The Palaeontology Newsletter

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Reminder: The deadline for copy for Issue no 66 is 8th October 2007.

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

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Association Business

Trustees Annual Report 2006

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

Trustees. The following members were elected to serve on Council at the AGM on 20th December 2006: *President*: Professor M. G. Bassett; *Vice-Presidents:* Dr P. C. J. Donoghue, Dr C. H. Wellman; *Treasurer*: Prof. J. C. W. Cope; *Secretary*: Dr H. A. Armstrong; *Chairman of the Publications Board*: Prof. D. A. T. Harper; *Newsletter Editor*: Dr R. J. Twitchett; *Book Review Editor*: Dr P. J. Orr; *Newsletter Reporter*: Dr A. J. McGowan; *Internet Officer*: Dr J. M. Hilton; *Publicity Officer*: Dr P. L. Manning; *Editors who are also Trustees*: Dr L. I. Anderson, Dr C. M. Berry, Prof. E. N. K. Clarkson, Prof. M. P. Smith (Secretary of the Publications Board), Dr P. D. Polly; *Ordinary Members*: Prof. N. Macleod, Dr T. Servais, Dr J. A. Rasmussen, Dr M. Sutton and Dr G. Budd (co-opted for two years). Dr T. J. Palmer continued to serve as the Executive Officer of the Association, and Prof. D. J. Batten (University of Manchester) as the Editor in Chief.

Membership and subscriptions. Individual membership totalled 1,275 on 31st December 2006, an overall increase of 5 over the 2005 figure. There were 754 Ordinary Members, a decrease of 1; 171 Retired and Honorary Members, an increase of 2; 350 Student Members, an increase of 30. There were 129 Institutional Members in 2006, of which 41 also subscribed to *Special Papers in Palaeontology*.

Professional Services. The Association's Bankers are NatWest Bank, 42 High Street, Sheffield. The Association's Independent Examiner is G. R. Powell BSc FCA, Nether House, Great Bowden, Market Harborough, Leicestershire LE16 7HF. The Association's investment portfolio of Common Funds was managed by Morgan Stanley Quilter, St Helen's, The Undershaft, London EC3A 8BB.

Reserves. The Association holds reserves of £590,699 in General Funds. These reserves enable the Association to generate additional revenue through investments, and thus to keep subscriptions to individuals at a low level, whilst still permitting a full programme of meetings to be held, publications produced and the award of grants-in-aid. They also act as a buffer to enable the normal programme to be followed in years in which expenditure exceeds income, and new initiatives to be pursued, without increasing subscription costs. The Association holds £60,228 in Designated Funds which contribute interest towards the funding of grants-in-aid, the Sylvester-Bradley, Hodson Fund and Mary Anning awards. Funds carried forward to 2007 totalled £650,927.

Finance. Subscriptions raised an income of £66,149. The Association gratefully acknowledges the

donations from Members which amounted to £2,506. Incoming resources from charitable activities included sales of £164,050 and investment income totalled £19,171. Total incoming resources were £251,876. Charitable activities resulted in publication costs of £128,090, sponsoring scientific meetings £24,931 and grants-in-aid £30,187. Administration costs were £22,660 and governance costs totalled £7,901. Investment management costs totalled £19,295. Total charitable expenditure was £183,573. Total resources expended were £233,064.

A new system for allocating Grants-in-Aid was agreed. In future there will be two rounds of funding per year, with application deadlines on 1st March and 1st September. The Association continues its membership of the International Palaeontological Association and remains a Tier 1 sponsor of *Palaeontologia Electronica*.

Risk. As part of the annual review, Trustees have identified two areas of low risk in the forthcoming year. Income from subscriptions to our online publications through Blackwell is unlikely to remain at the current high level. Funds will be made available from General Funds to continue support for our charitable activities. Trustees note that the Association would be exposed if the Executive Officer and Editor-in-Chief were to leave their employment. In this eventuality the Treasurer, Secretary and Chair of the Publications Board would be responsible for the financial, administrative and editorial roles of the officers until replacements could be found.

Council Activities. The Association continues to increase its range and investment in charitable activities, whilst continuing to keep individual membership subscriptions low. Of particular note this year is the increased funds allocated to the sponsorship of scientific meetings through Grants-in-Aid. We have continued to provide funds to support postgraduate students and speaker attendance at international meetings, including: a meeting to recognise the retirement of Dr. J. Galtier ("A life of ferns and seed ferns"); the 7th European Conference of Palaeobotany and Palynology (EPPC 2006); IGCP 503: Glasgow 2006; a symposium on Evolutionary Developmental Biology at the International Palaeontology Congress 2006; a special international symposium organised on the theme "Primitive Life, Ancient radiations," Dijon, France; a Geological Society of America Topical Session on "Extinction, dwarfing and the Lilliput Effect"; the 23rd Argentine Meeting of Vertebrate Palaeontology; and the 8th International Congress of Vertebrate Morphologists. Bursaries were provided for student members to attend the International Palaeontological Congress in Beijing.

Association meetings. Three meetings were held in 2006, and the Association extends its thanks to the organisers and host institutions of these meetings.

The *50th Annual General Meeting* was held on 18–21 December at University of Sheffield. Dr Wellman with much local support organised the meeting. There were 300 attendees. The Annual Address, given at the AGM and entitled "What should go into a systematic description," was given by Prof A. Boucot (University of Oregon, USA) and was attended by 300 people. President's Awards were made to Ben Fletcher (University of Sheffield) and Vincent Williams (University of Leicester). The Council Poster Prize was presented to Xiaoya Ma (University of Leicester). On the final day field trips were undertaken to the Coal Measures of the Sheffield area and the National Mining Museum.

Progressive Palaeontology was held at the University of Cambridge on 22nd June. The annual open meeting for presentations by research students was organised by Susannah Maidment and Laura Porro.

British Association Festival of Science, Palaeontological Association Symposium, the annual forum for presentations to the public and general scientists, was "Life in Extreme environments" organised by Dr C. Little (University of Leeds).

Publications. Publication of *Palaeontology* and *Special Papers in Palaeontology* is managed by Blackwell, who also make sales and manage distribution on behalf of the Association. A new publishing contract with Blackwell was negotiated in 2006 to reflect new online and e-publishing activities. Volume **49** of *Palaeontology*, comprising six issues and 1,378 pages in total, was published at a cost of £64,317. *Special Papers in Palaeontology* **75** "*Silurian and Lower Devonian thelodonts and putative chondrichthyans from the Canadian Arctic Archipelago*", by T. Marss, M.V.H. Wilson and R. Thorsteinsson, totalled 144 pages. *Special Papers in Palaeontology* **76**, *Early Silurian (Llandovery) orthide brachiopods from Anticosti Island, eastern Canada: the O/S extinction recovery fauna*, by R.Y. Li and P. Copper, totalled 72 pages. The cost of publishing Special Papers was £10,541. There were no *Field Guides to Fossils* or *Fold-Out Fossils* for 2006. Digital files of published papers in *Palaeontology* and multi-authored *Special Papers in Palaeontology* were given to authors in addition to free reprints. Reviewers of manuscripts now receive free online access to the appropriate journal for one year. Reviewers of books would receive a free copy of the book.

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

Awards. The Lapworth Medal, awarded to people who have made a significant contribution to the science by means of a substantial body of research, was made to Prof. A. Seilacher. The Hodson Award, for a palaeontologist under the age of 35 who has made an outstanding achievement in contributing to the science through a portfolio of original published research, was awarded to Dr Guy Harrington (University of Birmingham) and Dr Paul Barrett (Natural History Museum). Prof. Chaloner, Prof. Hudson, Prof. Hallam, Prof. Murray, Prof. Whittington and Dr Cocks were awarded Honorary Life Membership. The Mary Anning award, for an outstanding contribution by an amateur palaeontologist, was made to Mr B. Chandler. The Sylvester-Bradley Fund continues to attract a large number of high quality international applications, and awards totalling £10,396 were made. A "Golden Trilobite" award for an amateur website that best promotes the charitable aims of the Association was made to Mr Alan Morton. Council awards an undergraduate prize to each university department in which palaeontology is taught beyond Level 1.

Governance. The Association continues to improve its administration with further improvements to the *Newsletter* and website. The continuing series of primers on numerical analysis and cladistics in the *Newsletter* have been widely acclaimed. A highlight of the year has been the continued provision online of *Palaeontology* (back to volume 1) free to the palaeontological community. During the year the Association website was re-designed. It was agreed that the Association should host a Palaeobiology Database mirror site. A new publicity sub-domain has been developed for the website. Council also allocated resources for 2006–2007, to the Lapworth Museum (University of Birmingham), to sort and catalogue the archive. Significant items from the archive will be scanned and included on the website.

The Association continues to be proactive in generating publicity for palaeontology with major press

initiatives and a continued high profile on television. Further developments have been made to online purchasing of Association publications and meetings registration.

The Association was represented during the year by Prof. Crane and Dr Lloydell on the Joint Committee for Palaeontology. Council is indebted to the Natural History Museum, London and the Lapworth Museum (University of Birmingham) for providing meeting venues through the year.

Forthcoming plans. Council will continue to make substantial donations, from both General and Designated funds, to permit individuals to promote the charitable aims of the Association. In 2007, a similar programme of Association meetings and publications will be carried out. The Annual Meeting has continued to develop as one of the major international palaeontological meetings. A one-day symposium included a programme of internationally recognised speakers. Papers from the symposium entitled "Macroevolution," to celebrate the 50th Anniversary of the Association, will be published in a thematic issue of *Palaeontology*, volume 50(1). Further efforts will be made to promote "Rapid Communications" and review articles for *Palaeontology*. The 51st Annual meeting will be held at the University of Uppsala, Sweden in December, 2007. *Progressive Palaeontology* will be held at the University of Bristol in April 2007. The Association will increase its sponsorship of the Lyell Meeting and will again run a symposium at the annual meeting of the British Association for the Advancement of Science. Grants-in-Aid will be provided to carry out research into palaeontological subjects and to disseminate findings in print and at conferences. Funds will also be made available in 2007 to support the provision of palaeontological workshops. Electronic versions of *Special Papers in Palaeontology* will be produced and Council has agreed funds to scan the abstracts from *Palaeontology* to allow online searching of back issues. Funds will be made available for further development of the website aimed at encouraging outreach, including a members' section, an enhanced amateur section and online worksheets for school teachers. It is intended that one new *Field Guide to Fossils* will be published within the year.

Howard A. Armstrong
Secretary

Nominations for Council

At the AGM in December 2007, the following vacancies will occur on Council:

President (for 2008)
Vice-President
Publicity Officer
Webmaster
three 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 **Monday, 4th October 2006**. They should be sent to the Secretary: Dr Howard A. Armstrong, Department of Earth Sciences, University of Durham, Durham DH1 3LE; e-mail:<**h.a.armstrong@durham.ac.uk**> or via <**secretary@palass.org**>.

The following nominations have already been received:

President (starting 2008):	Prof. R. J. Aldridge (nominated by Council)
Vice President:	Prof. N. Macleod (nominated by Council)
Publicity Officer:	Dr E. Rayfield (nominated by Prof. M. Benton, Dr P. Barrett)
Webmaster:	Dr M. Sutton (nominated by Council)

Ordinary members (nominated by Council): Mr B. Fone, Prof. S. Donovan and Dr C. Jeffrey

Awards and Prizes

Nominations are now being sought for the Hodson Fund, Mary Anning Award and Sylvester-Bradley Award.

Hodson Fund

This Award is conferred on a palaeontologist who is under the age of 35 and who has made a notable early contribution to the science. Nominated by at least two members of the Association, the application must be supported by an appropriate academic case. The closing date for nominations is **1st September**. Nominations will be considered and a decision made at the October meeting of Council. The award will comprise a fund of £1,000, presented at the Annual Meeting.

Mary Anning Award

The award is open to all those who are not professionally employed within palaeontology but who have made an outstanding contribution to the subject. Such contributions may range from the compilation of fossil collections, and their care and conservation, to published studies in recognised journals. Nominations should comprise a short statement (up to one page of A4) outlining the candidate's principal achievements. Members putting forward candidates should also be prepared, if requested, to write an illustrated profile in support of their nominee. The deadline for nominations is **1st September**. The award comprises a cash prize plus a framed scroll, and is usually presented at the Annual meeting.

Sylvester-Bradley Award

Awards are made to assist palaeontological research (travel, visits to museums, fieldwork *etc.*), with each award having a maximum value of £1,000. Preference is given to applications for a single purpose (rather than top-ups of other grant applications) and no definite age limit is applied, although some preference may be given to younger applicants or those at the start of their careers. The award is open to both amateur and professional palaeontologists, but preference will be given to members of the Association. The awards are announced at the AGM.

Council will also consider awards in excess of £1,000, particularly for pilot projects which are likely to facilitate a future application to a national research funding body.

Electronic submission of applications is through the website and will comprise a CV, an account of research aims and objectives (5,000 characters maximum), and a breakdown of the proposed expenditure. Each application should be accompanied by the names of a personal and a scientific referee. Successful candidates must produce a report for *Palaeontology Newsletter* and are asked to consider the Association's meetings and publications as media for conveying the research results. **Deadline: 1st November**.

Golden Trilobite Award

Nominations are sought for the "Golden Trilobite Award" for prestigious websites.

The award is for the best institutional and amateur websites that promote the charitable and scientific aims of the Association, and the promotion of palaeontology and its allied sciences. The award will take the form of a statement of recognition that can be posted on the winning sites. Nominations are sought from the membership, and should be sent to the Secretary at <**secretary@palass.org**> by **1st September**. The websites will be judged by Council members.

Grants-in-aid: Meeting support, workshops and short courses

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

The Baldwin Lecture Series

The Association has initiated a new venture that originates with the generosity of Stuart Baldwin; it is to be called **The Palaeontological Association Baldwin Lecture Series**.

This is a way by which the PalAss can encourage and support lectures on palaeontology and other aspects of the history of life, to be given within the programmes that are yearly put together by Local Geology groups and Natural History societies in the UK, and by Geologists' Association Regional Groups. There are over 50 of these organisations, and the idea is that we will cover the costs (up to £150) and pay a Lecture Fee of £50 to each of the speakers, for some five lectures each year (no more than two to be given by any particular speaker within a single year).

It is up to the societies in question to arrange speakers and then to approach us for agreement. The PalAss does not want to get into the business of approving certain speakers and subjects to the exclusion of others. However, the societies in question have already started to ask whether we have any suggestions, and I shall therefore construct a list of possible speakers and topics that we can offer as possibilities. It will still be up to the soceties to make the approach once a possible speaker is identified, and there is no obligation on the invitee to accept.

Therefore, if you have a talk that you think could be made interesting for a local group, please get in touch with Tim Palmer <**palass@palass.org**> and I will add you to the list. The topic can be strictly palaeontological, or something much wider that involves living things and earth history. It is not our intention to pick nits about the specific palaeontological content. This invitation is aimed at all members: local fossil enthusiasts, students, teachers, university types, *etc*.

If you think you might have a topic (or more than one), and wouldn't mind talking about it for a fee of £50, please get in touch. I shall need the following information:

your name and address
title of proposed lecture(s)
your email(s)

Tim Palmer
Facilitator, Palaeontological Association

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THE PALAEONTOLOGICAL ASSOCIATION Registered Charity No. 276369
STATEMENT OF FINANCIAL ACTIVITIES FOR THE YEAR ENDED 31st DECEMBER 2006

			General Funds £	Designated Funds £	TOTAL FUNDS £	TOTAL 2005 £
Incoming Resources						
Incoming resources from generated funds						
Voluntary income	Subscriptions	66,149		0	66,149	65,646
	Donations	0		506	506	818
			66,149	506	66,655	66,464
Incoming resources from charitable activities						
Sales	*Palaeontology*	144,777				
	Special Papers	12,541				
	Offprints	2,739				
	Newsletters	850				
	Field Guides	2,440				
	Post & Packing	703				
			164,050	0	164,050	159,203
Investment income			16,288	2,883	19,171	19,078
TOTAL INCOMING RESOURCES			246,487	3,389	249,876	244,745
Resources expended						
Costs of generating funds						
for voluntary income	Administration	17,371				15622
Investment management: Stockbroker fees		1,924				1810
			19,295	0	19,295	17,432
Charitable activities						
Publications	*Palaeontology*	64,317				
	Special Papers	3,688				
	Offprints	2,608				
	Newsletters	8,674				
	Field Guides	1,151				
	Post & Packing	1,363				
	Marketing	2,166				
	Management	42,123				
	Total	126,090			126,090	164,535
Scientific Meetings & Costs		24,931			24,931	11,430
Grants		17,071		13,116	30,187	18,724
Admin. of charitable activities		22,660			22,660	0
			190,752	13,116	203,868	194,689
Governance costs	Examiner's fee	350				
	Trustee's expenses	3,473				
	Administration	4,078				
			7,901	0	7,901	8,452
TOTAL RESOURCES EXPENDED			217,948	13,116	231,064	220,573
NET INCOMING RESOURCES			28,539	-9,727	18,812	24,172
INVESTMENT GAINS						
Realised loss		-41				
Unrealised gain		32,057				
			32,016		32,016	43,519
NET MOVEMENT IN FUNDS			60,555	-9,727	50,828	67,691
FUNDS BROUGHT FORWARD			530,144	69,955	600,099	532,408
FUNDS CARRIED FORWARD			590,699	60,228	650,927	600,099

Notes to the Financial Statements for the year ended 31st December 2006

1. Accounting Policies

The principal accounting policies adopted in the preparation of the financial statements are set out below and have remained unchanged from the previous year and also have been consistently applied within the same financial statements.

1.1 Basis of preparation of financial statements

The financial statements have been prepared in accordance with the revised Statement of Recommended Practice applicable from 2005 and include the results of all the charity's operations, all of which are continuing. The incoming resources and resources expended have been analysed under the headings laid down in the new SORP and the comparative figures from 2005 have also been analysed on the new basis.

The effect of events relating to the year ended 31st December 2006 which occurred before the date of approval of the statements by Council has been included to the extent required to show the true and fair state of affairs at 31st December 2006 and the results for the year ended on that date.

1.2 Fund Accounting

General funds are unrestricted funds which are available for use at the discretion of the Council in furtherance of the general objectives of the charity and which have not been designated for other purposes.

Designated funds comprise unrestricted funds that have been set aside by Council for particular purposes. The aim of each designated fund is as follows:

- *Sylvester-Bradley Fund:* Grants made to permit palaeontological research.
- *Jones-Fenleigh Fund:* Grants to permit one or more students annually to attend the meeting of the Society of Vertebrate Palaeontology and Comparative Anatomy (SVPCA).
- *Hodson Fund:* Awards made in recognition of the palaeontological achievements of a worker under the age of 35.

1.3 Incoming Resources

The charity's income principally comprises subscriptions from individuals and institutions which relate to the period under review, and sales of scientific publications which are brought into account when due.

1.4 Resources Expended

All expenditure is accounted for on an accruals basis and has been classified under the appropriate headings.

Charitable expenditure is that which is incurred in furtherance of the charity's objectives. Administrative costs have been allocated to the various cost headings based upon estimates of the time and costs spent thereon.

1.5 Investments

Investments are stated at market value at the balance sheet date. The statement of financial activities includes net gains and losses arising on revaluations and disposals throughout the year.

2. Analysis of Financial Resources Expended

	Staff Costs	Other Costs	Total 2006	Total 2005
Generating Funds	11,804	7,491	19,295	17,432
Charitable activities	44,279	159,589	203,868	194,689
Governance	2,950	4,951	7,901	8,452
	59,033	174,031	231,064	220,573

3. Staff Costs

	Salary	National Insurance	Pension Contributions	Total 2006	Total 2005
Publications – 1 employee (2005 – 1)	23,603	2,381	3,540	29,524	28,117
Administration – 1 employee (2005 – 1)	23,603	2,381	3,525	29,509	28,117
	47,206	4,762	7,065	59,033	56,234

4. Trustees Remuneration and Expenses

Members of Council neither received nor waived any emoluments during the year (2005: nil).

The total of travelling expenses reimbursed to 12 Members of Council amounted to £3,473 (2005: £4,416)

5. Costs of Independent Examiner

	2006	2005
Examination of the accounts	350	350
Accountancy and payroll services	1,050	1,050
	1,400	1,400

6. Stocks

Stocks of Field Guides have been valued by the trustees and are included at the lower of cost or net realisable value.

7. Debtors

	2006	2005
Accrued income – receivable within one year	67,459	48,460
Prepayment re 2006 conference	0	500
	67,459	48,900

8. Creditors – Falling Due within One Year

	2006	2005
Social Security Costs	0	1,545
Accrued Expenditure	39,770	36,162
	39,770	37,707

BALANCE SHEET AS AT 31st DECEMBER 2006

2005					2006
£					£
		INVESTMENTS			
	452,554	At Market Valuation			489,537
		CURRENT ASSETS			
153,893		Cash at Banks	156,127		
12,692		Field Guide Stocks at Valuation	11,541		
48,960		Sundry Debtors	67,459		
215,545		Total		235,127	
		CURRENT LIABILITIES			
30,293		Subscriptions in Advance	32,354		
37,707		Sundry Creditors	41,383		
68,000		Total		73,737	
	147,545	NET CURRENT ASSETS			161,390
	600,099	TOTAL			650,927
		Represented by:			
	530,144	GENERAL FUNDS			590,699
		DESIGNATED FUNDS			
30,475		Sylvester-Bradley Fund		21,543	
20,618		Jones-Fenleigh Fund		21,044	
18,862		Hodson Fund		17,641	
	69,955				60,228
	600,099	TOTAL			650,927

These financial statements were approved by the Board of Trustees on 14th March 2007.

M.G. Bassett – President *J.C.W. Cope – Treasurer* *H.A. Armstrong – Secretary*

Independent Examiner's Report on the Accounts of The Palaeontological Association for the year ended 31st December 2006 as set out in preceding pages

Respective responsibilities of trustees and examiner

The charity's trustees are responsible for the preparation of the accounts. The trustees consider that an audit is not required for this year under section 43(2) of the Charities Act 1993 (the Act) and that an independent examination is needed.

It is my responsibility to:

- examine the accounts (under section 43 of the Act);
- follow the procedures laid down in the General Directions given by the Charity Commissioners (under section 43(7) of the Act); and
- state whether particular matters have come to my attention

Basis of independent examiner's statement

My examination was carried out in accordance with the General Directions given by the Charity Commissioners. An examination includes a review of the accounting records kept by the charity and a comparison of the accounts presented with those records. It also includes consideration of any unusual items or disclosures in the accounts and seeking explanations from the trustees concerning such matters. The procedures undertaken do not provide all the evidence that would be required in an audit and consequently I do not express an audit opinion on the accounts.

Independent examiner's statement

In connection with my examination, no matter has come to my attention:

(1) which gives me reasonable cause to believe that in any material respect the trustees have not met the requirements to ensure that:

- proper accounting records are kept (in accordance with section 41 of the Act) and
- accounts are prepared which agree with the accounting records and comply with the accounting requirements of the Act

have not been met; or

(2) to which, in my opinion, attention should be drawn in order to enable a proper understanding of the accounts to be reached.

