lyell that "there has been a plethora of reviews and I am really quite sick of myself". Suffice to say 2009 would not have been a year favoured by Charles Darwin. By the end of last year the entire country was a C.D. expert and I was fearful that this slight anthology was surely just going to add a little more unnecessary girth to an already swollen sack of books published within the last few months. I was, however, utterly mistaken.

Thanks to the efforts begun by Frederick Burkhardt with Sydney Smith in 1974, all of Darwin's correspondence up to 1867 (some 6,000 of a known 15,000 items) are now available to be searched or browsed through on the Darwin Correspondence Project's website. Through the continuing heroic work of this small team all the known letters recovered, dated and contextualized are also being gradually published as *The Correspondence of Charles Darwin*, which has this year swelled to 17 (of a planned 30) tome-like green volumes. Although an incredible resource for philosophers and historians of science, the sheer volume of material can be intimidating for the casual reader on a lunch break. The genius of *Evolution* is that, thanks to the editing work of Burkhardt and his colleagues, I read ten years' worth of Darwin's most salient letters in just a couple of evenings. *Evolution* is "a clear, accurate, and readable text containing necessary background information; and succinct and eloquent introductory material and annotations" which were the very conditions met by *The Correspondence of Charles Darwin* in 1991, enabling it to receive the Morten N. Cohen award from the Modern Language Association of America. The Tolstoy-esque biographical register (Carpenter, Gray, Haeckel, Hooker, Huxley, Lyell, Sedgwick and some two hundred others) makes keeping track of the who's who of 1860s academia a doddle, and in addition the reader is further supported by excellent introductory paragraphs before most of the letters which help contextualize them within Darwin's personal and political landscape. This is all on top of the bibliographical list of every academic work mentioned in the letters and in addition to the index.

The letters are not ordered in topics as they are on the project's website, but chronologically, resulting in one of the first criticisms Darwin received (from an old entomology rival he had known in Cambridge) kicking things off. As the years progress I found this was the first of only a few argumentative letters included, although this minority helped indicate that the apparent failings of the theory reported were mainly due, at least at first, to semantics. For instance, the perception of the term "Natural Selection" led some to the mystical conclusion that *Nature* was herself selecting intelligently.

Evolution, though, is much more than a book of spite and, indeed, such a collection would soon have grown repetitive and dull. The letters instead cover all corners of Darwin's polymath-like endeavours, and the geneses of the eight works that were to appear after *The Origin*, including *The Descent of Man,* are all present. We find them in the private correspondence between researchers on the facial muscles of hospital patients and in the role natural and sexual selection may have had on the evolution of man. Also included are experimental design protocols written for Asa Gray to perform on carnivorous plants, explanatory notes to gentleman farmers, journalists and amateur naturalists, bemusement at the inferred evolutionary pathways of dwarfs, elves and fairies, and more practical advice for the nineteenth century naturalist such as how not to irritate plate illustrators and how to look after your horse. Don't think there isn't any light relief, though. Joseph Hooker's gossipy account of the bashing Bishop Samuel Wilberforce received at the 1860 Oxford debate is a highlight: "My blood boiled, I felt myself a dastard; now I saw my advantage", which evidently worked out rather well for Joseph: "… and plenty of ladies flattered me".

It's through Darwin's correspondences with Asa Gray that we begin to move into the more intimate aspects of Darwin's family life, including pet names for his son bitten by the collecting bug (though it was stamps not beetles in his pockets) and grave concern for those whose support of *The Origin* may have hindered their own careers (the emigration of John Scott to Calcutta at Darwin's expense is a shocking revelation of the extent to which he felt responsible for anyone's misfortune due to their support of his theory). It's here, in the balance between his genius and his 'ordinariness', that we find the key to the book's success. Between the revealing reports of publishing and experiments, I would turn the page and find a couple still sending love letters after 22 years of marriage, Thank You letters to his daughter Henrietta whose edits probably explain why we can read his works so easily today, heartbreaking replies to bereaved friends, boasts about a luxuriously long beard he was just beginning to grow ("do I not look venerable?"), or sarcastic banter between Darwin and Huxley's wife concerning the merits of Tennyson's poetry.