Dated: 2nd April 2007

G R Powell F.C.A.
Nether House, Great Bowden, Market Harborough, Leicestershire LE16 7HF

Nominal	Holding	Cost (bought pre 2006)	Value end 2005
£19,000	6 1/4% Treasury 2010	£17,580.14	£20,856.00
£4,700	Treasury 2.5% I/L Stock 2013	£10,145.15	£10,918.00
£13,000	Treasury 2.5% I/L Stock 2011	£32,947.71	£35,343.00
£64,176.46	COIF Charities Fixed Interest Fund	£85,000.00	£85,983.62
804	Royal Dutch Shell B shares	£12,432.00	£14,938.00
600	BHP Billiton $0.5 shares	£4,341.48	£5,696.73
225	BHP Billiton $0.5 shares	£1,628.06	£2,136.27
1,200	Electrocomponents Ordinary 10p shares	£2,817.00	£3,372.00
925	HSBC Holdings Ordinary 0.5 US Dollar shares	£8,138.45	£8,630.00
900	HBOS Ordinary 25p shares	£7,913.49	£8,937.00
1,800	Premier Foods Ordinary 1p shares		
2,400	Premier Foods Ordinary 1p shares	£8,136.48	£7,176.00
600	Premier Foods Ordinary 1p shares		
1,055	Glaxo Smithkline Ordinary 25p shares	£16,608.00	£15,498.00
725	Smith & Nephew Ordinary £0.122 shares	£4,011.14	£3,882.00
775	Imperial Chemical Industries Ordinary £1 shares		
7,000	Ing Global Real Estate Securities Ordinary NVP shares		
2150	BT Group Ordinary 5p shares	£7,787.53	£4,789.00
1,400	Inmarsat Ordinary €0.0005 shares		
1750	Centrica Ordinary £0.0617 shares	£4,027.44	£4,458.00
460	Pearson Ordinary 25p shares	£8,069.00	£3,163.00
1350	Prudential Ordinary 5P shares	£7,063.25	£7,425.00
800	Resolution Ordinary 5P shares	£5,068.10	£5,184.00
650	RIT Capital Partners Ordinary £1 shares	£4,903.90	£5,918.00
750	JP Morgan Fleming Merc. IT Ordinary 25p shares	£5,168.79	£6,735.00
1500	British Empire Sec & Gen Trust Ordinary 10p shares	£5,005.61	£6,848.00
425	Findlay Park Partners US Smaller Companies	£6,158.47	£7,301.00
4450	New Star European Growth Instl Acc Nav	£6,079.59	£7,129.00
5417.67	Aberdeen Far Eastern Emerg Econs Trust	£3,938.86	£5,058.00
1000	Edinburgh Dragon Trust Ordinary £0.20 shares		
2900	Edinburgh Dragon Trust Ordinary £0.20 shares		
3100	Capita Morant Wright Japan B Inc Nav	£5,170.11	£6,139.00
1283.8	COIF Charities Investment Fund Acc Units	£75,000.00	£86,015.88
5,720	M & G Charifund Units	£4,073.00	£73,025.00
	Total	£359,212.75	£452,554.50
	Total Investment Income		
	Interest Receivable		
	Total Investment Income & Interest		

Proceeds (sold in 2006)	Cost (bought in 2006)	Gain realised during 2006	Value end 2006	Gain unrealised during 2006	Income in 2006
			£19,904.82	-£951.18	£1,187.50
			£10,911.09	-£6.91	£254.43
			£35,443.14	£100.14	£841.10
			£81,985.43	-£3,998.19	£4,620.72
			£14,391.60	-£546.40	£400.80
			£5,607.00	-£89.73	£118.89
£2,064.97		-£71.30			£22.63
£3,398.23		£26.23			£220.80
			£8,611.75	-£18.25	£378.48
			£10,188.00	£1,251.00	£340.65
£995.90	£–	£995.90			£–
			£7,242.00	£66.00	£228.00
	£1,110.00		£1,810.50	£700.50	£–
			£14,179.20	-£1,318.80	£485.30
			£3,864.25	-£17.75	£41.40
	£3,045.45		£3,503.00	£457.55	£–
	£7,084.00		£8,172.50	£1,088.50	£–
			£6,482.25	£1,693.25	£255.85
	£4,958.80		£5,348.00	£389.20	£161.39
			£6,203.75	£1,745.75	£184.63
			£3,548.90	£385.90	£126.50
			£9,443.25	£2,018.25	£221.94
£5,003.23		-£180.77			£–
			£6,347.25	£429.25	£20.15
			£9,367.50	£2,632.50	£166.88
			£6,791.25	-£56.75	£57.00
			£7,949.95	£648.95	£–
			£9,140.30	£2,011.30	£–
£4,631.66		-£426.34			£29.81
	£1,103.08		£1,325.00	£221.92	£–
	£3,375.02		£3,842.50	£467.48	£–
			£5,273.10	-£865.90	£7.65
			£97,749.94	£11,734.06	£–
			£84,910.77	£11,885.77	£2,042.13
£16,093.99	£20,676.35	£343.72	£489,537.99	£32,057.41	£12,414.63
					£12,414.63
					£5,206.77
					£17,621.40

news

Palaeontology *goes 'OnlineEarly'*

In response to a rapidly changing publication landscape *Palaeontology* will be taking advantage of Blackwell's OnlineEarly facility. OnlineEarly is a Blackwell Synergy service where fully corrected, fully web-functional and complete articles are published online as and when they are ready, prior to their ultimate inclusion in a print issue. Authors will be made fully aware of this facility when their papers are accepted for publication. Exceptions, however, are papers with new genera and species whose publication is governed by the rules of the ICZN and ICBN. These for the time being will not be published electronically in advance of the printed version. The OnlineEarly facility will be implemented for papers destined for part 6 of volume 50, but already from part 5 individual papers will be distinguished by their respective Digital Object Identifiers (DOIs).

David Harper (Chair of Publications Board) and David Batten (Editor-in-Chief)

SYNTHESYS

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

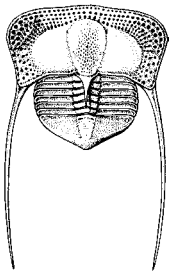
The 11 TAF institutions represent an unparalleled resource for taxonomic research, offering:

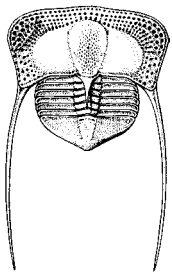
- Collections amounting to over 337 million natural history specimens, including 3.3 million type specimens.
- Internationally renowned taxonomic and systematic skill base.
- Chemical analysis.
- Molecular and imaging facilities.

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

Forthcoming deadlines: 28th September 2007
28th March 2008

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

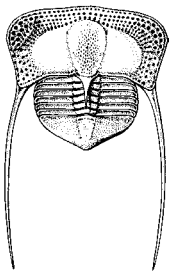




Palaeontology:
CALL FOR SHORT PAPERS!

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

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



ASSOCIATION MEETINGS

PalAss 2007
51st Annual Meeting of the Palaeontological Association
Uppsala, Sweden *16 – 19 December 2006*

Registration and Call for Abstracts

The year 2007 marks the 300th anniversary of the birth of the favourite son of Uppsala, Carl von Linné. As part of the tercentenary celebrations, Uppsala University is pleased to host the 51st Annual Meeting of the Palaeontological Association. The meeting will be organised by the Palaeobiology Group of the Department of Earth Sciences at Uppsala University, in association with the *Evolutionsmuseet* (Museum of Evolution) of Uppsala University and the *Naturhistoriska riksmuseet* (Swedish Museum of Natural History) in Stockholm. We look forward to welcoming you to Uppsala on 16–19 December 2007.

Registration and abstract submission is now open on the Palass Website (<**http://www.palass.org/**>), where the second circular, which supersedes previous information, can also be downloaded.

Meeting format

The Annual Meeting proper will be preceded by a **symposium** on the **Origin of Major Groups** during the afternoon (**starts 13:00**) of Sunday 16th December. The preliminary schedule of speakers can be found below. All talks will take place at the **Uppsala Concert and Congress Hall**. An icebreaker reception will be held on the evening of Sunday 16th December at the **Museum of Evolution**.

The Annual Meeting will take place on Monday 17th December and Tuesday 18th December, also at the **Uppsala Concert and Congress Hall**. The oral technical sessions will consist of talks scheduled for 15 or 20 minutes inclusive of questions. Parallel sessions may be organised as needed. Posters will be displayed throughout the course of the meeting, but a dedicated poster session will also be scheduled during a reception on Monday 17th sponsored by Blackwell Publishing, followed by the AGM and Annual Address by Dr Adrian Lister (NHM, London) on evolutionary aspects of Quaternary faunas.

The annual dinner will take place on the evening of Monday 17th December at **Norrlands Nation**.

In honour of the Linnaeus Tercentenary celebrations, there will be an **excursion** on Wednesday 19th December to several historical sites in Uppsala and Stockholm. The morning will be spent in Uppsala, visiting local points of interest including the Linnaeus Museum, the cathedral, and Linné's summer house (*Linnés Hammarby*) outside Uppsala, followed by lunch in the city. In the afternoon, participants will be transported to the Museum of Natural History in Stockholm. The total cost of this excursion is £30 per person.

Registration and Costs

The cost for early registration for Association members is £35 (ordinary and retired member) and £25 for student members. Non-members pay an added £10, *i.e.* £45 (non-member) and £35

(student non-member), respectively. Early registration ends on **7th September**, after which date all registration fees increase by £15. Abstract submissions will not be considered after this date. Final registration is **14th November**. No refunds will be considered after this date.

The cost of the annual dinner is £35. Registrants also have the option to purchase substantial seated lunches for the two days of the Meeting in advance during online registration, at a total cost of £13 per day. Lunch will take place at the conference locality within the restaurant of the Uppsala Concert and Congress Hall.

The President's Prize will be awarded for the best talk at the Annual Meeting produced by someone under the age of thirty who is a member of the Association. There is a cash prize of £100.

The Council Poster Prize will be awarded for the best poster at the Annual Meeting produced by someone under the age of thirty who is a member of the Association. There is a cash prize of £100.

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

The Palaeontological Association runs a programme of travel grants to assist student members presenting talks and posters at the Annual Meeting. For the Uppsala meeting, grants of up to £100 (or the Euro equivalent) will be available to student presenters who are travelling from outside Sweden. The amount payable is dependent on the number of applicants and the distance travelled. Payment of these awards is given as a disbursement at the meeting, not as an advance payment. Students interested in applying for a PalAss travel grant should contact the Executive Officer, Dr Tim Palmer, by e-mail to <**palass@palass.org**> once the organisers have confirmed that their presentation is accepted, and before 8th December 2007. No awards will be made to those who have not followed this procedure.

Speakers in the Symposium include:

Name	**Topic**
Dr Anthony Poole (Stockholm, Sweden)	Origin of life
Dr Greg Edgecombe (NHM, UK)	Origin of crown-group arthropods
Dr Andrew Smith (NHM, UK)	Origin of echinoderms
Prof. Per Ahlberg (Uppsala, Sweden)	Origin of tetrapods
Prof. Else Marie Friis (NRM, Sweden)	Origin of angiosperms

Updates will be posted on the website as available.

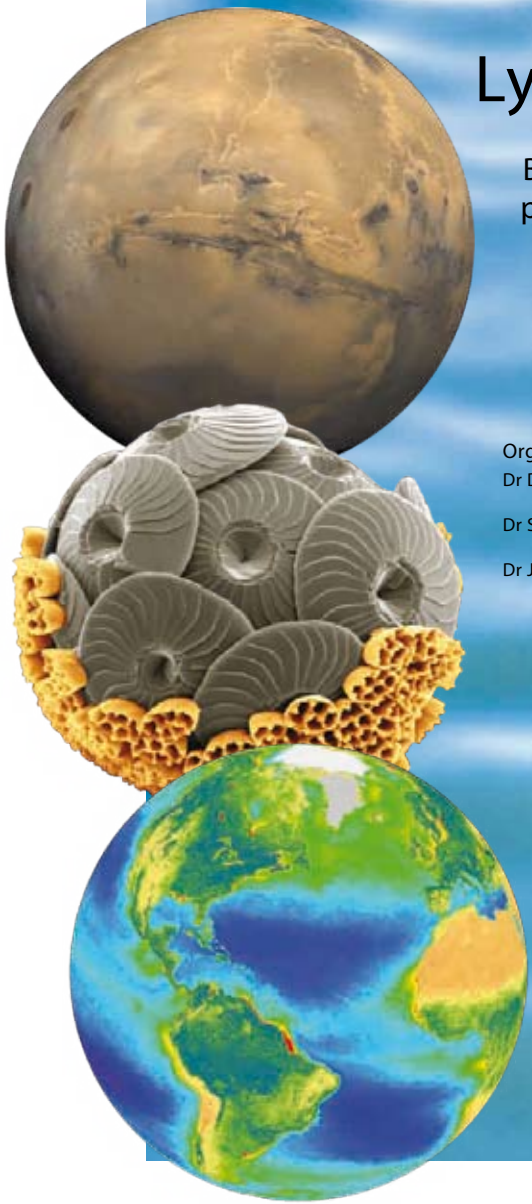
Meeting organiser

Dr Graham Budd
Palaeobiology Group, Department of Earth Sciences
Uppsala University
Contact: <**Uppsala2007@palass.org**>

Summary of dates and costs

1st July 2007	Early Registration opens	Early Registration fees: Ordinary member £35 Student member £25 non-member £45 student non-member £35
7th September 2007	Early Registration ends Late Registration begins	Late Registration fees: Ordinary member £50 Student member £40 non-member £60 student non-member £50
7th September 2007	**Abstract Submission Deadline**	
14th November 2007	**Registration Deadline**	
16th December 2007	• Symposium on Origin of Major Groups (13:00) • Icebreaker Reception	Included in registration
17th December 2007	• Technical Sessions • Poster Session and Reception by Blackwell Publishing • Annual General Meeting • Annual Address	Included in registration
17th December 2007	Annual Dinner at *Norrlands Nation*	Annual Dinner: £35
18th December 2007	Technical Sessions	Included in registration
19th December 2007	Linnaeus excursion	Excursion fee: £30

Marine climate change
past and future



Lyell Meeting 2008

Bringing together the science of past and present climate change to inform about the future

20 February 2008
The Geological Society,
Burlington House,
London, UK

Organisers

Dr Daniela Schmidt (University of Bristol, The Micropalaeontological Society)
Dr Sarah Cornell (University of Bristol, Challenger Society for Marine Sciences)
Dr Jennifer Pike (Cardiff University)

Themes

Ocean acidification
Temperature
Sea level
Climate active gases
Sea ice
Climate change policy

Confirmed Speakers

Henk Brinkhuis (Utrecht University)
Carol Turley (Plymouth Marine Laboratory)
Caroline Lear (Cardiff University)
Carol Robinson (Plymouth Marine Laboratory)
Robin Edwars (Trinity College Dublin)
Jeremy Young (Natural Histroy Museum)
Peter Liss (University of East Anglia)
Xavier Crosta (Université Bordeaux I)
David Vaughan (British Antarctic Service)

The Geological Society

www.geolsoc.org.uk

From our Correspondents

The Lost Column

Which opus gets top vote for prehistory in the public eye? I'd make a guess at Sir Arthur Conan Doyle's *The Lost World*. It's certainly the opus that I remember the most vividly, not least in the peculiarly vivid colours of the *Eagle*, a species of comic that has itself become extinct. For a few months, for us schoolkids, this adaptation edged out even the derring-do of Dan Dare and his faithful sidekick Digby as they averted, once more and again, the evil Mekon's attempts at galactic domination.

As a story, *The Lost World* was made to be converted into a comic strip. There were the contrasting physiognomies of the Professors Challenger and Summerlee, each a quite distinct species of scientist (no interbreeding of minds there). The more typically heroic profiles, also, of Lord John Roxton, both worldly-wise and jungle-wise, and of Edward Malone, cub reporter. The landscapes a gift for cartoonists (of the old school, naturally): all pinnacles and precipices, caves and swamps and tropical rivers. And, of course, the dinosaurs (*sensu lato*), with that neat symmetry of that pterodactyl, glimpsed first swooping over the campfire to filch the roast, and then, in the final pages, its kin making a final break for freedom from the Queen's Hall in London[1].

Quite rightly the book was a mighty success, and probably was more guilty than the average melodrama of influencing the popular perception of the past. It was flattered most sincerely by extensive repetition. There were books (Viktor Obruchev's 1915 *Plutonia*, for instance, placing the dinosaurs in a world beneath Siberia; and much later the direct crib of the original title by the climatologically infamous Michael Crichton). There have been films and television series, and of course that comic strip. So, how does the book now read to a more jaundiced and contemporary eye?

Re-reading the original novel, the catalogue of improbabilities becomes a delight in itself. First, the central conceit, that there exists a land, cut off from the rest of the world since the time of the dinosaurs. This plateau – named Maple White Land in the book after the luckless explorer who found it and then conveniently expired – was seemingly modelled on some combination of the Roraima plateau in Venezuela, while, according to Ian Duncan (1998) it also had its roots in the lost Eden – a 'steep wilderness … grotesque and wild' – of Milton's *Paradise Lost*.

Of whatever parentage, it seems now to represent an implausibly long spell of geographical solitude, a standard science fiction impossibility that nevertheless serves nicely as literary device to confront man with monster. To have a plateau standing for 65 million years? That interval seems long enough to erode the hardest of rocks; but, it is one that is only apparent in a contemporary perspective. The geological timescale these days seems almost hardwired within earth scientists, only occasionally being fine-tuned by a percentage point or two, as the

[1] Striking a blow for the downtrodden workers in the process, in precipitating the fall of the Duke of Durham into the orchestra pit during the melée.

geochronologists conjure a more refined isotopic ratio from some fossil-draped volcanic ash layer or other.

The Lost World was, though, published in 1912, a quite different era in geology. Conan Doyle was writing at a time when such a numerical timescale was to all intents and purposes non-existent, and one of the great debates was the age of the Earth. The battle lines were drawn between an assortment of largely stratigraphical geologists, working out an ever more complex history of the evolution of life and landscape, and demanding hundreds or thousands of million years for this history; and the physicists and astronomers, symbolized by the redoubtable Lord Kelvin, who modelled the cooling Earth (and cooling sun) into ages that were at least an order of magnitude smaller. Estimates of the age of the Earth in the late eighteenth century thus ranged from some three million years to fifteen billion years (Knell and Lewis, 2001).

Henri Bequerel's discovery of radioactivity in 1896 did not immediately lead to an appreciation of an extra heat source for stars and planets (Lord Kelvin never really accepted it as such), nor to widely accepted radiometric dates. After all it is one thing to establish that certain types of atom were breaking down, but much harder to work out what they broke down *into* (the complexities of long decay chains took a little while to unravel) or to establish that radioactive decay is constant and is unaffected by extremes of temperature or pressure. It was only in 1907 that Bertram Boltwood, working in America, demonstrated that the breakdown product of uranium was lead, and not radium, the latter turning out to be an intermediate decay product[2] (Lewis, 2001).

So, Conan Doyle, even if he did keep up with the geological controversies of the moment, would have felt quite free to have his menagerie floating freely in the mists of time, particularly when placing his ancient Eden in the jungles of South America, a place as remote, then, to most people in space and geography as the Mesozoic era was in time[3].

Maple White Land was more than a backdrop for the action, a habitat for the saurians. It has some intriguing geology in its own right. There is, to be sure, a fine literary ambiguity about the rock composition of the plateau. The cliffs are clearly stated to be red (though in places 'chocolate-brown'), and yet equally plainly in the text and on the hand-sketched map in my edition are said to be of basalt, that is generally darker-hued in exposure. Basalt is clearly a good choice, for the columnar jointed structure would help ensure a fine unscaleable cliff. Indeed, we have it on the authority of none other than Professor Summerlee that the 'whole formation is, of course, highly volcanic'. The good professor even notes that the whole of the plateau slopes down to a central crater lake; and hence none of the drainage went over the sides to erode valleys that might allow connection with the surrounding land.

Lord John Roxton, more financially-attuned than the good professor, went one better. He thoughtfully noted blue clay around the central crater lake and (in the written equivalent of a stage whisper) scouted around it, between and after the various perils and adventures. His haul of diamonds, revealed at the book's denouement, indicates the centre of the Lost World as coincident with a kimberlite pipe.

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[2] A radioactive herring, one might say.

[3] He indeed consulted on these mysterious landscapes the intrepid explorer Colonel Fawcett, a man who subsequently acquired perhaps even greater fame in death than in life, after he vanished without trace in the South American jungles on his final expedition.

Now that does make for drama, and one J. Phipps Morgan might sit up and take notice at this point. The connection with the basalt may not be coincidence. For Maple White Land sounds like a good candidate for the remnants of a major flood basalt province, erupted on to the surface after a mantle plume impinged like some vast blowtorch on to the underside of the South American continent. The eruption of diamond-bearing kimberlites is another phenomenon that has been linked with the upwelling of the plumes. The field relations suggest that the kimberlites here are younger than the basalt – they cannot be otherwise – and therefore resident dinosaurs of *The Lost World* might just have been the luckiest – or perhaps the most thick-skinned – on Earth.

Now, no human has ever seen a kimberlite eruption. The most recent of these seems to have been mid-way during the Tertiary (Sparks *et al*., 2006) – and no geologist has ever found the surface-erupted ash deposits from one. But given the modelled rate of ascent of the gas-hypercharged magma, it must have been a spectacular and fearsome sight, with the final jet likely dwarfing even that of a Plinian supervolcano. Kimberlites are certainly exceptional phenomena, comprising links – expressed most violently – between the Earth's surface and its core (Haggerty, 1994).

Some scientists have gone further, treading – and indeed self-consciously so – into the territory of Conan Doyle and Jules Verne. The redoubtable J Phipps Morgan and his colleagues, in 2004, speculated that the greatest of such eruptions may have mimicked the effects of a meteorite impact, extinction event, melt microspherules, shocked quartz, nanodiamonds and all – and further, intimated that one might have gone off just exactly at the K–T boundary, to fool us all.

Their reconstructed kimberlite eruptions admittedly used end-of-the-range estimates of scale. The phenomenon started from a pool of gas-charged magma pooling beneath some eighty kilometres thickness of lithosphere. It then punched through, as a jet that may have reached a speed of a kilometre a second as it broke the surface[4]. They envisaged such a jet carrying with it a column of lithospheric material that, impacting thousands of kilometres away, would have hit the ground like … well, a meteorite.

It's a wonderful idea and the authors, sensibly, took care to state that it might be a *far-fetched* wonderful idea. They called these imaginary hyper-eruptions 'Verneshots', after Jules Verne's description of the mighty gun, the Columbiad, used to propel the intrepid trio of Impey Barbicane, Captain Nicholl and Michel Ardan on their journey *Around the Moon* – not forgetting their two loyal dogs, Diana and the luckless Satellite; the latter foreshadowed poor Sputnik-entombed Laika, perishing in outer space.

So perhaps Conan Doyle, with his unmatched deductive powers[5] and his eye for melodrama, stumbled upon a literally Earth-shattering K–T Verneshot… That would make for a fine cinematic spectacular, the ultimate disaster movie for sure. A scriptwriter, pursuing such a scenario, might well have one or two problems to solve in developing this notion, though. How would the local dinosaurs have survived? Well, perhaps they sheltered in the caves within the basalt (these may have been lava tubes, given the good professor's volcanic diagnosis, and were later used as shelter by the much put-upon tribes-people of Maple White Land) for the brief but highly explosive duration of a kimberlite eruption.

[4] Sparks *et al*. (2006) took a more conservative 200 metres per second as representative. That's still pretty fast.
[5] Honed, of course, by long acquaintance with his creation and alter ego Sherlock Holmes.