Evolution tells an engaging story, but for all its humour, tenderness and historical value it was Darwin's subtle but pervasive sense of frustration that affected me the most and is uncomfortably evident in the extent of his illnesses, here laid bare. He was unable to travel to see his old professor of botany on his deathbed and, tragically, his own sister on hers. He suffered from depression, dizziness, problems with vision, vomiting, headaches, exhaustion and at times couldn't even stand to be read to let alone read for himself, whilst on top of this he had to withstand the lashings of a small but vicious group of contemporary academics. He wrote to Hooker "it is painful to be hated in the intense degree with which Owen hates me… I shall never forget his cordial shake of the hand, when he was writing as spitefully as he could against me". He grew weary of researching too heavily on one topic of interest and complained "one has no time for reading anything beyond what must be read: my room is encumbered with unread books". By 1870 he was concerned over Wallace "backsliding from the Darwinian theory" and so ill he was unable to travel even to Oxford to receive an honorary degree. One of the last letters of the collection finds him wishing he "had got a little more strength. I feel that each job as finished must be my last". His isolation in Down House hindered his work, but the palpable frustration in the painstakingly slow accumulation of facts on sexual selection for *The Descent* and behavioural experiments for *Expressions* pales in comparison to his desperate grasping at 'pangenesis' in order to describe a mechanism for heredity. Indeed Sir David Attenborough ends his foreword by lamenting Gregor Mendel's lack of use of the Czech Republic's postal service, and I'm sure anyone reading this excellent collection will at once recognize – perhaps as the editors intended to hint at – just how good we have it now. Waiting over three months to hear of the end of the American Civil War seems as alien to us today as a monk dabbling with the secret of life would have seemed to Darwin.

Finally, it is worth noting that in addition to the restrained editing of the Darwin Correspondence Project staff the book is, of course, carried along by Darwin's pen. Whatever the subject matter, he wrote with a grace (although he wasn't averse to using the odd 'poop-pooh') that makes it hard for us to believe he had – as he maintained – "lost all love for music, poetry and literature". Nowhere is this better exemplified than in the gentlemanly exchanges between himself and A. R. Wallace contained within this volume.

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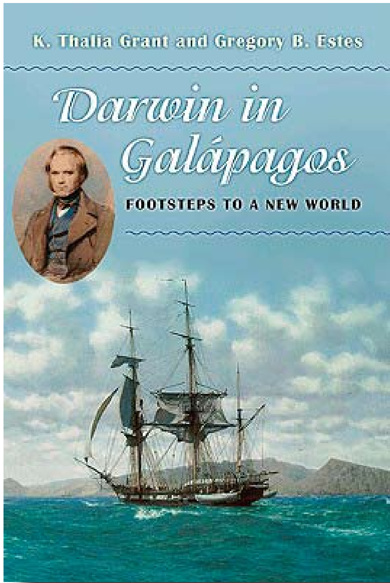
Darwin in Galápagos: Footsteps to a new world

K. Thalia Grant and Gregory B. Estes. 2009. Princeton University Press. 362 pp. 32 black and white plates, 32 colour. $29.95.

The year 2009 marked the bicentenary of the birth of the naturalist Charles Robert Darwin. Numerous celebratory events took place and many publications emerged exploring the broad range of the man's contributions to science. This book provides a welcome addition to that list, focusing on where Darwin went and what he actually collected and recorded during his short stay in the Galápagos Islands in 1835. The extended circumnavigation of the globe during the second voyage of HMS *Beagle* lasted almost five years. Yet for all the emphasized importance of his visit to the Galápagos, Darwin barely spent five weeks there.

The authors broadly divide their book into three parts. The first charts the lead up to Darwin's visit, the second the time he actually spent in the volcanic archipelago, and the third the resultant implications of his collecting and observation there. Much of what appears in the first part is the well-rehearsed story of Darwin's early education and influences. This will be very familiar territory



to Darwin scholars, yet still useful in that there is a strong emphasis on exploring Darwin's development as a field geologist. Furthermore, writing from the Galápagos perspective, we are introduced to the reason why this portion of the voyage was so important. Darwin's travels and collecting in South America had followed in the footsteps of the celebrated French naturalist Alcide d'Orbigny. Darwin felt over-shadowed by this, and writing to John Stevens Henslow in 1832, bemoaned the fact that d'Orbigny would "*… get the cream of all the good things before me …*". The Galápagos provided Darwin with effectively untrodden ground and fresh collecting opportunities, as d'Orbigny had not been there on his travels.

In Part 2, we are taken chapter by chapter, island by island on Darwin's itinerary of the Galápagos. Each chapter begins with a clear map illustration of an island annotated with a timeline of where he was when. Again, the strength of this account lies in the fact that equal weighting is given to Darwin's geological and zoological explorations. Much of what Darwin theorized about geology will probably come as quite a surprise to many. For example, on James Island (Santiago), he collected evidence to support his theory of the generation of different lavas from the same magma through fractional crystallization. Other observations relate to the formation and evolution of tuff cones from subaqueous through to terrestrial settings.

Part 3 provides insights into how the voyage after leaving Galápagos shaped Darwin's thoughts and theories. Effectively he had almost a month before the next projected landfall at Tahiti to sort out, organize and ponder over his collections and notes from the archipelago. This period of reflection allowed Darwin to consider what he had done, and perhaps should have done relating to the sampling intensity and labelling of his collections. Long after returning to England, he encouraged others travelling to the islands to make collections which would augment his own and fill in gaps in knowledge from the places he didn't get to or sample in sufficient depth.

At the back of the book, three appendices are provided for the reader's benefit. The first of these is a useful guide to the names of the sites and various islands of the Galápagos. This covers the names used by those on board the *Beagle*, the additional names in circulation in 1835 and the modern Spanish names now employed. Appendix 2 is a helpful checklist of those biological entities and landforms in Galápagos which bear Darwin's name in honour of his subsequent achievements. The third appendix provides the names of HMS *Beagle*'s complement of crew for the duration of the second voyage.

This represents a useful scholarly work in that it blends historical evidence ground proofed by the authors revisiting the areas that Darwin wrote about in his copious zoological and geological field notebooks. 75 pages of footnote references relating to the main body of the text are an important and valuable resource for anyone wishing to find out more. It will appeal to those with an interest in Darwin as a natural history collector. But more importantly the book provides a fuller picture of the role geology played in providing a framework and background to Darwin's subsequent zoological studies. As Galápagos is now on wildlife and ecotourism destination lists, this book may also serve to prime potential visitors on Darwin's explorations of the islands prior to their own.

The authors present an up-to-date account and draw heavily on Sandra Herbert's (2005) analysis of Darwin as a geologist. Darwin did search for fossils on the Galápagos, following on from his explorations of South America for 'upraised shells', but to no avail. This was valuable evidence for the continental uplift of South America at a time when sea level was thought to be an unchanging global constant. The fact that he didn't find similar fossil evidence of uplift at the Galápagos led him to understand how geologically recent these volcanic islands were. Consequently, this led him to theorize as to the time span over which the mutability of species could take place. Further 'boots on the ground' comment from Grant and Estes fill the reader in on how the islands' ecosystems have changed since Darwin's time. They also outline recent scientific research and conservation efforts in attempts to try to preserve endemic species against the onslaught of alien and introduced invaders.

The great strength of this book is the illustrations which bring to life much of the flora, fauna and landscapes that Darwin saw and wrote about. In particular the 32 colour plates lavishly illustrate the living biota of the Galápagos, with plates 12 and 13 devoted to the distinguishing characteristics of Darwin's mockingbirds and finches. At the advertised cover price for the hardback edition, this represents good value for anyone interested in sharpening up their own knowledge and understanding of why these islands were so important to Charles Darwin.