What of these survivors? They are the motliest of crews. Explicitly referred to the Jurassic by our learned professors, they include *Iguanodon*, a *Megalosaurus* – good Cretaceous Wealden taxa both, a *Stegosaurus*, and the aforementioned pterodactyls, in a whole flock – or perhaps it should be coven?[6] There are fresh-water ichthyosaurs and plesiosaurs, and a 'great white nocturnal thing' in the depths of a swamp.

Conan Doyle, through the words of the clean-cut Edward Malone[7], took quite a stance vis-à-vis the dinosaurs. He was utterly repelled by them. In the book, the prehistoric crew are the bad guys, without exception. Wonders of nature? Not the remotest chance. The pterodactyls are – to take a few sentences at random – a "crawling flapping mass of obscene reptilian life" that possessed a "mephitic, horrible, musty odour that turned us sick" and had "bloodshot, goggled eyes, like some devil in a medieval picture". The *Megalosaurus* fared no better, with a "horrible mask like a giant toad's, of a warty leprous skin, and a loose mouth all beslobbered with fresh blood".

Part of this might have been that good old literary device of making the reader's flesh creep like billy-o, a standard way of packing in the paying punters. But the piling on of the adjectives suggest a genuine, almost tribal disgust at these creatures that represent polar opposites both to human civilization and to the notion of progress (including, it seems, evolutionary) as self-evidently a good thing.

This stance is, to be fair, commonly taken vis-à-vis dinosaurs. It exactly parallels that seen in the dinosaurs of Jurassic Park (smarter, but bad hats all the same) and in the strongly dinosauric aliens of the *Alien* films. The only possible response to such creatures is to shoot-'em-up, for the world is better off without them. Conservation? Pshah! – the very notion…

It gets nearer the knuckle[8] once we move into the territory of the primates. Maple White Land is also shared by the noble, but oppressed indigenous humans, and by their oppressors, the savage and murderous ape-men ("shaggy red-haired creatures … horrible to look upon"), who delightedly hurl human captives to their doom off the bounding cliffs of the plateau. So, no kindred representatives of humanity, these. One had to wait for William Golding's *The Inheritors* to realise that *Homo sapiens* might compare with, say, the Neanderthals, much as the chimpanzee compares with the bonobo monkey: chimps typically settle differences by fighting, for instance, while the gentler bonobos adopt more sensual means of conflict resolution. The meek do not, by and large, inherit the Earth. Here, our gallant quartet help the native humans deal with the ape-men in a way that Jared Diamond (in his splendid *Guns, Germs and Steel*) has described as so depressingly typical of human intra-species competition: massacre, and the enslavement of the survivors.

Conan Doyle took much of his dinosauriana from one of the several popular books written by Edwin Ray Lankester, on *Prehistoric Animals*. Did he get the vituperation from the same source? I haven't tracked the book down yet, but I'd be surprised. Lankester was one of those late Victorian natural historians (a protégé, like Darwin, of John Henslow) who ranged far and wide.

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[6] Conan Doyle used the word 'rookery', slandering by association – given his remarks detailed below – this intelligent, sociable and gentle corvid taxon.

[7] Faithful to his uncaring Gladys to the extent of insisting on naming the central lake after her. 'Boys will be boys', as said Challenger in response to this gesture of dumb servitude. Quite.

[8] Which, of course, is closely adjacent to the opposable thumb.

His *Some Diversions of a Naturalist* (1915), for instance, deals with amber and with the strange luminescence produced by quartz; on the curiously persistent idea that barnacles gave rise to geese (the original canard, this, and learnedly expounded *inter alia* by no less a figure than the first President of the Royal Society); on dance in animals and in Anna Pavlova; on luminous sand-hoppers (doomed, alas, as their light emanates from bacterial infestation); and – of particular delight to me – a beautiful account of the colonial hemichordate *Rhabdopleura*, dredged from the depths of a Norwegian fjord.

He had made the journey specially, and studied the beast minutely and, for the time, definitively (Lankester 1884); it was a little wonder of observation and, foreshadowing the contemporary controversy over their better-known extinct relatives (graptolites: animal architects or not?), Lankester was quite clear that the little rhabdopleuran zooid constructed its own living tube. In his popular book, he added how, years later, he was in the basement of the Natural History Museum, unpacking cases among material dredged from the sea floor during Captain's Scott's Antarctic 'Discovery' expedition. There "jumped to his eyes" a "large and remarkable" new species of the allied genus *Cephalodiscus*.

That apart, Lankester's tone was rather one of wonder and delight in the natural world, no matter how creepy or crawly; it's a world away from Conan Doyle's revulsion over the saurians. Still, Lankester and Conan Doyle were friends. Lankester liked Conan Doyle's creations and wanted more of them, urging the novelist to include a sixty-foot snake, a *Toxodon* (an ox-sized rabbit-like beast) and pygmy elephants into the cast-list. Did he realise that he (and his hero Huxley) – combative, outspoken, passionate about their science, both – had equal shares in inspiring the character of Professor Challenger? Or at least so Lewis Feuer opined in 1979. In physiognomy Lankester seems to have lacked Challenger's barbarous chin, though he did possess the girth. Lord Walston as a child remembered him as "a very fat man with a face like a frog" [9]. That's also in Feuer, who, though, was mainly concerned with Lankester as the only scientist that Karl Marx ever grew close to. This suggests that there was something quite special about the man, because Marx generally kept within a small circle of friends – Engels and others – who shared his background and politics. And their friendship persisted even though Lankester's view on progress in the biological world (characters or organisms could 'degenerate' through time – become less complex or "adapted to less varied and less complex conditions of life" – quite as readily as they could 'advance') ran counter to Marx's (humankind will advance and solve all its problems).

How about other possible influences on Conan Doyle? Well, I wonder if he ever read Charles Kingsley, another person to whom the influential Henslow was a 'friend and beloved teacher'. Kingsley, when not writing the likes of *Water Babies* or *Hereward the Wake*, could turn his hand to some impressive (even now) popular geology. He prefaces, though, his *Scientific Lectures and Essays* (1890) with compliments to the science so backhanded that they come out spinning. Geology he makes clear, "may be a very pleasant study" but it is one for which he has "no special fancy" and he would "rather learn something of botany, astronomy, chemistry or what not"… And (departmental admissions officers please note) "it is specially, the poor man's science". Touché! [10]

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[9] The man was obviously a diplomat in the making.

[10] Or perhaps he was employing a delicate irony. Later in the book he says that "geology has been my favourite study since I was a boy".

That point made, though, Kingsley then turns in some very respectable palaeoenvironmental descriptions, particularly concerned with the ancient roots of everyday materials such as gravel, limestone and coal. He's particularly good on coal, weaving back and forth between the Coal Measures ("buried in the dark abyss of countless ages") and the Mississippi delta.

And his heart is in the right place on the early Palaeozoic rocks of Snowdonia, where he approvingly quotes Ramsey and Barrande (as well as Ruskin). And who could deny the proper rigour of the man as he says he cannot teach the reader better than by "asking them to first buy Sheet No. LXXVIII S.E. (Bangor) of the Snowdon district of the Government Geological Survey, which may be purchased at any good stationer's, price 3s; and study it with me". Let applause for the man ring to the rafters!

Like Lankester, he generally waxed rhapsodic (that Ruskinesque touch is palpable). A man of the cloth (rector of Eversley, Hants), there are sprinklings of Biblical quotations, but these are taken with admonitions to imitate Socrates and follow the *Logos* (argument, reason, the Word, truth) wherever it leads. He does, however, make an exception in his benevolence. He takes the reader on a walk through the Keuper strata of the Triassic, describing the hand-like footprints of the *Cheirotherium* (that he synonymised with the *'Labyrinthodon'*), a creature that must have been a "right loathly monster", and a "short squat brute, as big as a fat hog".

Give a dog a bad name… Perhaps the mighty dinosaurs and their ilk were always destined to be painted in the blackest of colours by small and frail primates with vivid imaginations. Mind, when it comes to character assassination, the palaeontologically inclined scientist also comes in for short shrift. Challenger is "a violent, dangerous cantankerous character, hated by everyone who comes across him", who "broke the skull of Blundell, of the *Telegraph*"; while Summerlee is a "tall, thin, bitter man" with "a dry, half-sarcastic and often wholly unsympathetic manner". For good measure, they insulted and denigrated each other virtually without pause. Now, there may well have been and still may be palaeontologists of that ilk: the legendary Cope *versus* Marsh feud comes to mind. But – unless the palaeontological profession as a whole has evolved towards increased mellowness since those days – this seems a little unkind. Take the yearly gathering of this very Association. A more tolerant and good-humoured lot it would be hard to find, even allowing for the legendarily relaxing qualities of the Annual Dinner.

Finally, it is interesting to note the size of Maple White Land. Challenger's expedition tries initially to find a place to climb up, and so they spend six days fruitlessly circumnavigating the plateau. Therefore – given that Malone notes that in their first day they covered twenty-two miles – its circumference must be roughly 140 miles. If the plateau is roughly circular that gives a diameter of some forty miles. That is quite modest for a habitat to provide sustenance for a terrestrial assemblage that includes top-of-the-food-chain predators. This is particularly the case on a high plateau akin to the Roraima, where the surface is depleted in nutrients, as rainwater continually washes these out to lower ground. What would really happen on an island of that size and type that had been isolated since the Cretaceous?

Firstly, one might imagine that evolution should not run slower – or even less grind to a halt – on such an island. It should run faster. It looks like a classic natural laboratory for allopatric speciation, where new species tend to arise in small isolated gene pools.

So, perhaps one should rather imagine morphological evolutionary change progressing quickly on Maple White Land. The carnivores might thus have developed a keen intelligence, sufficient to put to shame even the cunning velociraptors of *Jurassic Park*. The corresponding plant-eating dinosaurs, to keep up in this accelerated arms race, would need to be as alert and nimble as wildebeest. The ape-men might, for their part, have evolved a life of comfort and culture, composing polyphonic symphonies while running a post-modern economy powered by improvised nuclear fusion reactors.

Such a development might have seriously embarrassed our party of explorers. However, they and their Victorian *amour propre* may well be saved from complete confusion by the second common evolutionary trend common in island populations: that of dwarfing of larger animals, a trend driven by the lack of resources where space is restricted. There are quite a number of well-researched recent-ish analogies: the dwarfed red deer of Jersey described by Clutton-Brock, and the pygmy mammoths of Wrangel Island, for instance, to name but two of the better-known examples. Now, the dwarfing in these examples took place in interglacial times: that is, they took just a few hundred generations to accomplish. Given that Maple White Land had been excluded from the outside world for many times that length of time, the consequences might be quite striking. Let us take them to an extreme[11]…

Thus, these advanced, evolutionarily accelerated populations of proto-human and saurian may not represent any very dreadful peril to Challenger & Co. Now they would be the size of hamsters and guinea pigs and toy soldiers. The most the explorers could fear from one of the hyper-evolved megalosaurids might be a nip on the ankle. This forecast assumes, naturally, that the usual limitations of body size *vs* brain capacity have been overcome. Evolution in this instance might have run, rather exceptionally, akin to that now seen in modern computers, where smaller goes together with smarter.

The miniaturized, intelligent populations of this long-lost Eden may, as a bonus, have evolved the good manners to simply ignore the cultural crassness of these colonial-era newcomers, and treat them with a courtesy born of *noblesse oblige*. Who knows, perhaps they extended the same courtesy to a previous visitor, who may have secretly visited and then departed from their land, determined to turn the experience into edifying and thought-provoking prose – though changing some of the geographical details in the interests of secrecy. His name might even have lingered on the plateau as something of a folk memory, passed from generation to generation. Something like Djo-Nath-An Swift, perhaps?

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[11] Well, all right. To a ridiculous extreme. But the end of this essay is nigh.

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Missing values and Stratigraphy

We have now completed all that is necessary to carry out a computer cladistic analysis. This final article ties up some loose ends that be-devil palaeontologists – stratigraphy and missing values.

The unique property of fossils is that they come with a time dimension that palaeontologists cling to as their unique contribution to the reconstruction of the history of life. Unfortunately, stratigraphy and cladistic analysis have not always sat easily side by side, and the early days of cladistic discussions witnessed fierce arguments over the suitability of including fossils and stratigraphic data. Intuitively we would expect that taxa that occur earlier in the record would show more plesiomorphic states of any particular character and that they would be ancestral to later occurring taxa. But, given the imperfections of the fossil record, neither of these assumptions can be justified.

So what about ancestors? We saw in the introductory article that, for cladograms, ancestors were not recognised since cladograms are atemporal: they are statements about the distributions of characters. Cladistic relationships are expressed solely in terms of sister groups, and the nodes on a cladogram have no connotation of ancestry. Once the cladogram is interpreted as a tree then ancestors come into play – but, for cladists, only in certain circumstances. Figure 1A shows a cladogram translated to a tree by including a time dimension and the stratigraphic occurrence of the individual taxa. Some people will deem it desirable to move a stratigraphically older taxon into an ancestral position relative to another taxon (Figure 1B). There are two caveats i) the putative ancestral taxon should have no autapomorphies, and ii) the stratigraphic ranges of putative ancestor and descendant do not overlap. Some have argued that, in fact, this is a more

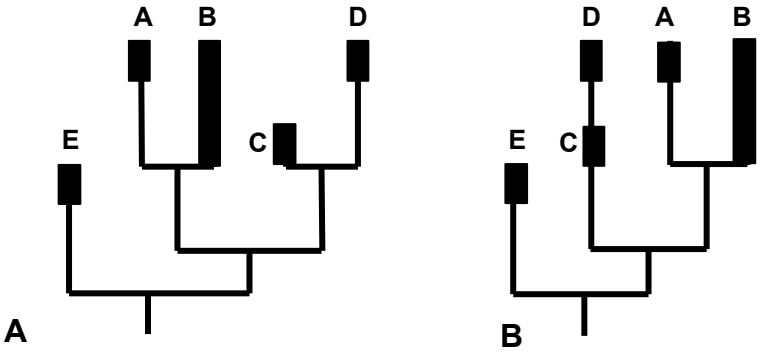

Fig.1. A. Recognising ancestors. Cladogram converted to a tree showing stratigraphic ranges of taxa, black boxes. B. In this circumstance it maybe possible to recognise that C is ancestral to D. See text

robust scientific theory than leaving them as sister groups because such a statement of ancestry and descent can be more easily disproved. Finding an autapomorphy in the presumed ancestor, or finding that the stratigraphic ranges do in fact overlap, will reject the theory.

In the early days, before computers, characters were polarised by using stratigraphy: the earlier occurring state was automatically accepted as the plesiomorphic condition with groupings established on the apomorphic state; a judgement made *a priori*. We have now seen in computer analyses that if a root taxon is chosen this automatically sets the plesiomorphic condition. This could be translated by choosing the oldest taxon as the root of the cladogram (Figure 2).

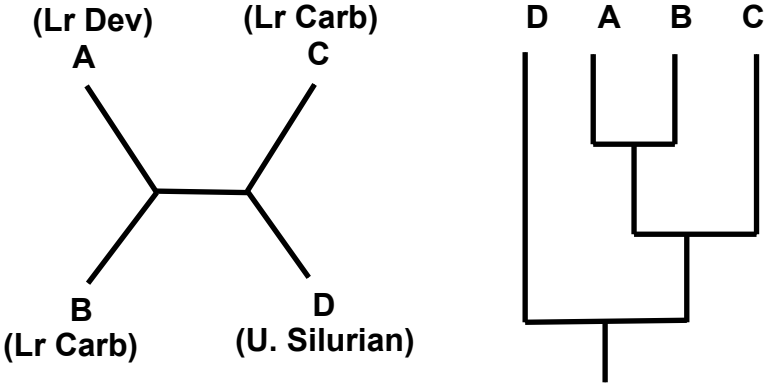

Fig. 2. Rooting the network calculated by PAUP* by using the stratigraphically oldest taxon will determine the shape of the tree.

Another way in which stratigraphy has been used is to consider the stratigraphic distributions of taxa as additional characters to be used alongside morphological characters as part of the tree building process. Steps are added to the length of each of the possible trees for any occurrence of a mismatch between the branching order and the stratigraphic occurrence. Alternative trees are examined and those that minimise the number of steps are chosen as optimal solutions. This procedure is known as stratocladistics. There are several problems with this method: some theoretical (*e.g.* time cannot be considered the same as a morphological character), and some practical (*e.g.* the method is sensitive to how finely we divide the stratigraphic record). If some of you wish to explore the issues further then a debate, moderated by Andy Smith (1998) on the *Nature* website, will lead you to the issues and literature. I'm having nothing more to do with it!

Once stratigraphic data has been added to a phylogenetic tree then this can be put to many uses most of which you probably know (*e.g.* calculating rates of evolution, comparing earth history with phylogeny, calibrating molecular clocks *etc*). There are a plethora of methods that have used different statistics to measure the congruence of the phylogeny with the stratigraphic occurrence of included taxa (see Norell 2001 for a summary of methods). Another way in which it has been used is to arbitrate between two equally parsimonious solutions derived from morphological or molecular data (or combination of the two). Let us say that, as a result of analysis, we ended up with two equally parsimonious trees (Figure 3). We can plot the stratigraphic distribution of the taxa (if the taxa were Recent then we would use the assumed fossil record of these taxa) and then

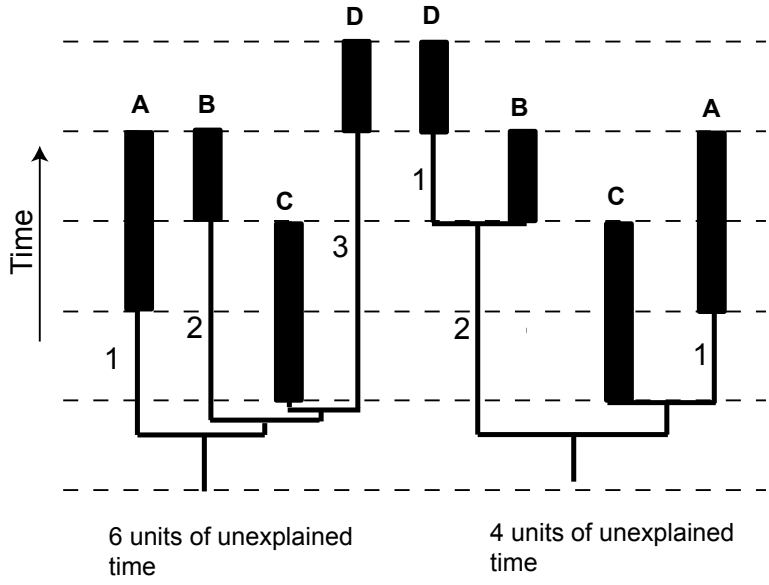

Fig. 3. Using stratigraphy to arbitrate between two equally parsimonious theories of relationship. The tree on the right assumes the least amount of unexplained time and might therefore be chosen on this evidence. The numbers refer to units of time.

calculate the amount of time that we must assume is unfilled by fossils ('unexplained time' in Fig. 3). We would then choose the tree with the least amount of unexplained time as the one to use for further analysis. Note, this is not saying that one tree is more optimal than another. It is simply choosing between two equals when there is no other evidence to hand. For a real example of the method see Smith & Littlewood (1994).

The other major area that palaeontologists have to deal with is missing values. Of course missing data can strike anywhere and for several different reasons. Unfortunately, they tend to be rife in data sets that try to combine modern with fossil taxa. For us there are two principal causes of question marks. First, genuine missing data: the part of the animal has not yet been found, or is unlikely to be found (*e.g.* soft parts). Second, question marks may be introduced due to evolutionary divergence (a phenomenon equally applicable to modern taxa). For example, let us assume that we were trying to establish the relationships between mammalian Orders. It is traditional to include a wealth of characters relating to teeth (presence, shape, height, angle *etc*, of particular tooth cusps). But, none of these characters could be scored for anteaters because they have no teeth (presumed lost). Technically the codes for these characters for anteaters would be 'not applicable' or 'illogical' since the structure to which the variation making up the character refers is not there. For computer cladistic analysis 'not applicable' codes are entered as question marks. That said, it is always a good idea to differentiate between genuine missing data and 'not applicable' in the written data matrix that you publish.

There are three adverse effects that question marks bring to computerised cladistic analyses. First, they can increase the number of equally parsimonious trees. Second, they can destroy resolution among taxa that are known by more complete data (question marks will not alter relationships known by complete data). Third, they can create spurious nodes on trees that have no evidential basis. Note the use of the word 'can'; question marks do not always have these deleterious effects. When PAUP* encounters a question mark it will try and insert real data codes to try and find a most parsimonious solution within the constraints offered by the real data.

Let's take these deleterious effects one by one. First, increasing trees, that I can best explain by an, admittedly old, example. This concerns a study done by Mike Novacek (1992), who was interested in the relationships between the orders of mammals (Figure 4). He analysed the relationships between the twenty recognised orders of living mammals using 88 morphological characters. He obtained eight equally parsimonious cladograms. To this analysis he added seven fossil taxa with varying amounts of missing data (25%–57%). Analysis of this combined matrix resulted in 6,800+ equally parsimonious cladograms (this was the limit of the computer memory in those days) and a strict consensus tree also destroyed resolution of a clade originally recognised to contain primates, tree shrews (Scandentia), flying lemurs (Dermoptera) and bats (Chiroptera). Notice here that it has not changed the topology because the original grouping of primates, tree shrews, flying lemurs and bats is not denied by the polychotomy here.

The situation is actually worse than it looks because of the limitations of the PAUP* algorithm. PAUP* will actually report trees that cannot be supported by any alternative 'real' data that is inserted in place of question marks (for a precise explanation of this see pages 82 – 85 in Kitching *et al*. 1998). These are spurious trees.

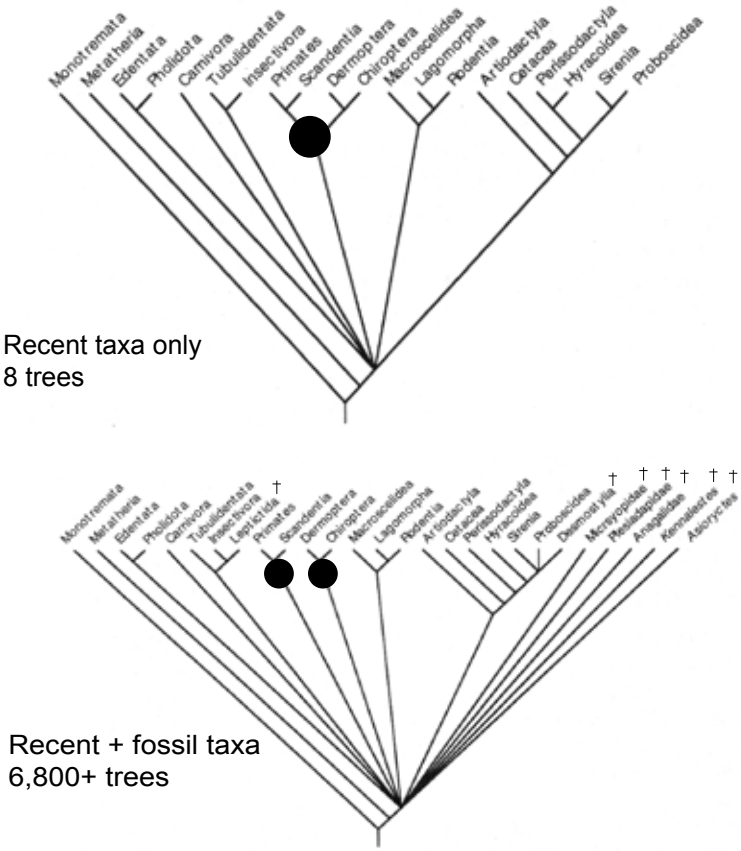

Fig. 4. Introduction of fossils with many missing values can result in significant increase in numbers of equally parsimonious trees and loss of resolution amongst taxa known by complete data. See text. (After Novacek 1992)

So, it would obviously be advantageous to reduce the number of question marks. We could delete characters that show high percentages of '?'. Or we could delete taxa with high percentages of '?'. Or we might recode characters (see later) and eliminate the need for '?'.