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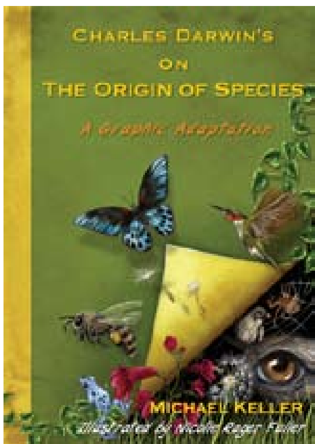
Charles Darwin's On the Origin of Species. A graphic adaptation

Michael Keller, illustrated by Nicolle Fuller. Rodale (distributed by MacMillan). 2009. 192pp. ISBN 1-60529-948-0. US$ 14.98.



There are a great number of books that have been recently published about Darwin's life, ideas and legacy. This one follows a predictable pattern of an introduction to Darwin's voyage and the development of his ideas that ultimately led to the publication of the *Origin of Species*, followed by details of the book itself. But this book is certainly different because it is a comic book. Now I have reviewed many books over the years and some of them have been good, some interesting and some not so good. This one was not only good but it was fun to read. The book centres upon short bursts of Darwin's words with the topics illustrated superbly well by Nicolle Fuller. The chapters on the *Origin of Species* are followed by a time line with Darwin's probable thoughts on later scientific developments right up to the Human Genome Project and Microbe Genetic Diversity.

Make no mistake, this book is not just any old comic. It could very well be the answer to introducing Darwin and his ideas to younger readers, and should be in every school – and I see every reason why every University library should have one as well, to enthuse all those students who know little about Darwin's life and work.

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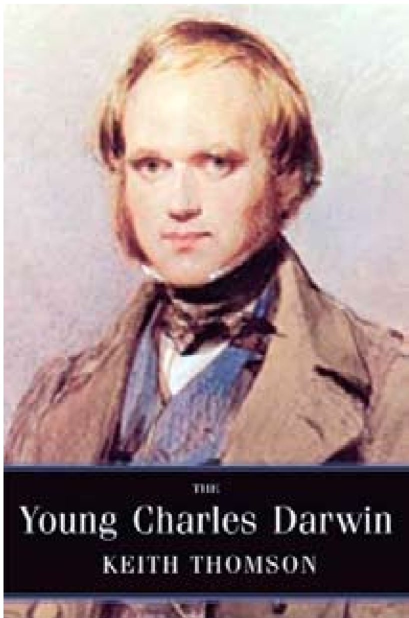
The Young Charles Darwin

Keith Thomson, hardback, 2009. Yale University Press, New Haven and London. 288 pages, 5 black and white illustrations. ISBN 978-0-300-13608-1.

Of the flood of books published in Darwin's bicentennial year, what better one to review than Keith Stewart Thomson's *The Young Charles Darwin*? The author is Professor Emeritus of Natural History, University of Oxford and Senior Research fellow of the American Philosophical Society. Despite impressive academic credentials, Thomson uses an accessible, engaging style and non-technical language that makes his work readable for a wide audience. This book is a much needed examination of Darwin *before* the Beagle voyage – a balanced view which details both genius and flaws. It draws closely on Darwin's original notebooks and autobiography, but is the first account to "inquire into the range of influences and ideas, the mentors and rivals and the formal and informal education."

Thomson usefully splits his book into three parts: 1 – childhood, school and university to January 1831; 2 – Cambridge and *HMS Beagle* 1831–1836; 3 – October 1836 to the publication of *Origin of Species*. It is well laid out with a small but clear font. The narrative could have been weighed down with footnotes on every page but this is wisely avoided. Instead, there are detailed notes at the end with explanations and bibliographic information, quotations from the Notebooks, correspondence and other published sources. The book itself is well produced with high standards throughout. At £18.99, the price is reasonable but may deter more general readers. Spartanly illustrated, more diagrams would perhaps increase the appeal, but this is a very minor point. It certainly does not detract from the text. The chosen illustrations are excellent, beginning with the cover which reproduces a well known 1840 watercolour.



The third figure (p. 194, chapter 16) is extremely well known – page 36 of Darwin's Notebook B where he first sketches his 'tree of life' metaphor for divergent evolution. The facing page shows another more complicated tree of development by Martin Barry (1837) of an idealized pattern of commonality and difference in developmental history. Thomson elegantly discusses this in five pages, avoiding the use of any technical jargon that might alienate a more general reader. The last illustration (pg 224, chapter 18) shows Darwin with his eldest son in an 1842 daguerreotype, the year when he had a working version of his theory and attempted to write a brief summary.

Thomson opens with *HMS Beagle*'s arrival at Falmouth in early October 1836 when Darwin jumped ship, by that time thoroughly sick of both the ship and her officers. The second chapter discusses the great intellectual influence of his paternal grandfather, Erasmus, and his father Robert. It is extremely interesting and could have been extended slightly since Erasmus Darwin deserves greater recognition. *Zoonomia* (1794) precedes his grandson's ideas by six decades by including a theory of transmutation of species (evolution) with all living forms related to each other in patterns of relationship by descent. The chapter ends with his mother's death in 1817, suggesting the roots of hypochondria stem from this loss. The narrative then proceeds rapidly through a relatively happy boyhood to the end of 1825. Thomson then discusses Darwin's mother in detail and how her death affected his character, producing a compelling case for 'the oddities and inadequacies as well as the positive factors of his adult life.' Chapters four to six detail the Edinburgh years. Professor Robert Jameson became an influence when Darwin attended his course and determined never again to read a geology book or study it in any way. He did, however, receive a thorough grounding in the subject.

The next chapter returns to the transmutation of species and may be of less interest to general readers. It does however tell us more about Erasmus Darwin, the origins of natural philosophy in the eighteenth century and Lamarckism, before bringing the narrative back to Edinburgh in 1827. Chapters eight and nine present an engaging profile of Darwin as a Cambridge undergraduate and a well-heeled amateur naturalist and sporting gentleman. From p. 88: "*To be at Cambridge in 1828 was not to partake of one of the shining moments of the English University system … more of a country club than a place of learning.*" Henslow and the famous British geologists Buckland, Sedgwick and Lyell are introduced, including their religious views and Flood/Catastrophist theories.

The next two chapters see Darwin still in Cambridge, planning an expedition to Tenerife, and then in North Wales with Sedgwick. The subsequent three are concerned with *HMS Beagle* and are particularly well written.

The third part concentrates on what happened from October 1836, the beginnings of medical problems and marriage to Emma Wedgewood (chapter 17). It examines why "*the dashing explorer of the Beagle Voyage became an invalid with more than a touch of hypochondria*." Thomson discusses the stages by which Darwin slowly developed his species theory into a full length book and ends chapter nineteen with the arrival of Alfred Russel Wallace's package sent from Indonesia. The last chapter is short, discussing Darwin's reaction to the manuscript that appeared to match his ideas and subsequent work to finish *On the Origin of Species*. Thomson considers this "the dawn of modern biological science." He is almost certainly right.

In conclusion, I was struck by the benefits Darwin gained from his wealthy family and connections. Readers who enjoy this book are directed to the excellent biography of Darwin's bulldog T. H. Huxley (*Huxley – the Devil's Disciple* by Adrian Desmond, published by Michael Joseph, London, 1994 – ISBN 0718136411) for an examination of the early years of a man with a much humbler start in life.

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- *Patagonian Mesozoic Reptiles* (Life of the Past), by Zulma Gasparini, Rodolfo A. Coria and Leonardo Salgado
- *Fishes and the Break-up of Pangea*, Geological Society of London, Special Publication no 295
- *Modelling Evolution*, by Derek Roff
- *Protogaea*, by G. W. Leibniz, translated by Claudine Cohen & Andre Wakefield
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