Deleting taxa is an obvious ploy: but, in a sense this negates the purpose of the analysis. Closer inspection of the possible disruptive effect that taxa with many '?' can have shows that it is not the ratio of real data to question marks that is important. Rather it is the complement of real data remaining that has the greatest effect. Remember that question marks cannot influence where a taxon is placed. But real data can. If the real data tends to place that taxon in very different parts of the tree it will have a very disruptive effect in collapsing nodes to result in poor resolution. [If you think back to the previous article, the Adams consensus dealt with situations

like this]. In situations like this we may decide to delete that taxon from the computer part of the analysis, then place the rogue taxon on the tree afterwards according to the real data that it had.

Mark Wilkinson has thought about this problem a little deeper and has come up with a rule of thumb to advise us on when it may be safe and when it may be unsafe to delete taxa with many question marks. He calls this procedure 'Safe Taxonomic Reduction' and has a program to scan data matrices that will isolate the safe ones (TAXEQ). The routine scans the matrix and looks for taxa that are computationally equivalent, and identifies those that can be safely deleted without affecting the resulting tree(s). Figure 5 illustrates this. Taxon B has exactly the same real codes as the more completely known Taxon A. The inclusion of Taxon B cannot yield any different trees but can only add to the number of trees and mask any signal produced by the real data. It can be safely deleted. Taxon C, however, shows a different real value for character 2 and thus cannot be deleted. This technique has been very successfully applied (Wilkinson & Benton 1996) but, unfortunately, does not always work.

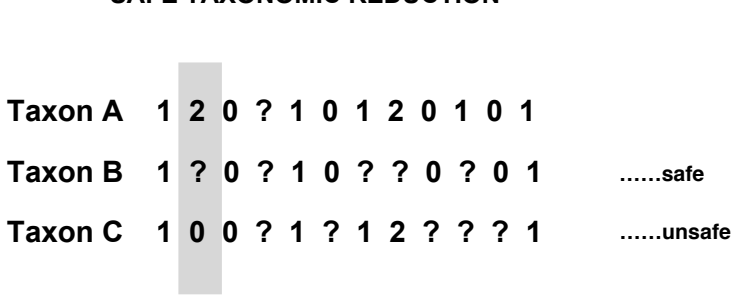

Fig. 5. Some taxa with many question marks can be safely removed from the matrix in the knowledge they cannot contribute new theories of relationship. See text.

Another tactic that you may be able to use to reduce the number of question marks is to recode some of the data that involves codes that stand for "non-applicable". We met this in the Character Coding article of this series. Suppose we had some taxa with tails and some without. Of those with tails some had red and some blue tails. A common way to code this variation is to use two characters. The first specifies the presence/absence of the tail. The second codes for the colour and assigns a 'non-applicable' code or '?' to taxa lacking tails. It has been shown through simulation analyses that such coding can actually lead to the identification of more parsimonious trees that can only be validated by assigning a colour to those taxa lacking tails (Maddison 1993). A solution to this problem is to use one multistate character where the '0' state is no tail, '1' state = blue tail; and '2' state = red tail (run the character unordered).

The last minefield for question marks that I will mention is the problem of spurious nodes. Sometimes, after analysis sister group pairings may be identified that cannot be justified by the data actually present. In other words, the only reason that the node is there is because the computer has assigned real data in place of question marks. This is not an uncommon occurrence and I have seen several studies where far reaching conclusions are drawn on

unjustified sister group pairings. The key is to check the character change output carefully, to make sure that, in all cases, both of the sister groups have real data for at least one of the relevant characters supporting that particular node.

If some of you are interested in following up on discussions of question marks in palaeontological data then I recommend reading five papers that were published sequentially in Volume 23, issue 2 of *Journal of Vertebrate Paleontology* (2003) pages 263–323.

I have come down rather heavily on the question mark. We all use them, sometimes by choice but usually by necessity. In most analyses their effects are relatively benign, particularly if you take care and check what they are doing in any particular analysis. For instance, you could run many analyses sequentially removing and replacing taxa with high percentages of question marks. Those taxa that can be removed without influencing the relationships among the rest are clearly only adding confusion and are best dumped. Ultimately we have to live with them.

This article concludes this short series on cladistic analysis. The intention of these articles is to strip away some of the mystery of cladistic jargon (spell check 'cladistic' and you get 'sadistic') and to allow you to read papers including cladistic analyses without a stiff gin. There are many other aspects to cladistics and techniques grouped under the cladistic rubric (maximum likelihood and Bayesian analysis are two). Usually these are more pertinent to analysis of molecular data. Some of the issues spoken about now centre on the analysis of supertrees. There are many many cladistic analyses of overlapping taxonomic animal and plant groups out there. The issue is how to combine information from these to form one supertree of life.

As a parting shot I will say that, in cladistic analysis, there is a lot of mathematical manipulation, ever more sophisticated. But we must never forget that most of the crucial decisions we have to make are biological/palaeontological. And this is especially true of the delimitation of characters and codes – how we partition the variation that we see. At the very least I hope these articles will allow you to read the results of cladistic analysis with an increased level of critical understanding. Some of you may even want to try it for yourselves. Good Luck!

Peter Forey

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PalaeoMath 101
Groups II

Last time we began to confront the problems presented by datasets that include group-level structure. We also developed some statistical tools we could use to determine whether that structure was reflected in statistically significant differences in group means and to assign unknown specimens to the closest group mean. So far so good. But what we really want is some way of defining a space—like a PCA space or a PCoord space—in which the groups are maximally separated.

You'll recall this plot of the *Iris* data from the previous essay (Figure 1, see Palaeontological Association Newsletter, **64**:35–45; also see that essay, or the *PalaeoMath101* Excel spreadsheet at <**http://www.palass.org/modules.php?name=palaeo_math&page=1**> for a listing of these data).

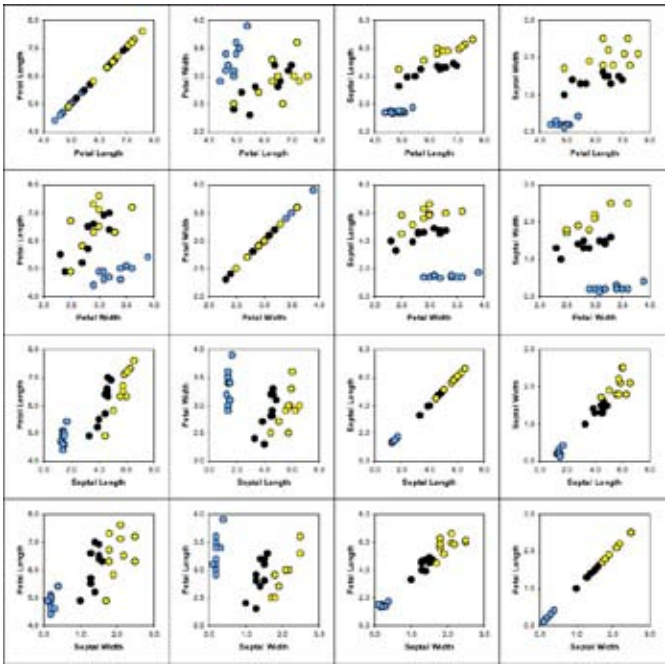

Figure 1. Crosstabulation diagram for Fisher Iris *data.* I. setosa *(cyan),* I. versicolor *(black),* I. virginica *(yellow).*

This captures the problem nicely. Given just four variables there are effectively six different ways of looking at the problem, if we ignore plots of the four variables against themselves and the plots in which the same variables are plotted on different axes. Each plot yields some information about both within-group variation and between-group separation. Some plots seem more informative than others. But no single plot tells the whole story.

Ideally we'd like to see our data transformed into a low-dimensional space, such that the majority of the between-group separation is summarized in just a few axes. Also, if the equations

of the axes could give us some indication of which single or combination of the original variables was most important for achieving group discrimination (which is another way of saying 'most important for group characterization'), that would be nice too. It's another tall order, but our colleagues over in the maths department have some ideas along these lines. Let's have a look.

Before we can begin our discussion we need to make sure we have some basic concepts straight, specifically the difference between discrimination and classification. Both involve groups, but there is a world of difference between them—mathematically speaking—that we need to understand before the mathematical operations will make much sense. Understanding these concepts will also help us understand the difference between the material I presented in the Groups I essay and what I'll be presenting below.

Discrimination is the act of determining a mathematical expression that distinguishes between groups of measurements or observations. In order to perform a discrimination or 'discriminant' analysis the groups need to be specified at the outset of an investigation. *Classification* is the act of determining how many groups are present in a collection of measurements or observations. This procedure does not require knowledge of the number of groups beforehand. Rather, that information is the purpose or result of the classification analysis. One group of techniques tells you how best to separate groups (discriminant analysis), the other tells you how many groups a sample contains (classification analysis). Of course, in the real world palaeontologists want to know both. The problem is you can't get at both questions in any single analysis. The mathematics that optimize the discrimination of groups of data require specification of the number of groups to be discriminated, and the mathematics of classification analysis require that the characteristic differences between groups be known. What to do?

Inevitably, we fall back on using combinations of analyses. Principal components analysis, factor analysis, principal coordinates analysis, correspondence analysis and the rest of the 'single group' methods can be used to obtain a sense of how many groups there might be in a dataset. They can do other things too, but practically speaking this is one of their primary uses. Once some hypotheses about possible classification schemes have been developed based on results of a single-group analysis, those can be checked for statistical significance using the methods of mean-difference analysis (*e.g.*, likelihood-ratio test, Hotelling's T^2-test). These results will allow decisions to be made regarding a viable classification scheme, after which consideration of the discriminant problem can begin. Mahalanobis distances can be used to effect identification by assigning individuals to groups based on their proximity to the group centroid (after scaling the variables by the inverse of the pooled covariance matrix). However, the space in which the Mahalanobis distance operates has not been optimized for maximal group separation. Nonetheless, it is possible to create a space that optimizes the difference between classification groups—at least the distances between their centroids. It is to this missing piece of the puzzle we now turn.

Most discussions of discriminant analysis begin with a discussion of the two-groups case—where the point is to find a linear discriminant function that separates two groups. This is obviously the simplest case of discrimination, and because of this the mathematics involved can be simplified. Nevertheless, the two-sample case hardly ever comes up in real situations. For the most part we need to distinguish between three or more groups, and so need an approach to determining discriminant functions that is powerful enough to handle any number of groups. Since the

simplified mathematics of two-group linear discriminant analysis cannot be extended to the multiple-groups case, we'll proceed directly to the multiple-groups problem, the most popular solution to which is called canonical variates analysis (CVA). Should we ever need to discriminate between just two groups, CVA works fine for those data too.

In our example analysis we'll stick with the Fisher *Iris* data from the previous essay, but bump up the number of individuals in each group in order to get a better estimate of group variation and to illustrate some features of the technique. The following table lists these example data.

Table 1. First twenty-five specimens from each species included in Fisher (1936) Iris data

	Iris setosa				*Iris versicolor*			
	Petal		Sepal		Petal		Sepal	
	Length	Width	Length	Width	Length	Width	Length	Width
1	5.1	3.5	1.4	0.2	7.0	3.2	4.7	1.4
2	4.9	3.0	1.4	0.2	6.4	3.2	4.5	1.5
3	4.7	3.2	1.3	0.2	6.9	3.1	4.9	1.5
4	4.6	3.1	1.5	0.2	5.5	2.3	4.0	1.3
5	5.0	3.6	1.4	0.2	6.5	2.8	4.6	1.5
6	5.4	3.9	1.7	0.4	5.7	2.8	4.5	1.3
7	4.6	3.4	1.4	0.3	6.3	3.3	4.7	1.6
8	5.0	3.4	1.5	0.2	4.9	2.4	3.3	1.0
9	4.4	2.9	1.4	0.2	6.6	2.9	4.6	1.3
10	4.9	3.1	1.5	0.1	5.2	2.7	3.9	1.4
11	5.4	3.7	1.5	0.2	5.0	2.0	3.5	1.0
12	4.8	3.4	1.6	0.2	5.9	3.0	4.2	1.5
13	4.8	3.0	1.4	0.1	6.0	2.2	4.0	1.0
14	4.3	3.0	1.1	0.1	6.1	2.9	4.7	1.4
15	5.8	4.0	1.2	0.2	5.6	2.9	3.6	1.3
16	5.7	4.4	1.5	0.4	6.7	3.1	4.4	1.4
17	5.4	3.9	1.3	0.4	5.6	3.0	4.5	1.5
18	5.1	3.5	1.4	0.3	5.8	2.7	4.1	1.0
19	5.7	3.8	1.7	0.3	6.2	2.2	4.5	1.5
20	5.1	3.8	1.5	0.3	5.6	2.5	3.9	1.1
21	5.4	3.4	1.7	0.2	5.9	3.2	4.8	1.8
22	5.1	3.7	1.5	0.4	6.1	2.8	4.0	1.3
23	4.6	3.6	1.0	0.2	6.3	2.5	4.9	1.5
24	5.1	3.3	1.7	0.5	6.1	2.8	4.7	1.2
25	4.8	3.4	1.9	0.2	6.4	2.9	4.3	1.3
Σ	125.7	87.0	36.5	6.2	150.3	69.4	107.8	33.6
Min.	4.3	2.9	1.0	0.1	4.9	2.0	3.3	1.0
Max.	5.8	4.4	1.9	0.5	7.0	3.3	4.9	1.8
Mean	5.0	3.5	1.5	0.2	6.0	2.8	4.3	1.3
Median	5.0	3.4	1.5	0.2	6.1	2.8	4.5	1.4
Variance	0.2	0.1	0.0	0.0	0.3	0.1	0.2	0.0
S. Dev.	0.4	0.4	0.2	0.1	0.5	0.4	0.4	0.2

	Iris virginica			
	Petal		Sepal	
	Length	Width	Length	Width
1	6.3	3.3	6.0	2.5
2	5.8	2.7	5.1	1.9
3	7.1	3.0	5.9	2.1
4	6.3	2.9	5.6	1.8
5	6.5	3.0	5.8	2.2
6	7.6	3.0	6.6	2.1
7	4.9	2.5	4.5	1.7
8	7.3	2.9	6.3	1.8
9	6.7	2.5	5.8	1.8
10	7.2	3.6	6.1	2.5
11	6.5	3.2	5.1	2.0
12	6.4	2.7	5.3	1.9
13	6.8	3.0	5.5	2.1
14	5.7	2.5	5.0	2.0
15	5.8	2.8	5.1	2.4
16	6.4	3.2	5.3	2.3
17	6.5	3.0	5.5	1.8
18	7.7	3.8	6.7	2.2
19	7.7	2.6	6.9	2.3
20	6.0	2.2	5.0	1.5
21	6.9	3.2	5.7	2.3
22	5.6	2.8	4.9	2.0
23	7.7	2.8	6.7	2.0
24	6.3	2.7	4.9	1.8
25	6.7	3.3	5.7	2.1
Σ	164.4	73,2	141.0	51.1
Min.	4.9	2.2	4.5	1.5
Max.	7.7	3.6	6.9	2.5
Mean	6.6	2.9	5.6	2.0
Median	6.5	2.9	5.6	2.0
Variance	0.5	0.1	0.4	0.1
S. Dev.	0.7	0.4	0.6	0.3

Canonical variates analysis was invented by R. A. Fisher (1936) with important contributions by Bartlett (1951, regarding how to calculate the inverse of a matrix), Mahalanobis (1936, regarding use of Mahalanobis distances in discriminant analysis), and Rao (1952, in synthesizing Fisher's and Mahalanobis' concepts into the modern procedure). The basic idea behind modern approaches to CVA is reasonably simple. It is in essence a two-stage rotation of a data matrix that has been subdivided into groups, hence the name *canonical* variates.

Campbell and Atchley (1981) provide an excellent discussion of the geometric transformations implicit in CVA. Their presentation has served as a model for the geometric explanation presented below. In the actual algorithm (which we'll discuss after the geometric presentation) several of these steps are performed simultaneously. Most textbook descriptions of CVA only focus on presenting a recipe of equations and plots, such that comparatively few practitioners gain much understanding of the geometry inherent in the methods. In my presentation we'll review a few basic equations (which readers of this column have seen before) and then let the pictures do most of the talking.

First, recall that in our previous discussion of the likelihood-ratio test we developed the idea that total similarity relations (*T*) within grouped data matrices could be subdivided into 'within-groups' (*W*) and between-groups (*B*) partitions.

$$T = B + W \tag{11.1}$$

There are different ways to operationalize this concept, but in the case of CVA the T matrix usually represents the total sums of squares and cross products (SSQCP) for all variables, and has the following form.

$$t_{r,c} = \sum_{j=1}^{k} \sum_{i=1}^{n_j} (x_{i,r,j} - \bar{x}_r)(x_{i,c,j} - \bar{x}_c) \tag{11.2}$$

In this expression r and c refer to the rows and columns of the T matrix (any cell of which is occupied by a value t) with $\bar{x}_r$ and $\bar{x}_c$ representing the grand means for the entire, combined dataset. The grand mean is the centre of the pooled sample of all measurements. Matrix T then summarizes the dispersion of the total dataset about this group-independent, fixed reference.

The W matrix represents the within-groups SSQCP matrix and has a corresponding form.

$$w_{r,c} = \sum_{j=1}^{k} \sum_{i=1}^{n_j} (x_{i,r,j} - \bar{x}_{jr})(x_{i,c,j} - \bar{x}_{jc}) \tag{11.3}$$

Once again, r and c refer to the rows and columns of the W matrix (any cell of which is occupied by a value w). Now the variables $\bar{x}_{jr}$ and $\bar{x}_{jc}$ refer to the analogous group-specific means. Here, the group mean is the centre of the cloud of points representing each group in Figure 1. Matrix W, then, summarizes the dispersion of each dataset relative to its own group-specific reference.

Once T and W have been found, the most obvious way of determining the B matrix is to simply subtract each element of the W matrix from the corresponding element of the T matrix ($B = T - W$). Conceptually though, the between-groups matrix summarizes the dispersion of the group means from the grand mean.[1]

[1] Confusingly (in my view) a number of programs currently available for implementing CVA operate on matrices that violate the basic $T = W + B$ relation. In such cases the authors of those algorithms are usually trying to take account of differences between the number of specimens representing each group. Unfortunately, they rarely specify exactly how their programs undertake this correction, often resulting in slight non-comparabilities between the results reported by different programs.

In our geometric example analysis we'll reduce the Table 1 data to just two variables: petal width and petal length.[2] Canonical variates analysis begins (conceptually) with a standard PCA analysis of the within-groups dispersion matrix (Figure 2).

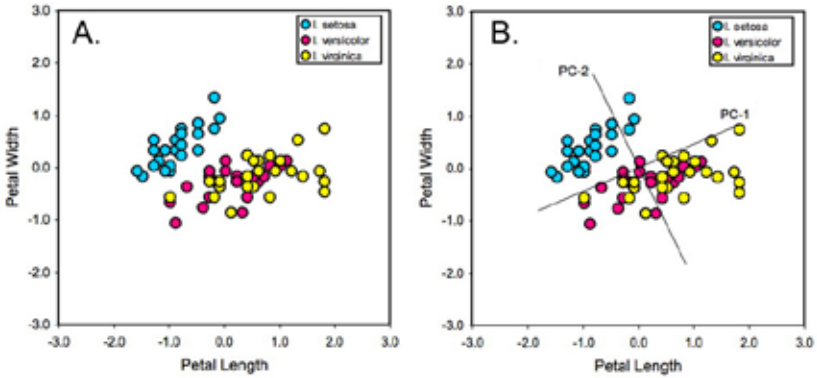

Figure 2. Stage 1 CVA implicit rotation. A. Scatterplot of first two Iris *variables for example dataset. B. Orientation of the two pooled-sample principal components of the within-groups SSQCP matrix (W).*

The purpose of this step is to re-describe the dispersion of the entire dataset in terms of a set of uncorrelated variables. Although the W matrix calculates dispersion from the group means, this operation involves a rigid rotation of the data about the grand mean. In order to facilitate plotting, it is often convenient to mean-centre the entire dataset about the grand mean prior to analysis, in which case the grand mean will be the origin of the data's coordinate system. This convention has been followed in Figure 2 and throughout all subsequent analyses.

Next, CVA performs a somewhat counter-intuitive scaling operation. As you can see from Figure 2B, the scatters of the original groups are elongated with much more variance along PC-1 than PC-2. This reflects the greater variation of the petal length relative to petal width data, which in turn reflects the fact that *Iris* petals are much longer than they are wide. In order to achieve maximum separation between the group centroids, the principal components are scaled by the square root of the associated eigenvalue. This operation involves multiplying each individual's PC score by the reciprocal of that square root. The result of this intermediate scaling operation is illustrated in Figure 3.

[2] A listing of all calculations is provided in the *PalaeoMath101* Excel spreadsheet at <**http://www.palass.org/modules.php?name=palaeo_math&page=1**>.

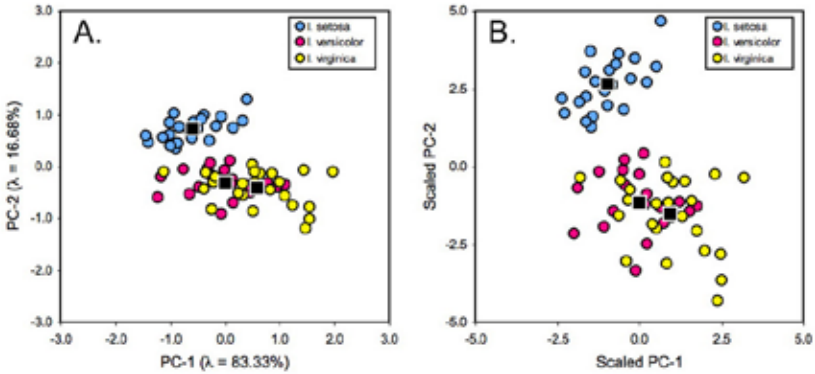

Figure 3. Intermediate scaling operation of a CVA. A. Scatterplot of Iris *PC scores for the Stage 1 rotation (see Fig. 2). B. Result of scaling the two within-groups principal components by the square roots of their associated eigenvalues. Note difference in separation of the group centroids (black squares) after scaling.*

The effect of this scaling is subtle, but important. Note how the range of variation for each group has been adjusted so that it is subequal along both axes. This is a form of data standardization. The scaling operation forces each eigenvector (= principal component) to have the same length. Thus, the data have been relatively stretched along PC-2 (the shorter eigenvector) and compressed along PC-1 (the longer eigenvector). This transforms the formerly elongate distributions of the group-based point clouds into forms that are more spherical. Note also how this operation has greatly increased the separation of group centroids or means from one another, especially in terms of the separation of *I. setosa* from the other two species. That looks like a big advantage in terms of accomplishing discrimination, which is what CVA is all about. But the significance of this operation is actually both more and less profound than it might appear at first.

What we're doing by scaling the PC space in this way is reminding ourselves of what we mean by 'distance' in a multivariate space. As we discussed last time, correlations between variables matter when it comes to assessing the separation between any two points in a space defined by multiple variables. We apply a similar scaling operation to the Mahalanobis distance calculation specifically to correct for the distortions caused by inter-variable correlations. The scaling operation we've just performed in the intermediate stage of our CVA analysis distorts the PC space such that the geometric reality of the distribution of points in that space matches our 'common sense' notion of distance (recall that we performed the original PC rotation on W, not T). This scaling operation shows us that the notion of distance between points in the standard PC multivariate space can be just as distorted as it is in ordinary scatterplots. By using the eigenvalues to scale the eigenvectors we can construct a 'true' picture of the separations between points in this group-defined space, one that conforms to the world of spatial relations in which we live. Thus, our three *Iris* species are actually more distinct than figures 2A, 2B, or 3A would have us believe. That's the profound bit. The trivial bit is that all this complexity is taken into consideration by the Mahalanobis distance. Thus we've had a way of taking the distortions inherent in the spaces represented by 2A, 2B, and 3A into account all along.

The second and final stage of a CVA focuses on the group centroids. While the first rotation summarized within-groups dispersion patterns, a second rotation is required to summarize between-groups dispersion patterns. This is accomplished by conducting a second PCA, this time using only data from the positions of the group means in the orthogonal *and* variance standardized—or orthonormal—space (Fig. 3B). Figure 4 illustrates the result of this operation.

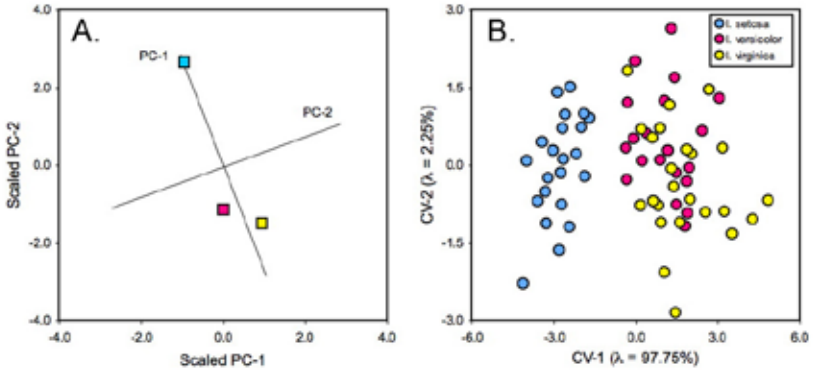

Figure 4. Stage 2 CVA implicit rotation. A. Iris *group centroids plotted in the within-groups orthogonal-orthonormal space (see Fig. 3B) with between groups PC (= CVA) axes. B. Reduced* Iris *dataset plotted in the space defined by the CVA axes.*

The scatterplot shown in Figure 4B is typically presented as the CVA ordination. Generally speaking there are one fewer CVA axes with positive between-groups eigenvalues than the number of groups present in the analysis. Once these results have been obtained, most routines will also report statistical tests for group distinctiveness (*e.g.*, Hotelling's T^2) and a Mahalanobis distance-based cross-tabulation analysis of the data used to define the CVA space. The former are used to confirm group distinctiveness (see previous column for examples and details of these calculations) while the purpose of the latter is to determine the degree to which these particular CVA results can provide a reliable basis for achieving discrimination between the groups.

Note these are very different questions. It is quite possible for group means to be distinct relative to their within-groups dispersion, yet contain so much overlap between their respective point clouds that effective discrimination is more-or-less impossible. Results of this cross-tabulation analysis are usually presented in the form of a 'confusion matrix' that summarizes the extent to which specimens assigned *a priori* to a given group are placed in the appropriate group by a Mahalanobis distance analysis (see previous column for details of this calculation). The confusion matrix for the two-variable *Iris* dataset is provided below.

Table 2. Confusion matrix for the reduced Iris dataset

Species	*I. setosa*	*I. versicolor*	*I. virginica*	Total	%Correct
I. setosa	25	0	0	25	100.00%
I. versicolor	0	16	9	25	64.00%
I. virginica	0	8	17	25	68.00%
Total	25	24	26	75	77.33%

As can be seen from both this matrix and Figure 4B, *I. setosa* is perfectly discriminated from *I. versicolor* and *I. virginica* by the first CVA axis. However, approximately one-third of the specimens assigned to the latter two species are mis-assigned to these other groups. Is this a good result? The answer depends on the question you're asking, along with your ability to collect other information and/or access additional specimens of each group. If it is of the utmost importance to identify all specimens perfectly using only these variables, the fact that this analysis produced something like 35 percent incorrect identifications for two of the three groups *for the sample used to define the discriminant space* is a matter of concern. Still, for many applications—including most replication-based studies of systematic identifications—a consistent identification accuracy of 65 percent is competitive with most human experts (see MacLeod 1998; Culverhouse in press). Of course, this question is moot for the *Iris* dataset as we have ready access to measurements from additional specimens (which would improve our estimates of W and B) and additional variables (see below).

There is one additional issue we need to discuss before we leave this simple example. As with all the single-group data analysis methods we've discussed to date, we would like to use the equations of the CVA axes to tell us something about the geometric meaning of the space portrayed in Figure 4B, especially the identities of the variables most useful for group characterization/discrimination. For CVA this is more complex than for the previous ordination methods we've discussed.

The first interpretational complication arises because of the nature of the mathematical operations implicit in CVA. In Figure 4B the CVA axes are portrayed (correctly) as being orthogonal to one another. But recall: the PCA that produced those axes was undertaken on a series of group centroid locations that had already been transformed from their original positions through rotation (Fig. 2) and differential scaling (Fig. 3). In order to determine how the CVA axes relate to the original variables it's not enough simply to inspect the CVA axis loadings because those refer to the rotated and scaled variables. Rather, we must undo these prior transformations in order to understand how the CVA loadings relate to the original data. Figure 5 illustrates the results of these back-transformation operations.

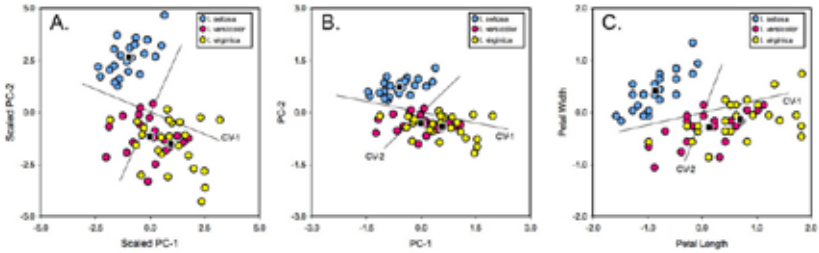

Figure 5. Back-calculation of final CVA axis orientation through the intermediate stages of the canonical rotations and scalings.

A. Orientation of final CVA axes in the space of the scaled within-groups principal components (compare to Fig. 3A).

B. Orientation of final CVA axes in the space of the raw within-groups principal components (compare to Fig. 3B).

C. Orientation of final CVA axes in the space of the original variables (compare to Fig. 2).

The really important thing to note in these diagrams is that, unlike PCA axes which are orthogonal in the space of the original variables (see Fig. 2A), CVA axes are usually non-orthogonal (*i.e.* not oriented at right angles to one another) in the space of the original variables. This makes CVA axes more difficult to interpret, because the same original variable(s) may have a dominant influence on the projection of specimens onto more than a single CVA axis. In this particular *Iris* analysis, petal length is the dominant variable involved in separation of *I. versicolor* and *I. virginica*, but petal width has a strong influence on group separation as well. Regardless, these variables are not very efficient discriminators of those groups. Both petal length and width variables are also involved in the discrimination between *I. setosa* and the other two species. Because the traces of both CVA axes exhibit positive slopes in the space of the original variables, *their relative proportions of influence are similar*. But in the latter case the discrimination efficiency is much better. By comparing the sequence of Figure 5 plots we can also trace the alignment of the final CVA axes with the dominant modes of within-groups and between-groups variation.

There is yet another problem with the assignment of importance to the canonical variables, though. Campbell and Atchley (1981) note that many authors assess importance of the variables to between-groups discrimination by scaling the canonical variate loadings by the standard deviations of the pooled within-groups variables. This operation produces a crude and *ad hoc* measure of the correspondence between high levels of variation in aspects of the sample and alignment of the between-groups discriminant axes. The fly in the ointment here is covariation. If two variables covary to a substantial degree, both could be identified as having either a large or a small importance with respect to group discrimination, whereas one may be the real driver of this relation and the other a more passive passenger. Campbell and Reyment (1978, see also Campbell 1980) advocate analysis of the stability of the CV loadings as a method of approaching this problem, and have developed the method of 'shrunken [CVA] estimators' to be used in this context.

Now that we understand exactly what CVA is doing to our data we can briefly review the mathematics used in contemporary approaches to implementing this method (in which several of the steps outlined above are combined) and undertake an expanded example analysis using the full 3 group, 25 specimen, and 4 variable *Iris* dataset.

The modern algorithm is based on the parallel between CVA and the statistical procedure known as analysis of variance (ANOVA). We begin with the T, W, and B matrices calculated in precisely the manner given by equations 11.1, 11.2, and 11.3 (above). Rather than undertaking the separate rotation and scaling operations outlined in our previous geometric dissection of the method, these steps are combined by noticing that the quantity we are after is a set of axes that are aligned with the maximum differences between the B and W matrices. In effect we need to maximize the B/W ratio. Without going into the precise matrix equation derivation, suffice it to say that this ratio will be maximized by calculating the first eigenvector (principal component) of the $W^{-1}B$ matrix[3]. Subsequent eigenvectors of this matrix represent subdominant modes variation that contribute most (in a major-axis sense) to maximizing the distinction between B and W. Together, this set of eigenvectors will represent the best single set of discriminant

[3] Recall the -1 superscript refers to the inverse of a matrix. The $\mathbf{W}^{-1}\mathbf{B}$ matrix then is the matrix formed by the between-groups SSQCP matrix being pre-multiplied by the inverse of the within-groups SSQCP matrix (see example calculations in the PalaeoMath101 Excel spreadsheet at <**http://www.palass.org/modules.php?name=palaeo_math&page=1**>.

axes that can be calculated for the sample. Of course, since discrimination between groups is the focus of this analysis there will be one fewer eigenvectors than the number of groups in the dataset that are assigned positive eigenvalues.

A minor complication arises owing to the fact that the $W^{-1}B$ matrix will not be symmetric. This is a direct reflection of the implicit differential scaling of B by the within-groups eigenvalues. Fortunately, this situation is easily handled by employing singular value decomposition (SVD) as the basis for decomposition of the $W^{-1}B$ matrix. Recall that the eigenanalysis of a non-symmetric matrix produces non-orthogonal eigenvectors in the context of the original variables, which we have also seen is the case for CVA axes (see Fig. 5).

Applying these relations to the full *Iris* dataset, the total, within-groups, and between-groups matrices are given below.

Table 3. Total, within-groups, and between-groups SSQCP matrices for *Iris* data

Total SSQCP Matrix

	Petal Length	Petal Width	Septal Length	Septal Width
Petal Length	0.7342	-0.0514	1.3375	0.5222
Petal Width	-0.0514	0.2194	-0.4004	-0.1447
Septal Length	1.3375	-0.4004	3.2942	1.3468
Septal Width	0.5222	-0.1447	1.3468	0.5922

Within-Groups SSQCP Matrix

	Petal Length	Petal Width	Septal Length	Septal Width
Petal Length	0.3284	0.1164	0.2143	0.0444
Petal Width	0.1164	0.1302	0.0646	0.0431
Septal Length	0.2143	0.0646	0.2179	0.0460
Septal Width	0.0444	0.0431	0.0460	0.0395

Between-Groups SSQCP Matrix

	Petal Length	Petal Width	Septal Length	Septal Width
Petal Length	0.4508	-0.1677	1.1233	0.4778
Petal Width	-0.1677	0.0892	-0.4650	-0.1877
Septal Length	1.1233	-0.4650	3.0763	1.3009
Septal Width	0.4778	-0.1877	1.3009	0.5526

The basis matrix for the CVA analysis, then, is as follows.

Table 4. $W^{-1}B$ Matrix

Total SSQCP Matrix

	Petal Length	Petal Width	Septal Length	Septal Width
Petal Length	-2.5459	0.9822	-6.8481	-2.9116
Petal Width	-0.0514	0.2194	-0.4004	-0.1447
Septal Length	1.3375	-0.4004	3.2942	1.3468
Septal Width	0.5222	-0.1447	1.3468	0.5922

Note the non-symmetrical form of this matrix. Decomposition using SVD yields the following eigenvectors and eigenvalues.

Table 5. Eigenvectors and eigenvalues of $W^{-1}B$

	CV-1	CV-2	CV-3	CV-4
Petal Length	0.8533	-0.1369	0.2130	-0.4557
Petal Width	-0.5134	-0.1994	0.5025	-0.6665
Septal Length	-0.0909	-0.1359	-0.8378	-0.5210
Septal Width	0.0022	0.9607	0.0162	-0.2770
Eigenvalue	85.5979	0.3820	0.0000	0.0000
Variance (%)	99.5557	0.4443	0.0000	0.0000
Cum. Var. (%)	99.5557	100.0000	100.0000	100.0000

Observe, there are only two eigenvectors with non-zero eigenvalues. These are the canonical variate (= discriminant) axes. Plotting the original data in the space of these two axes produces the following ordination.

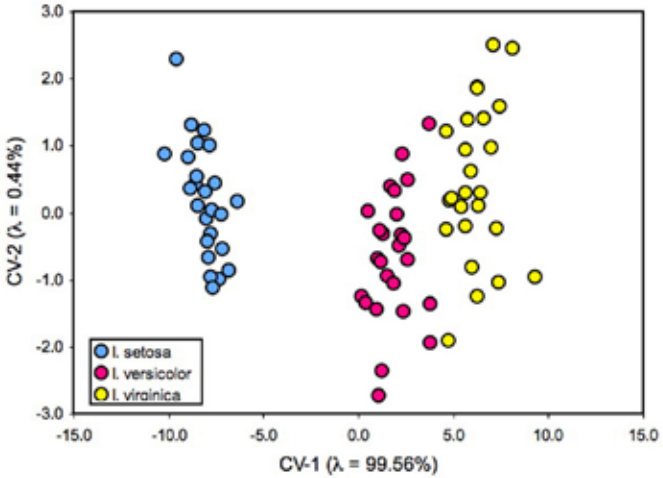

Figure 6. Scatterplot of Iris *data in the space of the two CVA axes.*

Once again, *I. setosa* is well separated from *I. versicolor* and *I. virginica*. Unlike the previous two-variable result, however (see Fig. 4B), the presence of the additional septal variables allows a much better discrimination between these latter two species, albeit along the same CV axis. The fact that CV-2 plays such a small role in between-group discrimination is reflected in its small eigenvalue. This far superior discriminant result is reflected in the confusion matrix for the analysis which measures the ability of the variable set to characterize-discriminate between the different groups.

Table 6. Confusion matrix for the *Iris* CVA analysis

	I.setosa	*I. versicolor*	*I. virginica*	Total	Correct (%)
I.setosa	25	0	0	25	100.00
I. versicolor	0	24	1	25	96.00
I. virginica	0	0	25	25	100.00
Total	25	24	26	75	98.70

There are many variants to this generalized procedure, as there are with all the methods we've covered. The important thing, as always, is to understand the basic concepts so you can make appropriate interpretations of the results reported by any program.

As I hope you can appreciate now, CVA is very different from PCA, principal coordinates (PCoord), factor analysis (FA), correspondence analysis (CA), and the other data analysis procedures we've discussed to date. Whereas it wouldn't make much sense to (say) perform a PCA analysis and then submit the result to a correspondence analysis, there is an inherent logic to submitting the results of a PCA to a CVA. For example, PCA could be used to gather the principal sources of variation in the raw data into a small number of composite variables. Then these could be used as the basis for optimal discriminant functions.

A final word on the 'supernatural' aspects of CVA (and other multivariate methods). As should seem obvious to you by now, multivariate procedures are absolutely dependent on using sets of specimens to estimate the within-groups and between-groups geometry of their variables or measurements. Single-group methods (*e.g.*, PCA, PCoord) focus only on within-groups variation, while multiple-group methods (*e.g.*, PLS, CVA) focus on the within-groups and between-groups distinctions. In the *Iris* dataset we saw dramatic improvement in the between-groups discrimination resulting from addition of two variables: septal length and septal width. Generally speaking the more sources of information you have about a system of measurements the better. But this improvement comes at a cost.

Consider a square space containing 100 evenly spaced points. If the square is 10 units on a side the inter-point distance is 0.010. That's pretty good characterization of the space. However, if we turn the square into a cube by adding another variable, the same number of points only achieves an inter-point spacing of 0.1. That's an order of magnitude reduction in our information about the space in which our data reside. In order to achieve the same resolution in the cube space we'd need to increase sample size to 1,000. If we added additional variables we'd need to increase sample size to … you get the picture.

Adding variables to a multivariate problem almost always results in a substantial drop in resolution. This is called the 'curse of dimensionality' (Belman 1957). The effects of the curse are especially noticeable in discriminant analyses because we're trying to estimate the character of within-groups variation, *and* between-groups variation. For the *Iris* dataset, because the number of variables was small and the number of specimens relatively large our CVA analysis was able to pick up major differences in W and B despite the fact that addition of the septal variables resulted in an overall loss of resolution. In other words, we beat the curse of dimensionality, this time. If you undertake multivariate procedures be mindful of the curse and don't expect to beat it all the time.

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Meeting REPORTS

Leicester's fossil celebrity: *Charnia* and the evolution of early life
University of Leicester *10 March 2007*

Fifty years ago, some of the most important fossils in Britain were discovered in a quarry in Leicestershire: these were first Ediacarans to be identified as the macroscopic remains of Precambrian life. This year, for its annual symposium, Section C of the Leicester Literary and Philosophical Society celebrated the anniversary of this historic discovery with a day of talks revolving around "Leicester's fossil celebrity: *Charnia* and the evolution of early life". The event ran in conjunction with National Science and Engineering week as part of the Geological Society's Bicentennial and Geologists' Association 150th anniversary celebrations. Some one hundred and twenty people attended the symposium, including members of the public, and were treated to a series of presentations from a veritable who's who of Ediacaran workers from across the world.

After a welcome from the University of Leicester's Vice-Chancellor, Bob Burgess, where better to start than with the story of how it all began: **Roger Mason** (China University of Earth Sciences) related the tale of his discovery of the first British Ediacaran fossil whilst out climbing with friends (although he noted it was one Richard Blachford who drew his attention to the fossil; credit where credit's due). Things might have gone no further; Roger emphasised it was the contribution of his teachers and father (a Unitarian Minister) in fostering his interest in science and the scientific method that encouraged him to pursue the matter and contact the day's next speaker. **Trevor Ford** (University of Leicester) picked up the story with his coining of the genus *Charnia* for the aforementioned discoveries. His recognition of the Leicestershire fossils as a Precambrian biota catalysed Australian workers to re-interpret their specimens, discovered ten years previously by Reginald Sprigg and dismissed as "freaks of nature". And so Ediacaran science was born. **Helen Boynton** (Leicester) then reviewed subsequent developments; namely Leicestershire's burgeoning number of Ediacaran localities and taxa: her gallery of recent discoveries around the county suggests there is great potential for further finds in the area.

John Carney and **Steve Noble** (British Geological Survey) discussed the broader context of the Charnwood fossils in space and time. Adopting a uniformitarian approach to the interpretation of the geological setting of the Leicestershire fossils, John Carney argued that the marine surroundings of the volcanic arc island of Montserrat offered a good analogue for the Charnwood environment. Steve Noble then outlined the latest zircon geochronology of the Charnwood specimens, dating them to around 562 Ma, with some potentially as old as 600 Ma.

Also playing the dating game was **Dan Condon** (NERC Isotope Geoscience Laboratories) who moved the focus outward to global correlation of the various Ediacaran biotas. He emphasised the necessity of a well-calibrated record to integrate the biotic and abiotic events of the Ediacaran period worldwide, something which is currently lacking. Considerable progress is being made however, with both zircon and whole-rock dating techniques offering the promise of a better

understanding of the relationship between glaciations, carbon isotope excursions and metazoan evolution during this period of earth history.

Nick Butterfield (University of Cambridge) contrasted Ediacaran ecosystems to those of the Phanerozoic and the remainder of the Precambrian. He argued that the Ediacaran period represents a pivotal transition from the stable, low diversity, and evolutionarily sluggish microscopic biosphere that had dominated since the inception of life, to the higher diversity, ecologically complex and furiously evolving metazoan ecosystems of the Phanerozoic, with the Ediacarans representing (in ecological, if not phylogenetic, terms) a precursor of what was to come.

The afternoon session started with **James Gehling** (South Australian Museum) who showed us some of the spectacular recent finds of three-dimensionally preserved Ediacarans from the Flinders Range, dominated by shallow marine forms. He suggested that the small, apparently motile organisms that lived in the shadow of these quintessentially Ediacaran frond- and mat-like forms may have represented the antecedents of phyla that later exploded during the Cambrian. As a postscript to his talk, James espoused the virtues of geotourism, something to be embraced as a matter of urgency and necessity to preserve Ediacaran and other fossil sites from destruction (a danger only too well understood by those trying to protect the Leicestershire fossils).

Thousands more three-dimensional Ediacaran fossils awaited us in **Guy Narbonne**'s (Queen's University, Canada) talk, preserved at high-resolution in deep-water turbiditic mudstones from Newfoundland. Many of the Newfoundland finds constitute census populations, permitting robust conclusions to be drawn regarding Ediacaran ecology and ontogeny. He concluded that the dominant rangeomorphs (frond-like fossils akin to *Rangea*, with a modular construction) displayed tiering patterns similar to those of Phanerozoic filter-feeders, again indicating ecological similarities with metazoans of later times. Biometric analyses also suggested that rangeomorphs grew by inflation of existing modules rather than by addition of new ones.

Dima Grahzdankin (University College Dublin) unified the various Ediacaran biotas discussed throughout the day within one framework comprising three distinct assemblages, each occupying different environments: the early Avalon-type biota (such as Charnwood and Newfoundland), occupying deeper shelf environments; the Ediacaran-type assemblage, typical of shallower water prodeltas (such as the earliest Australian taxa); and the Nama-type, favouring shallow water distributary mouths (Namibia and the new Australian forms mentioned above). This suggests that the Ediacarans formed ecosystems of cosmopolitan yet ecologically specialised organisms, characterised by a low diversity community structure atypical of Phanerozoic communities.

The final talk of the day, co-presented by Professor **Martin Brasier** and **Jonathon Antcliffe** (University of Oxford), brought discussion back to the Charnwood fossils, in an attempt to determine the phylogenetic position of Ediacarans. Their laser scanning of the fossils allows detailed examination under controlled conditions (a technique that doubles as a means of conservation). They asserted that ontogeny is the key to phylogeny, and is best understood using a theoretical morphospace based upon variation in generative fractal characters; their work suggests it is more likely that Ediacarans grew by addition of new modules rather than inflation of existing ones.

There followed a lively open floor discussion, which revealed the continued disagreement regarding aspects of Ediacaran phylogeny, ontogeny and ecology, demonstrating both the vibrancy of

Ediacaran research and providing an example of healthy scientific debate, which perhaps the public witnesses all too rarely. Encouraging public attendance at more informal academic meetings might be beneficial in combating the ignorance and misrepresentation of science (particularly evolutionary science) that seems disturbingly prevalent today.

Mark Purnell closed the symposium by thanking the speakers for a day of excellent talks, and a not-entirely-flippant reminder that in palaeontology in particular it is important to see things as they are, based on evidence, rather than using preconceptions (whether uniformitarian or something less scientific) to justify interpreting things as one wants them to be. His (albeit non-palaeontological) examples included the highly dubious manifestations of scripture and religious iconography in tomatoes and toasted sandwiches. Finally, the action moved to New Walk Museum and Art Gallery, with a reception sponsored by the BGS to open the new "Charni@ 50" Exhibition, celebrating Leicestershire's iconic fossils.

The symposium clearly demonstrated how far perceptions have shifted from the notion of Ediacarans as inconsequential oddities to realising their significance to the understanding of the earliest evolution of metazoans and the origination of the first complex ecosystems. This shift has been facilitated by spectacular new finds from Australia, Canada and Russia; but the Leicestershire fossils continue to provide new insights, justifying their international importance and representing an invaluable part of Britain's geological heritage.

David Jones
University of Leicester

Rising Seas Fossil Festival
Lyme Regis *4 – 6 May 2007*

"Who is responsible for global warming?" was one of the key questions asked at this year's *Rising Seas Lyme Regis Fossil Festival* on the Jurassic Coast. The festival was opened by West Dorset MP Oliver Letwin on Friday 4th May, and included a Youth Climate Change Summit, which was attended by approximately 900 students.

The scientific input to the Festival was led by The Natural History Museum (London) who filled an entire marquee with a dazzling range of exhibitions and interactive stands. Experts were on hand to identify fossils for members of the public, and a Scanning Electron Microscope gave visitors a chance to appreciate the true beauty and complexity of foraminifera and calcareous nannofossils. The National Oceanography Centre (University of Southampton) moored their research vessel 'Callista' at the Lyme Regis Cobb harbour. On Friday afternoon and all day Saturday and Sunday, the public were invited to hop aboard and see how scientists investigate sea-level rise and climate change whilst afloat on the open ocean.

The University of Plymouth introduced visitors to the scientific study of palaeontology and palaeoenvironments with an interactive display of fossils, rocks and thin sections, along with a fossil dig and "Walk Like a Dinosaur" runway aimed at stimulating interest in science among the young and old. Emphasis was placed on local marine fossils, and most discussions centred on the classic Blue Lias strata of southern England.

Figure 1. Jodie Fisher dealing with a swarm of schoolchildren on the fossil-dig.

Microfossils were on display under the microscope to show the variety of work undertaken in palaeontology and how many of these tiny specimens can be used to find out more about the geological past. Fossil pollen was used to investigate the diet of the dinosaurs and foraminifera were used to reconstruct the temperature of ancient oceans. Inquisitive visitors were particularly keen to learn about the biology of extant marine pteropods. The paper-thin aragonitic shells of these tiny gastropods are particularly susceptible to dissolution under conditions of elevated atmospheric CO_2 and thus are monitored closely by the scientific community for the effects of anthropogenic carbon emissions.

The fossil-dig enabled children to find and identify their own fossil specimens, learn how old they were, discover where in the ocean their specimens might have lived and what they would have looked like whilst alive in the Jurassic. The dinosaur runway gave participants the opportunity to create their own dinosaur track-way by wearing modified Wellingtons smeared with brown paint. Measurements of stride length were made to determine "the dinosaur's" possible speed; the contest to be the fastest dinosaur ever resulted in near-catastrophic efforts to attain maximum stride length!

The BGS, Environment Agency and numerous other organisations provided the public with a wealth of information on climate change and natural history. Booksellers, fossil collectors and local performance artists offered a myriad of daytime distractions, while the evenings afforded an opportunity to listen to distinguished speakers on topics ranging from climate change (Sir Crispin Tickell), to spiny trilobites (Prof. Richard Fortey, FRS).

All the volunteers had a thoroughly enjoyable (if slightly manic) few days and hope to be back next year with bigger and better displays! Marcus Dixon, the Jurassic Coast team and all the attending organisations (including many not mentioned here) are thanked for their hard work and enthusiasm, which resulted in a hugely successful public outreach initiative.

Figure 2. Kate Donovan (University of Plymouth) showing off a (hopping?) 'dinosaur' track-way.

Luke Mander and Jodie Fisher
University of Plymouth

23rd Argentine Meeting of Vertebrate Paleontology
Museo Paleontológico Egidio Feruglio, Trelew, Argentina *21 – 24 May 2007*

Even though it was late May, the air was freezing and the sun had not yet risen. It was, after all, the beginning of Patagonian Winter, and a beautiful rose-coloured dawn greeted 150 participants on the first day of the **23rd Argentine Meeting of Vertebrate Paleontology** in Trelew, Argentina.

The meeting was held in the **Museo Paleontológico Egidio Feruglio**. Beyond the tongue-twister of a name is a new world-class institution boasting an exhibition hall with a medley of Argentine dinosaurs and Cenozoic mammals; a huge, state-of-the-art fossil preparation lab; an elegant reception area and atrium adorned with living examples of ancient plants; and a modern auditorium with room for all. Argentine students and faculty already had their *mates* (bitter green tea) ready as museum director **Ruben Cuneo** officially opened the conference. He welcomed everyone to Trelew and spoke about the long history of Argentine palaeontology but also about a recent revolution in terms of number of students, quality of research projects, funding, and new museums – for which the surroundings served as a brilliant example!

First up to bat was **Jimena Trotteyn** (Universidad Nacional de San Juan) who showed us new material of the giant crurotarsan *Saurosuchus* from the Late Triassic of Ischigualasto. **Marta Fernández** (Museo de La Plata) presented some exquisitely preserved internal moulds of the antorbital cavity of a metriorhynchid, supporting previous reconstructions of the antorbital cavity of archosaurs made using extant phylogenetic brackets (EPB method). More marine crocodiles followed as **Diego Pol** (Museo Paleontológico Egidio Feruglio) looked at the phylogenetic position of thalattosuchians. His results demonstrated that characters often correlated to the longirostrine condition in crocodilians actually vary independently, supporting the position of Thalattosuchia within Neosuchia. Another member of the home team, **Agustina Lecuona** (Museo Paleontológico Egidio Feruglio), used the EPB method and osteological correlates to reconstruct the appendicular musculature of the small crurotarsan *Gracilisuchus,* while **Zulma Gasparini** (Museo de La Plata) wrapped up the first session by presenting a three-dimensionally preserved pliosaur skull from the Late Jurassic of Cuba.

After a mid-morning coffee break, delegates took a trip to 'Turtle Town' with **Marcelo de la Fuente** (Museo de Historia Natural de San Rafael) who showed off the diversity of turtle remains from this and other new Cretaceous localities in Chubut. **Juliana Sterli** (Museo de Historia Natural de San Rafael) continued the turtle theme with a detailed anatomical description of *Kayentachelys*, identifying it as a stem turtle instead of a stem cryptodire. **Jeff Wilson** (University of Michigan, USA) looked at the abundant but poorly resolved titanosaurids. Using a carefully tabulated core of independent characters (no 'sausage datasets' here!) he intends to produce a species-level phylogeny of these massive sauropods. Thanks to arrangements with local petroleum companies, **Leonardo Filippi** (Museo Municipal Argentino Urquiza, Rincón de los Sauces) showed us how his team discovered and excavated a large new species of titanosaur from Rincón de los Sauces, and **Rubén Juárez Valieri** (Universidad Nacional del Comahue, Neuquén) presented loads of new basal hadrosaur material from the Late Cretaceous of northern Patagonia.

The lunch break promised to include 'Welcome Cocktails' in the museum reception area (are midday libations a good idea at conferences?). However, it also included mountains of wonderful food

so that participants returned to the afternoon session stuffed and slightly tipsy. We were quickly shaken from drowsiness by **Martin Ezcurra**'s (Museo Argentino de Ciencias Naturales, Buenos Aires) presentation of the beautifully articulated hand of a new species of herrerasaurid, followed by **Ricardo Martinez** (Universidad Nacional de San Juan) who presented more new herrerasaurid material from the oldest member of the Ischigualasto Formation. It was time for theropods, and **Oliver Rauhut** (Bayerische Staatssammlung für Paläontologie und Geologie, Germany) identified *Elaphrosaurus* as the most basal member of Noasauridae and the oldest abelisauroid, while **Juan Porfiri** (Universidad Nacional del Comahue, Neuquén) revealed new material of the dromaeosaurid *Neuquenraptor* from Portezuelo Formation of Neuquén. This was followed by **Fernando Novas** (Museo Argentino de Ciencias Naturales, Buenos Aires) who gave an entertaining account of his exploration team nearly drowning in fossil frogs before finding a small new enantiornithine bird from the Late Cretaceous of Salta. **Martín Chavez** (Universidad Austral de Chile, Valdivia) presented new information on Cenozoic Sulidae (boobies and gannets) from Peru, and **Sebastian Apesteguía** (Museo Patagónico de Ciencias Naturales, General Roca) compared the faunas of South America and Europe in the Early Late Cretaceous and found a surprising amount of Gondwanan influence in Europe, begging the question what was the 'native' European fauna of the time?

After a few tasty *alfajores* (a pair of biscuits sandwiching a layer of *dulce de leche* or 'yummy goo' as some British colleagues call it) for an afternoon break, **Daniel Perea** (Facultad de Ciencias, Montevideo, Uruguay) introduced us to the fauna of the Late Jurassic Tacuarembó Formation of Uruguay, while co-worker **Matías Soto** (Montevideo, Uruguay) took a closer look at lungfish and ceratosaurid teeth from the same locality. **Alejandro Haluza** (Museo Municipal Ernesto Bachmann, El Chocón) presented remains of both tapejaroid and basal pterosaurs from Rio Negro, suggesting a high diversity of pterosaurs in the Upper Cretaceous of Patagonia. The emphasis then shifted to fish

Figure 1. Students enjoying a morning tea break at the 23rd Argentine Meeting of Vertebrate Palaeontology in Trelew, Patagonia. From left to right: Andrea Cambiaso, Marcelo Isasi, Jorge Gonzalez, Nadia Domonovich, and Martin Ezcurra.

with a double-header by **Adriana López-Arbarello** (Bayerische Staatssammlung für Paläontologie und Geologie, Germany), who redefined Semionotiformes to include gars and Macrosemiidae, and then presented evidence for a new family of perleidiform fishes from the Late Triassic of Argentina. The session ended with a final pterosaur talk by **Laura Codorniú** (Universidad Nacional de San Luis) demonstrating the positive relationship between size and length of the cervical vertebrae in *Pterodaustro*. As the day ended, around 8pm, the programme included two activities open to the general public. First, a conference on the Gigantism of Dinosaurs by **Oliver Rauhut** brought many interested people to the museum's auditorium. After this conference, it was time for the opening of an artistic exhibit in the city's cultural centre focused on reconstructions of extinct organisms, including paintings and sculptures of artists coming from different parts of Argentina and neighbouring countries.

Day two of the conference began with a 'tapir super session'. First was **Mario Cozzuol** (Universidade Federal de Minas Gerais, Brazil) who presented intriguing evidence (in the form of a recently hunted skull) of a new, *living* species of tapir in the Amazon. While some audience members prepared to go off and find the mystery beast, **Elizete Holanda** (Universidade Federal do Rio Grande do Su, Brazil) gave back-to-back talks on the Late Pleistocene tapirs of Brazil and new information on *Tapirus cristatellus*, and **Martín Ubilla** (Facultad de Ciencias, Montevideo, Uruguay) reviewed fossil tapirs from Uruguay. The focus then switched to dicynodonts with **Nadia Domnanovich** (Universidad de Buenos Aires) redescribing a Lower Triassic specimen from Mendoza as a shansiodontid, thus expanding the stratigraphic range of this group. **Teo de Oliveira** (Universidade Federal do Rio Grande do Su, Brazil) presented a new and virtually complete cynodont from the Triassic Santa Maria Formation of Brazil. **Francisco Prevosti** (Museo de La Plata) described a sabertooth cat found in a tar pit – not one in central LA but from the Pleistocene of Venezuela, with the critter appearing to belong to the tribe Homotheriini. A new Middle Jurassic basal triconodont from Chubut was presented by **Leandro Gaetano** (Universidad de Buenos Aires) before glyptodonts took centre stage. **Nicolás Toledo** (Museo de la Plata) put forward a reconstruction of the anterior facial muscles of glyptodonts and suggested that the enlarged nasal capsule made up for limited visual capacity in these animals, while **Juan Carlos Fernicola** (Museo Argentino de Ciencias Naturales, Buenos Aires) reported a new occurrence of *Neoglyptatelus* from the Miocene of Uruguay. The morning session was ended by **Diego Brandoni** (CICYTTP, Diamante, Entre Ríos) who provided a review of pampas giant ground sloths.

After lunch we began the student prize session, with an award for the best presentation by a PhD student. It almost could have been called the 'Laura Session'! First up was **Laura Cruz** (Museo Argentino de Ciencias Naturales, Buenos Aires) who presented evidence to support the validity of the glyptodont species *Panochthus subintermedius*. Next was **Laureano González** (Universidad Nacional de la Patagonia San Juan Bosco, Esquel) describing the temporal and geographic distribution of the Miocene armadillo *Vetelia* in Patagonia. He was followed by **Laura Chornogubsky** (Museo Argentino de Ciencias Naturales, Buenos Aires) who demonstrated the similarities between Eocene *Polydolops* species from Antarctica and those from the South American mainland. **Daniel Udrizar Sauthier** (CENPAT, Puerto Madryn), explored changes in the distributions of small mammals by using remains found in owl's nests, while **Cristina Bertoni-Machado** (Universidad Federal do Rio Grande do Sul, Brazil) demonstrated how sequence stratigraphy and taphonomy could be used to predict the occurrence of fossils. Returning to the 'Lauras', **Laura Nicoli** (Universidad de Buenos Aires) gave

an intriguing presentation on how the basal anuran *Notobatrachus* could swim but not hop like modern frogs (so what makes a frog?), while **Laura Porro** (University of Cambridge, UK) presented a novel mechanism for chewing in the basal ornithischian dinosaur *Heterodontosaurus*. Rounding out the prize session were **Agustín Scanferla** (Museo Argentino de Ciencias Naturales, Buenos Aires) presenting a new fossil tropidophiid snake from Bolivia that reinforces the South American origin of this clade, and **Rodolfo Garcia** (Universidad Nacional del Comahue, Neuquén) with observations on the embryonic dentition of titanosaurids from Auca Mahuevo, noting thick enamel and posteriorly displaced tooth rows relative to adults.

The talks ended early so that participants could browse among the dozens of posters on display before the conference dinner. After the poster session, another presentation was held for the general public, this time on the evolution and origins of the marine mammals by **Mario Cozzuol**, which strongly interested the local people as the region is distinguished as one of the best places in the world to observe focids, sea lions, penguins, dolphins and whales in their natural environment. Finally, in typical Argentine fashion, the dinner began promptly at 10:30 in the evening. *Asadors* (professional grill guys) were on hand outside the museum tending an enormous bonfire over which they grilled a dozen whole Patagonian lambs. The meat was brought inside on mini-*parillas* (grills) to keep it hot and excellent food, company, and, of course, wine were shared amongst all the delegates beneath the museum's towering atrium.

Day three was dedicated to Cenozoic mammals, starting with an interesting symposium entitled 'Endemic Ungulates from the Paleogene of South America' (covenors: Marcelo Reguero and Darin Croft). The morning talks began with **Daniel Pera** (Facultad de Ciencias, Montevideo, Uruguay) reviewing the notoungulates from the Fray Bentos Formation and comparing this association with other Deseadan localities. Next, **Darin Croft** (Cape Western Reserve University, USA) used tooth mesowear not only to determine the diet of fossil notoungulates but also to suggest the earliest open grassland environment in Bolivia by the late Oligocene. The focus stayed on notoungulate teeth as **Marcelo Reguero** (Museo de La Plata) looked at the relationship between body size, hypsodonty, tooth mass, and tooth complexity. After a short presentation on dating of the Sarmiento Formation by **Richard Madden** (Duke University, USA), **Ana María Ribeiro** (Fundação Zoobotânica do Rio Grande do Sul, Brazil) described several new specimens of leontiniid notoungulates from this formation in Chubut. **Alexandro Kramarz** (Museo Argentino de Ciencias Naturales, Buenos Aires) described a new astrapothere, an unusual mammal with a proboscis and procumbent canines, showing extreme complexity of the molar surfaces, while **Teresa Dozo** (CENPAT, Puerto Madryn) reported new records of notoungulates and macrauchenids from the late Oligocene of Chubut. Ending the morning session was **Javier Gelfo** (Museo de La Plata) describing a new xenungulate from the Paleocene of Patagonia, greatly expanding the geographic range of this family.

The afternoon symposium was entitled 'Associations of South American Oligocene–Miocene vertebrates: chronologic and biostratigraphic implications' (covenors: María Pérez and Amalia Villafañe). The session began with an encore appearance by **Richard Madden** who used records of New Zealand sheep to demonstrate the correlation between increased tooth wear and increased amounts of abrasive particles (from volcanoes, dust storms, and glaciers) in soils. **Sergio Vizcaino** (Museo de La Plata) then described a rich new vertebrate fauna from the Miocene Santa Cruz Formation and, afterwards, **Teresa Dozo** reappeared to present a complete

Figure 2. An traditional asador grilling some lamb for the conference dinner!

and beautifully preserved cranium of a capybara relative from the even more beautiful Valdés Peninsula of Argentina. After a short break we were into the final stretch of the day. **John Flynn** (American Museum of Natural History, USA) reviewed nearly 20 years of field work in the Tertiary volcanic sediments of Chile, resulting in a vast number of specimens from many localities and allowing precise radiometric dates for South American Land Mammal Ages. **Esperanza Cerdeño** (CRICYT, Mendoza) reported on the state of field work searching for fossil mammals in the Cuyo, while **Annie Hsiou** (Fundação Zoobotânica do Rio Grande do Sul, Brazil) provided an account of new squamates from the Miocene of the Brazilian Amazonas, including the earliest record of amphisbaenians for South America. Last, but certainly not least, was **Marcelo Sánchez-Villagra** (Palaeontologisches Institute und Museum, Switzerland) discussing vertebrate fossils such as fish, turtles, crocodiles, and various mammals, from the Middle Miocene of central Venezuela, including a duck-faced crocodilian and a fossilized sea turtle nesting beach.

With the symposium finished, the committee and delegates turned to business, beginning with the distribution of awards. The prize for best presentation by a PhD student went to **Laura Nicoli**, while the prize for best poster went to **Teo de Oliveira** and **Cesar Schultz** (Universidade Federal do Rio Grande do Sul, Brazil). The next item on the agenda was to decide on the location for the 2009 meeting (there will be no meeting in 2008 as the Third Latin American Congress of Vertebrate Paleontology is taking place in September 2008 in Neuquén). Buenos Aires, San Rafael, and General Roca all presented themselves as possible venues. After much discussion regarding location, facilities, location, and the availability of wine, it was decided that San Rafael will be the host of the 2009 meeting.

The activities of the following day included three presentations and a field trip, centred on the geology and palaeontology of the fossiliferous Cenozoic beds of the Patagonian Chubut Province. The morning conferences opened with **Eduardo Bellosi** (Museo Argentino de Ciencias Naturales) providing an extensive account of the sedimentology and environmental conditions of the Eocene–Miocene sequence deposited in Eastern Patagonia, including the continental Sarmiento Formation and the marine Gaiman and Puerto Madryn formations. Next, **Guiomar Vucetich** (Museo de La Plata) gave a complete update on continental vertebrates collected in recent years in different sections of the Sarmiento Formation, ranging from the Eocene to the earliest Miocene. The morning session ended with **Mario Cozzuol**, who went up in the sequence and discussed the Miocene marine vertebrates from these beds and similarities with the fossil record of Eastern Brazil. After the conference, approximately 80 people moved to the **Geoparque "Bryn Gwyn"** located half an hour away, close to Gaiman, a traditional town founded by Welsh settlers in the late 1800s. A quick barbecue lunch was waiting for the participants before they started hiking across the fantastic outcrops, beginning at the continental facies of the Sarmiento Formation and going uphill towards the marine Miocene beds of the Gaiman and Puerto Madryn formations. Eduardo Bellosi and Mario Cozzuol took turns leading the crowd around the park and providing a great account of the environment as well as the fossils found in this classic locality. Some of the fossils are truly wonderful and are exhibited *in situ* (protected within glass domes), including marsupials, edentates, penguins, focids, and both baleen and toothed whales. The party returned down to the Interpretation Center for coffee and pastries after a breath-taking view of the Chubut River valley from the top of the hill right before sunset.

So as Argentina prepared for the long holiday weekend, delegates began leaving Trelew. It was a superb conference – great talks, wonderful camaraderie, a growing, modern museum, and a fun atmosphere. A perfect way to spend four not-so-idle days in Patagonia.

Abstracts of all talks and posters will be published in the December issue of *Ameghiniana*. The conference organisers would like to thank the following sponsors: The Palaeontological Association, CONICET, Aluar, PanAmerican Energy, and the Ministerio de Educación of Chubut Province.

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The reflections of another taxi member

You may be interested to have the following brief addendum to Frank Hodson's account of the origin of the Pal Ass reprinted in the last *Palaeontology Newsletter*.

As Frank recalled, the main concern of the palaeontological 'Young Turks' was the frustrating inadequacy of the contemporary publishing facilities in the UK. Following representations to the Geological Society, Gwyn Thomas and I were deputed to appear before the Society's Council to present the case for enhancing the publication of palaeontological papers in QJGS. Our principal suggestion was that the format of the journal should be increased in size, accompanied by improvements in the quality and quantity of the plates to enhance the illustration of palaeontological papers. Alternatively, it was suggested that a separate series of papers might be produced in the enlarged format. However, the Society decided that it could not encompass these proposals, although the primary point regarding the format was met some years later when QJGS became the *Journal of the Geological Society*.

Following this rebuff, representations were made to the Palaeontographical Society and, again, Gwyn and I were invited to present our case at a meeting of their Council. In this instance, we suggested that Pal Soc consider the publication of a sister journal to its long-established and prestigious series of monographs and, in addition, that it should institute regular meetings to facilitate and promote the presentations and discussion of palaeontological papers. Again, the Society decided that this would be too great a departure from its long-established constitution.

Thus, we had arrived at an impasse, the resolution of which ultimately resulted in the birth of the present, wholly admirable and eminently successful Palaeontological Association. In the foundation of this organisation a signal contribution was made by Gwyn Thomas, for it was he who was instrumental in establishing the structure and layout of papers submitted for publication in *Palaeontology*. Its continued eminence owes much to his punctiliousness and foresight.

Dr Bill Ball

Soapbox

Science Communication and the 'Ask A Biologist' project

It probably fair to say that science communication with the public at large does not always get the attention it deserves. The recent debate about 'framing' aside, few professionals seem to give the problem a moment's thought. Scientists seem to run the full spectrum from "it is essential that the public understand and respect our work" through to "I work to increase my knowledge and add to the literature, if the public care, they know where to look". Both opinions are valid – if all we did was try to re-educate the public into even the basics of biology, I doubt we would get any research done, but nor should we isolate ourselves from them, if for no other reason than ultimately they are the source of our grants and wages.

Personally, I am very pro-communication. What use are we if no one understands our work? And at the extreme end of that, how are we supposed to influence opinion when the public are distrustful of us and ill informed of the problems at stake. If *everyone* knew and understood the evidence for evolution, would creationism last more than a few weeks? Would we see the media storms over the MMR vaccine and GM foods if people read and followed the research? I doubt it.

Nowadays I don't have to look far to be irritated by how science is perceived by the general public and the media. Science is reduced to sound bites on the TV where all researchers wear a lab coat and sit in front of a computer, or palaeontologists stand in front of a dinosaur skeleton. As a palaeontologist, announcing my job to a new face is invariably met with the comment "Oh. Like Ross from *Friends*?". Reporters (even the science correspondents) frequently make basic mistakes and whole stories can be badly distorted, exaggerated or given a completely reversed meaning to the one scientists intended.

If that wasn't bad enough we have the Internet. Yes, it is amazing, yes it has transformed both work and recreation, but as the 'information superhighway' it leaves a lot to be desired. Creationists, the 'tin-foil hat' brigade, the enthusiastic but misguided amateurs and the just plain mad come together to provide one colossal raft of misinformation. And let's face it, it's not as though many scientists are out there providing anything better. Most departments, let alone labs or individual researchers, provide little more than a couple of half-hearted pages describing research in such specific terms that only another expert could understand. How are the public supposed to know what is good and what is bad? Where are they going to get their information from, if not from the media? Is GM food dangerous? What is the evidence, how do we know? Why should we trust your research?

The Solution

I decided to try and make a very minor dent in the web misinformation mountain by starting my own blog, but I soon ran into problems. A lack of inspiration left me rather short of material, and though I soon hit on the idea of asking for topics to write about, without a readership this was not

of much use. I realized that the solution was to start again, deliberately targeting a young audience and persuading a number of friends and colleagues to form a collective panel so that questions and topics could be discussed by research scientists.

Various friends of mine who are science teachers gamely volunteered to put forward questions from their pupils about biology and these started to appear on the blog. However, traffic was slow and the blogging website we were using was hardly user friendly. If the site was going to work as a concept we needed a proper interface and a much bigger audience.

After some searching it was suggested that the Palaeontological Association might fund a site redesign and relaunch. After some negotiations they agreed to cover the costs of a complete revision and saved us further problems by hosting the new site on their server. The necessary work was carried out by my colleague Sarda Sahney (herself a palaeontologist at Bristol) and her husband Paul Ferry in a third of the time I thought it would take, despite my best efforts to 'help'.

After much to-ing and fro-ing the website was named **Ask A Biologist** (and was appropriately registered as <**http://www.askabiologist.org.uk/**>). The new site has a searchable archive of old questions and answers, mini-biographies of the experts, links to news and science sites, and most importantly an easy to use interface. Questions can be left in any of a number of categories (*e.g.* mammals, evolution, or human biology) and then our experts pick them up and add their answers. We are happy to take any serious question from anyone, though we are especially keen to encourage children into science and biology, and of course we are aiming primarily at the UK though we have had questions from Germany, the USA and Australia.

Through word of mouth (well, e-mail) we have massively increased our panel of experts from an initial dozen to over 70, the site has taken well over 300 questions in three months, and we have had over 20,000 visits to the site. We receive hundreds of views each week, with most visitors to the site simply browsing through the archives rather than sending us new questions, but we are still providing a real service and reaching thousands of interested people.

Our intention is to attempt to combat, at least a little, the bad information that is out there on the Internet and provide an easy forum for biologists and palaeontologists to get their message across. We are (we hope) getting across good information, based on real science and proper research, put forward by real experts and dispelling a few myths about ourselves and our work. We would hope to foster a new respect and understanding for science and scientific research, and perhaps even encourage a few more students to further their studies in biology.

It also provides an easy forum for scientists to talk about their work, interests and science in general, and it is delightful to see some of the feedback I get both from satisfied enquirers and from experts. I have certainly learned some interesting things from the answers of my colleagues, and it is a genuine pleasure to see some academics get to grips with an audience they never knew they had.

Our only real remaining challenge is to reach the masses – despite the healthy numbers, far too few people realise we exist. This is where the ranks of Pal Ass members can come to our aid. Please pass on our name and address to anyone who might be interested, especially school children or teachers. I'd be amazed if anyone reading this didn't know a teenager, primary school or biology teacher who might be interested. We have posters and handouts (A4 and A3) that can be printed up and handed out, or put in classrooms, local libraries *etc*., and banners for websites. If a few hundred

people can put up or hand out half a dozen each, we will achieve more coverage in a week than we have in three months, so do please help. Anyone who wants to spread the word or join up as an expert is welcome to do so, and do please pass on our details to any of your friends and colleagues who might be interested. Anyone who wishes to contact me about the site, promotional activities, joining as a member and any other queries can get me at <**d.hone@lrz.uni-muenchen.de**>.

I would like to take this opportunity to thank all those who have helped to get this project off the ground. Too many people have put in their time and efforts to mention them all, but special mentions are deserved for Mike Taylor, Neil Gostling, David Wynick, Manabu Sakomoto, Dave Warburton, Al McGowan, Graeme Lloyd, Paolo Viscardi and John Hutchinson.

Finally a large 'thank you' to the Palaeontological Association for funding and hosting the redeveloped site; especially Jason Hilton and Mark Sutton of the web team, for having faith in me and giving me the freedom to direct the project. I hope that I and the other members have repaid that faith.

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>>***Future*** Meetings of Other Bodies

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

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

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

Meeting website: <**http://www.palaeontology.geo.uu.se/Mainpages/WOGOGOB/Layout.htm**>.

SPCC/SVPCA
Glasgow, Scotland *27 August – 1 September 2007*

The 15th Symposium of Palaeontological Preparation and Conservation will be held in Glasgow on 28th August, followed by the 55th Symposium of Vertebrate Palaeontology and Comparative Anatomy (SVPCA) from August 29th to 31st, 2007. Both events will be hosted by the University of Glasgow's Faculty of BioMedical and Life Sciences/Hunterian Museum in the lecture theatres of the Graham Kerr Building (Zoology Department). Accommodation (including breakfast) will be at the Queen Margaret residence (15 minutes walk through the Botanic Gardens to the main Uuniversity campus), which has free parking.

The annual Jones-Fenleigh auction will take place during the meeting, as will the annual conference dinner. The annual field trip will visit one of three localities, depending on the relative interest expressed in response to the first circular. In addition to these regular features, a plenary session will discuss the possible ramifications of the 2009 meeting of SVP in Bristol for SVPCA (see 2nd circular for more details).

Meeting website: <**http://www.svpca.org/years/2007_glasgow/first.circular.php**>

Organizer: J. J. Liston, e-mail: <**jliston@museum.gla.ac.uk**>

40th AASP Annual Meeting
Panama City, Panama *8 – 12 September 2007*

The meeting will be held at the Smithsonian Tropical Research Institute in Panama City, Panama.

Events

- Opening mixer
- Pre-meeting field trip to Barro Colorado Island or to the Canopy Crane at Metropolitan Park
- Tour of the Miraflores Locks at the Panama Canal

Guidelines

- Contributions accepted until July 5th
- Student financial aid available
- Hotel rooms reserved at discount rate at the Hotel El Panama

Further information is available from Carlos Jaramillo by e-mail to <**jaramilloc@si.edu**> and from the meeting website at <**http://www.striweb.si.edu/aasp07**>.

Flugsaurier – The Wellnhofer pterosaur meeting
Munich, Germany *10 – 14 September 2007*

The meeting is in Munich's famous Bayerische Staatssammlung für Paläontologie und Geologie (Bavarian State Palaeontological Collection – BSPG), and will focus on the pterosaurs and their world to celebrate the works of Dr Peter Wellnhofer.

The foremost authority on pterosaurs for the last four decades, Dr Wellnhofer spent much of his career in Munich as a curator at the BSPG, so it is appropriate that the meeting celebrating his work will be held in this world class collection. It is rightly considered one of the best pterosaur collections in the world and includes the 'Zittel wing', Anurognathus, and the 'Munich Pterodactylus', among other fossil treasures such as the Munich Archaeopteryx.

Many of the world's foremost pterosaur researchers have confirmed their attendance and a full proceedings volume based upon this meeting is planned for the journal *Zitteliana*. This international meeting will consist of two days of talks (in English), a day of open discussions and poster sessions, and a field trip to the world famous Jura Museum in Eichstätt.

Further details are available from David Hone at the address below or at <**http://flugsaurier.blogspot.com/**>.

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Computer Aided Visualisation in Palaeontology
Imperial College, London *13 September 2007*

This is a newly instituted one-day symposium intended to bring together those working on all aspects of three-dimensional reconstruction of fossil material to present and discuss methods and results. The meeting is intended for researchers interested in the applications of new techniques for 'virtual palaeontology', as well as those involved in their development.

Confirmed speakers at present include Martin Dawson (Leeds), Neil Gostling (Bristol), Norm MacLeod (NHM), Phil Manning (Manchester), Emily Rayfield (Bristol), Sue Rigby (Edinburgh), and Mark Sutton (Imperial). Poster presentations and interactive demonstrations will also be on show.

The meeting is sponsored by the Palaeontological Association. Registration and morning/afternoon refreshments will be provided free of charge. A limited amount of money is also available to assist with transport costs, particularly for students; please contact the organisers for more details.

Formal registration is not required – you can simply turn up on the day. The organisers do request however that you inform them by e-mail if you plan to attend, especially if you are bringing several people; this will assist logistical planning. Please also contact the organisers if you are interested in giving a poster or oral presentation.

See <**http://www.virtualpalaeo.org/**> for more details, including an up-to-date list of speakers and topics, travel directions, and other announcements. The organisers (Mark Sutton and Imran Rahman) can be contacted at <**conference@virtualpalaeo.org**>.

Seventh International Symposium, Cephalopods Present and Past
Sapporo, Japan *14 – 17 September 2007*

We are pleased to send you the first circular of the 7th International Symposium, Cephalopod – Present and Past. As shown in the first circular and on our website at <**http://www.cephalopod.jp/**>, registration started in March 2007. We would appreciate your attendance at the symposium.

9th International Symposium on Fossil Algae
Zagreb, Croatia *19 – 20 September 2007*

The meeting celebrates the 100th anniversary of research on fossil algae in Croatia. Presentations on any aspect of calcareous algae and microbes are welcome. Two field-trips are planned: pre-symposium field trip to Dinarides Mts., and post-symposium field trip to NW Croatia.

Meeting website: <**http://www.geologija.hr/symposium/**>.

Meeting organizer: Dr. Tonci Grgasovic, Croatian Geological Survey, Sachsova 2, HR-10000 Zagreb, Croatia, e-mail: <tonci.grgasovic@hgi-cgs.hr>, tel: 385-1-6160-707, fax: 385-1-6144-718.

Joint Meeting of CIMP Spores, Pollen and Acritarchs Subcommissions
Lisbon, Portugal *24 – 28 September 2007*

This meeting will involve three days of technical sessions at the Geological Survey in Lisbon, followed by a two-day post-meeting field trip in southern Portugal.

The meeting will be organized by INETI (Portuguese Geological Survey) and held in the Portuguese Geological Survey headquarters in Lisbon.

Further details are available at <**http://e-geo.ineti.pt/CIMPLisbon07**>, or contact Zélia Pereira by e-mail to <**zelia.pereira@ineti.pt**>.

International Conference on Geology: Indian Scenario and Global Context
Kolkata, India *January 7 – 11 2008*

About the conference

The conference is a part of the Platinum Jubilee celebration of the Indian Statistical Institute to be held during 2007–2008, which is also the 50th year of the establishment of the Geological Studies Unit in this Institute. The conference aims to provide a platform for interaction between Indian geologists and the global geological fraternity.

The conference will be focused around Precambrian geology of cratons and orogenic belts, Proterozoic and Gondwana basin studies, Gondwana and related vertebrate faunas, alluvial depositional systems, and quantitative analysis of geological data and numerical simulation. The conference will be held at the Indian Statistical Institute, Kolkata, India.

Accommodation
The organizers will arrange modest on- and off-campus accommodation. ISI Guest House accommodation rate is Rs. 250/- per day, per person. Some expensive off-campus accommodation may be arranged.

Academic Sessions

Session I: Quantitative Analysis and Numerical Simulation in Earth Science
Quantitative data analysis and numerical simulations are increasingly being used in almost all branches of Earth Science to test the models against ground geological facts and to explore newer understandings of process–product relationships. This session of the conference intends to address the present state of the art and identify newer directions for future research.

Themes:
- Size and shape analysis of geological objects including fossils
- Methods of geological data analysis
- Application of remote sensing techniques in geology
- Application of GPS and GIS techniques in geology
- Modelling of geological processes

Session II: Precambrian Terranes and Tectonics

The session will focus on tectonic evolution of the Precambrian orogenic belts and the associated cratonic sedimentary basins occurring in different parts of the globe. The conference aims at evolving a better understanding of the tectonic processes during the Precambrian that had driven the supercontinent cycle. In this context, special emphasis will be on the Eastern Ghats Granulite Belt and the neighbouring sedimentary basins of the Indian shield.

Themes:
- Metamorphism, structure and tectonics in Precambrian continental fragments
- Collisional tectonics and related basins
- Fold-and-thrust belts
- Proterozoic cratonic basins: depositional systems, palaeogeography, sequence stratigraphy, tectono-sedimentary evolution

Session III: Evolution and Diversity of Late Palaeozoic and Mesozoic Terrestrial Vertebrates

The terrestrial vertebrate communities of the Late Palaeozoic and Mesozoic eras witnessed several important ecological and evolutionary events including the emergence and extinction of several lineages of the amphibians, amniotes and the mammals. The present conference aims to consolidate and exchange fresh ideas on the diversity, evolution and distribution patterns of the Late Palaeozoic and Mesozoic vertebrate communities of the Gondwana and their relatives from the Laurasia, change in the nature of the vertebrate communities during the Late Mesozoic due to the rifting of the continents and finally the emergence of the mammalian and avian faunas.

Themes:
- Origin, evolution and extinction of the Late Palaeozoic and Mesozoic terrestrial vertebrates
- Functional anatomy and systematics
- Diversity and distribution patterns
- Biochronology, taphonomy and palaeoecology

Session IV: Evolution and Diversity of Late Palaeozoic and Mesozoic Terrestrial Vertebrates

Modern fluvial systems are known to be responsive to the surface gradient, amount and fluctuation of discharge, and sediment load supplied to the system. These factors are in turn controlled by tectono-geomorphology of the terrain, climate and provenance. Thus geological records of ancient fluvial systems are considered to be a useful tool for basin analysis and palaeoclimatic studies. The recent work on the alluvial systems and their deposits has two major trends: 1. Study of the modern alluvial systems in different climatic and tectonic settings to evolve a generalised relation between the alluvial system and tectono-climatic regime, and 2. Study of the ancient alluvial deposits to infer through inductive logic, the probable tectono-climatic regime in which they formed. The focus is on the study of modern fluvial system and ancient fluvial deposits that attempts to recognize the signatures of climatic and tectonic influences on the alluvial system.

Themes:
- Modern and ancient alluvial deposits
- Mud-dominated alluvial systems
- Climatic and tectonic controls on fluvial systems
- Palaeosols in fluvial deposits

Post conference workshops

Two post-conference field workshops are proposed, which will be held concurrently, on 13–19 January 2008. Fees for each trip: Rs. 3000/- (Indian participants), US$ 200 (foreign participants and same for accompanying members). The fees include Kolkata-Field-Kolkata train fares, cost of field vehicles, food and lodging.

Field workshop 1:
Geo-traverse across the Eastern Ghats Belt, adjoining terranes and the South Indian craton
The Eastern Ghats Belt along the eastern margin of the Indian peninsula, ranging in age from Archaean to late Proterozoic, represents a deeply exhumed collisional orogen with multiple events of magmatism, high-grade metamorphism and deformation. This belt, south of the Godavari graben, is flanked successively westward by the Nellore Schist belt, Prakasam alkaline province, and the Nallamalai fold-thrust belt. Features of Nal-lamalai fold-thrust belt is comparable to the external part of an orogen. A traverse across the Eastern Ghats Belt to the cratonic Cuddapah basin through the Schist belt, the alkaline province and the fold-thrust belt is planned.

Contact: Dilip Saha, e-mail <dsaha@isical.ac.in>

Field workshop 2:
Sedimentology and vertebrate palaeontology of the Satpura Gondwana succession, central India

Permo–Jurassic Gondwana succession is excellently developed in a number of basins spread across the Peninsular India. The Satpura Basin is one of the major Gondawana basins of India that preserves about 4 km of sedimentary strata representing one of the longest and most complete records of Gondwana sedimentation spanning over a period from Permian to Jurassic. Excellent exposures of Permian glacio-marine deposits, fluvio-deltaic coal measures, lacustrine strata, Triassic mud-dominated alluvial deposits with calcareous palaeosols and horizons with vertebrate fossil assemblages are the key attractions of the Satpura Gondwana succession. The field workshop would provide excellent scope for observing records of different sedimentological processes, climatic fluctuations and sediment–biota interactions as preserved in this basin. The trip will cover different spots spread across three districts and over more than 120 km.

Contact: Tapan Chakraborty, e-mail <**tapan@isical.ac.in**>.

Meeting Contact

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Meeting website <**http://www.isical.ac.in/~gsu2008**>.

8th International Congress on Rudists (IRC 8)
Izmir, Turkey *23 – 25 June 2008*

The meeting will be held at the Dokuz Eylul University-Izmir, and dedicated to Turkish rudist specialist Necdet Karacabey-Öztemür who made very valuable palaeontological studies on the rudists of Turkey. The theme of the congress is "Cretaceous Rudists and Carbonate Platforms". The congress includes major sessions and field trips as follows:

A Major sessions

1 Palaeogeography and Depositional Environments of Cretaceous Carbonate Platforms

2 Origins, Events and Demise of Rudist Palaeocommunities

3 MacGillavry session: Taxonomic and Phylogenetic Studies in Preparation for the Revision of Rudist Section in the Bivalvia Treatise (organization by P.W.Skelton)

B Field Trips

- Pre-meeting field trip (1): Campanian–Maastrichtian rudist-bearing mixed siliciclastic–carbonate transgressive–regressive system tracts of the eastern and southeastern Anatolia: Faunal correlation, depositional facies and palaeobiogeographic significance.
- Post-meeting field trip (2): Rudist-bearing marbles of the metamorphic Menderes Massif and the Upper Cretaceous rudistid limestones of the Bey Da_lar? (western Taurides) carbonate platforms.
- Post-meeting field trip (3): Lower Cretaceous rudist faunas from the Zonguldak region, western Pontides (northern Anatolia).

The presentation and examination of the rich rudist material collected by Dr Sacit Özer (DEU-Izmir) from the Pontide belt (northern Anatolia), the Anatolian and Arabian platforms (central-eastern and southeastern Anatolia), metamorphic Menderes Massif and western and central Tauride platform will be available during the meeting at the congress centre.

The congress will also contain effective social events such as selected historical and touristic regions and Turkish folkloric activities.

For more information, please consult the meeting's web site at <**http://web.deu.edu.tr/irc8/**>, or contact the chairman of the organizing committee at <**sacit.ozer@deu.edu.tr**> or the secretary at <**bilal.sari@deu.edu.tr**>.

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

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

The Second International Congress on Ichnology
Cracow, Poland *1 – 5 September 2008*

Following the successful First ICI, held at Trelew, Argentina in 2004, number 2 is being organized in Europe. Papers are invited on all subjects ichnological, including bioturbation, bioerosion, ichnofacies and ichnofabrics, leaf mines, coprolites, ichnotaxonomy and fringe areas. Field trips to the Carpathian and Holy Cross Mountains will be included. Intending participants are asked to visit the web page and to pre-register at <**http://www.uj.edu.pl/ING/ichnia08/**>.

For further information, please contact Alfred Uchman at <**alfred.uchman@uj.edu.pl**>.

Cluj-Napoca, Romania, e-mail <**sorin@bioge.ubbcluj.ro**>.

Mike Kaminski, UCL, e-mail <**m.kaminski@ucl.ac.uk**>.

8th International Workshop on Agglutinated Foraminifera
Cluj-Napoca, Romania *September 7 – 13 2008*

The Grzybowski Foundation and the Department of Geology, Babes-Bolyai University are pleased to announce the dates of the next International Workshop on Agglutinated Foraminifera. The workshop is open to all participants interested in the taxonomy, ecology, evolution and stratigraphy of the Agglutinated Foraminifera, and follows workshops previously held in Amsterdam, Vienna, Tübingen, Kraków, Plymouth, Prague, and Urbino over the last 27 years. The workshop will consist of three days of technical sessions, followed by a field excursion in the spectacular Transylvanian Basin and Southern Carpathians.

The meeting will be held in the Department of Geology, Babes-Bolyai University, situated in the former Roman town of Cluj-Napoca, Romania. The conference room offers modern projection facilities, and lunchtime meals will be taken in the University Restaurant opposite the Geology Department. Microscopes will be available for working groups and demonstration purposes.

Costs:
The registration fee for the conference is estimated to be approx. €120 euros, and a discount will be given to student participants. The fee will cover conference materials, refreshments at the meeting, and the welcoming reception. Field trip costs will be calculated separately. The Grzybowski Foundation will make available a limited number of travel grants for participants from eastern European countries. Accommodation will be at local hotels near the central square, at the discount rate of approximately €50 a night. Full details of costs will be made available in the second circular.

Preliminary Programme:
Sunday 7th September: arrival and welcoming reception
Monday 8th September to Wednesday 10th: Technical Sessions
Wednesday 10th September: Conference Dinner
Thursday 11th September to Saturday 13th: Field Excursion (Transylvania, Carpathians).

Information and Registration:

Sorin Filipescu, Department of Geology, Babes-Bolyai University, str. Kogalniceanu 1, 400084 Cluj-Napoca, Romania, e-mail <**sorin@bioge.ubbcluj.ro**> or Mike Kaminski, UCL, e-mail <**m.kaminski@ucl.ac.uk**.>.

An International Conference on the Cambrian Explosion
Banff, Alberta *August 3 – 7 2009*

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

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

International Scientific and Organizing Committee (as of April 2007)

Co-Chairs:

Dr Jean Bernard Caron (Royal Ontario Museum, Toronto), <**jcaron@rom.on.ca**>
Dr Doug Erwin (Smithsonian Institution, Washington), <**ERWIND@si.edu**>
David Rudkin (Royal Ontario Museum, Toronto), <**davidru@rom.on.ca**>

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Matthew Devereux (The University of Western Ontario), <**mdevereu@uwo.ca**>
Dr Stephen Dornbos (University of Wisconsin-Milwaukee), <**sdornbos@uwm.edu**>
Dr Sarah Gabbott (University of Leicester), <**sg21@le.ac.uk**>
Dr Robert Gaines (Pomona College), <**robert.gaines@pomona.edu**>
Dr Charles Henderson (University of Calgary), <**cmhender@ucalgary.ca**>
Dr Paul Johnston (Mount Royal College, Calgary), <**pajohnston@mtroyal.ca**>
Kimberley Johnston (Palaeontographica Canadiana), <**kimberley@paleos.ca**>
Dr George Pemberton (University of Alberta), <**george.pemberton@ualberta.ca**>
Dr Jean Vannier (Université Claude Bernard Lyon 1), <**jean.vannier@univ-lyon1.fr**>
Dr Xingliang Zhang (Department of Geology, Northwest University,Xian), <**xlzhang@pub.xaonline.com**>
Dr Maoyan Zhu (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), <**myzhu@nigpas.ac.cn**>

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

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

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

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

Palaeontology in all four dimensions

Spatial variation in palaeontological data is often overlooked, despite the importance of spatial variation in projecting ecological and evolutionary processes observed in the extant flora and fauna back into the fossil record. Geologists and palaeontologists are justly proud of the contribution they have made to the understanding of the evolution of earth and life in "deep time". Too often the "fourth dimension" becomes the only dimension that palaeontology represents. The iconic Sepkoski curve has time as the axis, and the past quarter of a century has witnessed the development of many hypotheses and analytical techniques that treat all taxa known from an interval as a single data point. These hypotheses have been scientifically fruitful, but there is a growing realization that we need to address spatial variation to gain deeper insights into evolutionary patterns recorded in the fossil record, and make the crucial links to processes.

This is not because of a lack of understanding of the spatial dimensions that geological and palaeontological data are collected in. Most palaeontologists studied some geology as undergraduates and have made maps. A geological training stresses spatial variation and methods of quantifying and analyzing that variation. The shift to research in palaeontology often involves deep immersion in the study of the morphology of a group or lab-based studies. It is not that the spatial aspects are forgotten. They just tend to decrease in importance. Some notable exceptions exist among the subdisciplines that make up palaeontology, notably palaeobiogeography and palaeoecology. Field mapping and spatial issues may be far from their mind. Yet there are good reasons for all researchers to consider the additional insights that spatial information could bring to their research.

Jackson and Erwin (2006) presented an argument that much of the best palaeontological research has been done when palaeontologists have gone into the geological record and worked it in a similar fashion to modern ecologists, and have collaborated with their colleagues in other areas of the earth sciences to produce independent data on stratigraphy, palaeoenvironments and other changes through time that might be relevant to the hypothesis under investigation. But a glance at the major ecological journals concerned with data analysis techniques (*Journal of Biogeography* and *Diversity and Distributions* are two good examples which publish many papers containing techniques and ideas that could be useful to palaeontologists), reveals that ecologists are particularly interested in spatial relationships and accurate collection of spatial data (georeferencing). By collecting detailed information on where collections are from, the scientific value of collections is enhanced in two ways. The first is of immediate benefit to the researcher(s) who are collecting the data. Firstly, a wider range of analyses may be performed on the data. The second benefit is to the wider community. Other researchers will be able to find the locality, even decades later. The data associated with the accession of samples into museum collections will also be fuller, increasing the scientific value of the specimens. Accurate georeferencing is much easier with the advent of cheap, handheld GPS units. The value of collections is enhanced in a number of ways by the use of GIS. Most importantly, the locality can be found again with reasonable ease. Too many older reports featured poor locality descriptions. Many readers will have come across locality descriptions of the form "One hundred yards from the barn on Smith's farm", only to find that there is no longer any barn or Smith within a mile of the site. Palaeontology is not the only field to suffer from these problems. Botany, which also

deals with static sites and locality information, also suffered from this problem. This problem is overcome in the UK, and in many other countries, by having people responsible for particular regions (in the UK vice-counties and counties) who collect and collate records. This has led to the rapid georeferencing of many sites as GPS became widely available. Palaeontology and geology do not really have a system like this, and given the reduction in university geology departments, the closure of local museums and the wide variation in knowledge of sites among local geological societies, where all of the local knowledge may be in the heads of two or three members, it is an issue that we should be giving some thought to as a community.

A survey of the past six issues of *Palaeontology* gives a snapshot of how maps and geographic information are used. Obviously there are some papers where georeferencing would be irrelevant, particularly the crop of review papers from 50(1), but this brief survey does give some insight into how spatial data are used and presented. Geographic and geological maps are routinely included and some are very detailed, but georeferencing, which I have defined as the publication of location information to at least the nearest second of latitude, is much less frequent. If the landscape and buildings in a large-scale map change it is much more difficult to relocate a locality.

Volume (Issue)	Papers	Geographic/geological map	Palaeogeographic map
49(4)	16	7	0
49(5)	15	5	0
49(6)	12	6	1
50(1)	15	4	0
50(2)	12	9	1
50(3)	13	5	1
Volume (Issue)	**Papers**	**Georeferencing**	**Other spatial data**
49(4)	16	1	0
49(5)	15	0	1
49(6)	12	1	1
50(1)	15	2	0
50(2)	12	0	0
50(3)	13	0	0

Table 1. Counts of the number of papers using different types of geographic and spatial data. Some papers did employ multiple data types and contribute to more than one column. "Other spatial data" consists of tables that list the country in which a fossil is from.

The use of palaeogeographic maps is much more limited. It could be argued that such maps are not scientifically relevant in many papers. Another difficulty with palaeogeography is rotating present-day coordinates to palaeocoordinates. This is one difficulty that our counterparts working on the extant flora and fauna do not have to cope with. Surprisingly there were two papers that mentioned biogeography, but showed neither geographic nor palaeogeographic maps.

The category of 'other spatial data' is a problematic one. These data represent cases in which a country is give as the location information. While this is somewhat helpful, geology – like species

– is no respecter of arbitrary geopolitical boundaries. More detailed information on the location of specimens or outcrops would be useful in these cases too, because there are countries, such as Indonesia, Greece and Canada, that are composed of large numbers of microterranes which have very divergent histories.

Plotting the data

One of the maxims of good data analysis is "plot your data". By plotting data, patterns that were previously unsuspected or unclear become obvious, and provide the basis for further analysis and generating new hypotheses. The rise of good computer drawing packages has revolutionized the composition and production of good maps. Gone are the days of tracing paper, Letraset and coloured pencils. All of the maps in the six issues of *Palaeontology* surveyed look as though they were prepared in electronic drawing packages.

However, this is not to say that producing maps is always easy. There are a number of factors. One is the availability of appropriate base maps. The coming of webmapping tools has helped to some extent, but there are still significant issues with copyright. Google Earth uses copyrighted data that may be used for non-commercial purposes. NASA's World Wind uses terrain layers that are in the public domain, as are all US Government works. ArcView, published by ESRI, is a high-end package and many universities now have bundled academic licences; it offers the means to produce publication-quality maps, and plot and analyse geospatial data. It also has the option for integrating geospatial analysis packages, and ArcView has a lot of useful extras because of the underlying Access relational database that is built as you put your data into the package. However, Arcview does require a fair amount of effort to learn and if your institution does not possess licences it is an expensive package to buy.

Alternative solutions for simple plotting of points on the modern globe do exist. The best known are Google Earth and Google Maps. However, they are not the only options. ESRI is producing a geobrowser with similar capabilities to Google Earth. An open-source project 'OpenLayers' offers a set of free tools for working with and visualizing geospatial data. NASA's Worldwind browser is another option. This group of packages is particularly useful if you only want to plot points on modern day geography. The tools available in these programs are becoming more and more sophisticated. Many of the measurement and point-marking tools that used to be difficult to find outside of Arcview are now available. A great feature of many of the geobrowsers is the ability to overlay other images, such as geological maps, as additional, semi-transparent layers. Watching Ken Johnson overlay geological maps on to Google Earth's geographic layer to check which geological units containing corals were cropping out, and where, was what initially sparked my interest in geobrowsers.

The amount of data that can quickly be linked with geobrowsing tools, usually with simple mark-up languages, is another impressive feature. It is possible to mark points, put some information in a dialogue box using HTML and a link to a website that contains much more information. The potential for these tools is enormous, particularly for public communication and data sharing. Such overlays and linking to other web resources are referred to as 'mash-ups'.

Geospatial data in deep time

Palaeogeographic maps are a more difficult subject. There are a number of sources of good palaeogeographic reconstructions on the web, which are now regularly used as the basis for

plotting data. Chris Scotese (<**http://www.scotese.com/**>), Ron Blakey (<**http://jan.ucc.nau.edu/~rcb7/globaltext2.html**>), Allister Rees (<**http://www.geo.arizona.edu/~rees/movies.html**>) and Alan Smith (<**http://www.esc.cam.ac.uk/new/v10/teaching/geology/ia/JPGVideo.avi**>) all provide maps on the web, and can be approached to use them in publications. Geobrowsers are at a serious disadvantage when it comes to palaeogeographic maps. I don't know of any palaeogeographic reconstructions available for geobrowsers and there may be significant problems relating to different map projections. Most palaeogeographers use Mollewide projections, rather than the familiar Mercator projection. Differences in map projections are also a potential pitfall when overlaying data layers from other sources on to base maps, so make sure that the projections match. Rotating points from present-day locations to the correct palaeolatitude and palaeolongitude is another aspect of accurately plotting data on paleogeographic maps, and the accuracy of the rotations significantly decreases beyond the Late Triassic, due to the lack of preserved seafloor. The only package that currently exists that can rotate co-ordinates and plot them within a single package is PalaeoGIS, which runs in ArcView.

Research and public engagement benefits of thinking about palaeontology in all four dimensions

One of the most direct benefits would be the ability to find outcrops and localities again, even if many years have passed. Jackson and Erwin (2006) noted that new hypotheses will require new data and associated field collections, and we should do all we can to increase the scientific value of new collections to ourselves, our colleagues and future researchers. Older collections can have new geographic data added to them, if we can still find the localities. An example of the potential value of retrospective georeferencing of museum collections can be found in Guralnick and Van Cleve (2005). They were interested in comparing estimates of modern avian diversity between museum collections and field-based studies in southern Colorado. By having accurate coordinates we can put data in a clear spatial context, both during projects and at later stages when other analyses occur to researchers.

Viewing multiple datasets simultaneously on the same maps should improve our ability to link data sets in meaningful ways. By taking a spatially explicit view of our data, previously unsuspected patterns may emerge. Breaking out of thinking of all fossils from an interval as, for instance, "The Albian", and moving towards a more regional approach will extend the usefulness of data and allow alternative models and ways of thinking about the fossil record. Emphasising regional differences has been an important advance in thinking about recovery from mass extinctions, where there have been significant advances in thinking about recovery by the simple expedient of avoiding lumping data. The use of spatial data will allow the tools developed to address ecological and biogeographic questions to be applied to a wider range of palaeontological questions. They will also make it easier to integrate geological data, particularly from the relatively recent past, to tackle issues such as biotic response to climate change.

The widespread use of Google Earth, and the rise of 'mash-ups', offers an excellent opportunity for public engagement and the development of new teaching tools and presentations. It is possible, as outlined above, to place a marker, add some information and links using HTML. The possibilities deserve to be explored further, particularly in relation to sites that are difficult to travel to, or to which access may be restricted. An excellent example would be the Burgess Shale. The quarry site itself could be marked on Google Earth, then links could be made to photos of the

fossils themselves and the appropriate museums. It is then possible to build a 'tour' in Google Earth that would 'fly' the user to a number of other related localities such as Sirius Passet and Chenjiang. However, there is an even greater potential in combining palaeogeographic maps, particularly the animated versions, and palaeontological data on the history of life. Just as the famous 'Earthrise' photos of Earth taken from the moon are credited with creating a psychological shift in those who saw them towards an understanding that we are a 'spaceship' in a hostile void, there is great potential to use virtual vistas in the "fourth-dimension", to broaden understanding and appreciation of the impermanent nature of the Earth and its species. All this without ever leaving your seat.

Al McGowan
Newsletter Reporter

Acknowledgments:

Thanks to Ken Johnson for showing me the potential of data 'mash-ups' for handling locality data. Jon Blower and Stuart Ballard organized a two-day workshop at the National Institute for Environmental Science (NIEeS) that allowed me to further my knowledge of the potential of geospatial data.

REFERENCES

GURALNICK, R. and VAN CLEVE, J. 2005. Strengths and weaknesses of museum and national survey data sets for predicting regional species richness: comparative and combined approaches. *Diversity and Distributions,* **11**, 349–359.

JACKSON, J. B. C. and ERWIN, D. H. 2006. What can we learn about ecology and evolution from the fossil record? *Trends in Ecology and Evolution,* **21**, 322–328.

Finding out more about geobroswers and geospatial data analysis

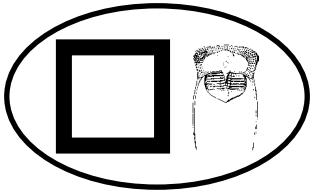
Rather than list lots of links here, a new subsection will be added to the Online analytical resources for Paleobiology, at <**http://www.palass.org/modules.php?name=palaeo&sec=links&page=114**>.

A number of presentations demonstrating the potential uses of geobrowsers across the environmental sciences can be found at <**http://www.niees.ac.uk/events/GoogleEarth/**>.

The Reading e-Science Centre has a strong group developing geospatial applications and datasets for use in the sciences; see <**http://www.resc.rdg.ac.uk/index.php**>.

A networking site arising out of the meeting discussed above has been built using the new social networking site established with NIEeS's new SciSpace tool, which is a "social networking site for scientists". Full instructions are on the site itself, at <**http://www.scispace.net/geobrowsers/**> To prevent spamming of the site, you have to send an email request to register.

Outside The Box



Science Communication

Introduction

"So, why did you move out of research?" asked Matt Walker, news editor at *New Scientist*. It was a valid question given that I'd spent the previous five minutes chatting enthusiastically about the joys of palaeontology. I paused for thought…

Just a year or so earlier I had been a content palaeontology PhD student, considering a future in research. But two revelations changed my mind. First, and unusually for a PhD student, I *enjoyed* writing my thesis. All of it. There was something satisfying about weaving together the various disparate elements into a coherent whole (so it was that, long before I began a course in science communication, I was aware that scientists are masters of narrative. But more of that later).

Secondly, I remembered my reasons for choosing science. Every week, a wide range of innovative scientific research is published. New dinosaurs are found, new drugs are developed for serious illnesses, and new planets with the potential for harbouring life are discovered. I chose science for the excitement. And yet, as a practising scientist, I felt oddly excluded from the fun. Often, the scientist cannot see the wood for the trees. Even as a PhD student spared the misery of academic bureaucracy, there was precious little time to devote to reading beyond my own subject. It seemed paradoxical, but to get the most out of science, I had to get out of science. Science journalism seemed perfect: days spent reading about the latest research and then writing about it.

Matt nodded his approval. But how did I get from palaeontology PhD student to an interview for an internship at *New Scientist*? And was my application successful?

The next step

Networking is as important in the media as it is in science. A straightforward route into the network is through a course in science communication. There are three science communication courses on offer in the UK today, run by Cardiff University, Bath University and Imperial College London. After four years of PhD research based largely at the Natural History Museum in South Kensington, the short move up Exhibition Road to Imperial College was the obvious choice. The Imperial course has additional advantages. The UK's media is very London-centric, and there are more work opportunities for those based there. And because Imperial's course has been running since the early 1990s, its graduates occupy positions in virtually every major media organisation. Mention of 'The Course' offers instant access to this influential network.

Course content

The course runs for 12 months. Although all of the tutors have backgrounds in science, the course is taught in the humanities programme, and covers the philosophical and social aspects of science from the enlightenment to the present day. The second term is devoted to an array of pure humanities course options, from the role of ethics in science to the importance of narrative

structure in science. The latter was a personal favourite. Palaeontology is, of course, a series of interconnected narratives. Evolution itself is narrative on a grand scale. There is also the 300 to 400 year long narrative of palaeontological research. And at the smallest scale, there is a narrative structure within any palaeontological research paper. And yet, because narrative is often taken as a pejorative synonym for fiction, many scientists are unwilling to accept that narrative has a role in science. As is no doubt clear from the above, the science communication course is surprisingly academic for a course that purports to offer vocational media training. But students are encouraged to participate in as many extra-curricular activities as possible to build up a portfolio of practical work. There are student radio and television stations, and a range of newspapers and magazines to write for at Imperial.

Work Experience

During the Summer, the course offers the opportunity to experience work in a media organisation. This is another good reason to choose the Imperial course. There are a wide range of placements available, including several at the BBC and national broadsheet newspapers. Also on offer are placements at academic journals, including *Nature* and *The Lancet*, and science magazines such as *New Scientist*. Choosing which media organisations to apply to is a matter of weighing up pros and cons. The higher impact organisations look more impressive on a CV but can provide little useful work experience. Rohan Mehra, a student on this year's course, has just completed a four-week spell on the *Horizon* programme at the BBC. He talks of feeling like a 'tool', manipulated by senior members of staff. He also complains that his work on a number of upcoming programmes went uncredited. Those who opt for work at smaller organisations tend to find the experience more rewarding, and are integrated into the team to a greater degree. Some of this year's students who chose to work at independent media companies have been offered permanent work there.

And ultimately, that is the reason for taking a course in science communication. Fun though it is to spend several weeks pondering the 'truth' of scientific investigation and the current state of play in the 'Two Cultures' debate between sciences and the arts, it is the promise of work in the exciting and ever changing world of science communication that spurs students on. Media job adverts are forwarded to course students on a regular basis; I can rely on several adverts appearing in my inbox each week. It was through one such email I heard about *New Scientist* internship programme. I had applied for similar schemes a year ago, but even on the strength of several years researching for a PhD I did not progress far. This year, with a science communication course on my CV, I reached the final five applicants. I got no further, but my interviewer, Matt Walker (himself a former science communication student at Imperial) was impressed enough to encourage me to apply for a Summer placement at *New Scientist*. I begin a six-week placement there shortly. It's a foot in the door…

Colin G. Barras
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Useful links:

Imperial College London science communication website:
<**http://www3.imperial.ac.uk/humanities/sciencecommunicationgroup/**>

University of Bath science communication group:
<**http://people.bath.ac.uk/hssdcg/SCandC_2.html**>

University of Cardiff science, media and communication website:
<**http://www.cardiff.ac.uk/jomec/en/ma/346.html**>

Association of British Science Writers. An organisation to help those who write about science and technology, and to improve the standard of science journalism in the UK:
<**http://www.absw.org.uk/**>

Geoconservation and Geoeducation

On completion of my PhD on trilobite terrace ridges, I unsurprisingly found myself somewhat surplus to requirements in the trilobite job market. Feeling an urgent need to earn some money and having to do so in the wilds of Worcestershire, to where I was relocating from the bright lights of the Natural History Museum, I contacted the local Geology Trust on the off chance that they might have some work I could do for them. Surprisingly enough, they did. That was in January 2005, and since then I have worked full-time on a series of geological and palaeontological contracts, primarily for the Herefordshire and Worcestershire Earth Heritage Trust (H&WEHT), all on a self-employed basis.

The H&WEHT (<**http://www.earthheritagetrust.org/**>) is one of several member groups of the Geology Trusts. The Geology Trusts (formerly the Western Association of RIGS Groups) is an association of Geoconservation and Earth Heritage groups in England and Wales, which currently also includes Bedfordshire, Gloucestershire, Gwent, North-East Yorkshire, Oxfordshire, Shropshire, Warwickshire and Wiltshire. (Website addresses for most of these are available on the Geology Trusts pages at <**http://www.earthheritagetrust.org/**>.) The aims of the various Geology Trusts are broad-ranging, but in essence they exist to protect, conserve and enhance geological sites and landscapes and raise awareness of local earth heritage. They are non-profit making organisations, deriving their income from various grants, funds, charitable trusts and foundations.

The Geology Trusts employ many full- and part-time staff. The funded work is predominantly project-based, this being more attractive to potential funders than the 'core' geoconservation work of site recording and designation of RIGS (Regionally Important Geological (and Geomorphological) Sites). Projects can be quite short-term, funding sometimes only being granted for a few months' work, although several larger projects at the H&WEHT have been funded for two or three years. This means that long-term job prospects cannot be guaranteed, although a series of carefully targeted grant applications has kept several Trust staff in employment for many years.

Over the last couple of years or so I have been involved with a variety of projects for the H&WEHT, many of which have fortuitously had strong palaeontological elements. Initially I was tasked with producing several local geological trail guides, and devising some new educational activities and teaching materials for the Trust's *Rock and Fossil Roadshow* programme, aimed at schools and the public. The educational activities project ended up including the design and manufacture of a

very popular (somewhat larger-than-) life-sized wooden *Velociraptor*, which I manufactured with the help of a local school Technology department. As you can probably tell from the photograph, taken at a Rock and Fossil Roadshow at Eastnor Castle, Vernon is essentially scaled up from a stylised shop-bought wooden kit. The plans were produced using CAD/CAM (computer-aided design and computer-aided manufacturing) and then the pieces were mainly cut using a CNC (computer numerical control) milling machine. Although this particular job did not end up being especially palaeontological, my woodworking skills have improved enormously as a result! Vernon has recently undergone an overhaul and now sports realistic white acrylic teeth, a more anatomically accurate skull, and hips which stay on; he is now even more of a hit with the young audiences.

Vernon at Eastnor Castle (photograph by the Hereford Times)

As well as devising educational outreach activities, I have helped out at many of the Trust's hectic Rock and Fossil Roadshows (suppported by Heritage Lottery Funding), at which I frequently end up providing a fossil (and anything else that gets brought in) identification service to the general public. This is one of those times where as a lowly trilobite worker I can feel quite out of my depth, but it is very much a "kingdom of the blind" situation. Equally, as the local palaeontologist, although not much of a dinosaur specialist, I got involved with work on a new dinosaur trackway discovery near Cirencester, in association with Gloucestershire Geology Trust.

Whilst this trail and activity-devising work was for the H&WEHT, several other Geology Trusts also run Rock and Fossil Roadshows and produce local geology trails, so I feel these give a fair reflection of some of the work going on in these organisations. Local Geodiversity Action Plans (LGAPs – see Natural England's downloadable report IN164) are also currently being produced in many geoconservation groups, including the H&WEHT.

Although I have continued to be involved with various other Trust projects, as well as undertaking core work such as attending council meetings and considering planning applications, since August 2005 I have been the full-time project manager of the "Whitman's Hill Geodiversity Discovery Venture". This project is funded by Natural England through DEFRA's Aggregates Levy

Sustainability Fund, and concerns the conversion of a disused limestone quarry near Malvern (which exposes the Coalbrookdale and Much Wenlock Limestone Formations) into an interesting and safe educational and research resource. The future of this important site was threatened but, thanks to the funders, the Trust now has a ten year lease on the site. Although the details are only relevant to this project, this brief account will hopefully provide a flavour of a type of project being undertaken at the Geology Trusts.

Initially, I recruited and ran a Steering Group made up of local interested parties and organisations. This was especially important as community involvement was crucial to the success of the project. More people were subsequently attracted to the project at the launch event, thanks to the attendance of the local MP and media. Early on, I commissioned a geotechnical safety audit and supervised the recommended site safety works, which mainly involved bunding off dangerous areas of the quarry, but I also managed to persuade the JCB operators to clear some of the faces at the same time, especially to expose the (gradational) boundary between the Coalbrookdale and Much Wenlock Limestone Formations.

Subsequently I conducted geodiversity and palaeontological audits, which resulted, most interestingly, in the commissioning of the analysis of zircons and apatites in the bentonite layers, to ascertain the radiometric age and magmatic provenance respectively. Despite great collection and identification efforts (with much appreciated help from former colleagues at the NHM), the fauna turned out to be quite unremarkable, but the site is excellent for fossil hunting, especially for children. Additionally, I supervised a Biodiversity Audit of the quarry and woodland by Woolhope Naturalists' Field Club Volunteers (who also erected several birdboxes and dormouse tubes in the woodland) and oversaw research into the quarrying heritage of the site by Cradley Heritage Group Volunteers.

Once the site had been studied and made safe, a busy programme of events, visits, seminars, workshops and activities was arranged, primarily exploring the geology and palaeontology of

Young children fossil hunting at Whitman's Hill (photograph by Abigail Brown)

the site, but also its wildlife and history. Our very own Dr Herringshaw did the honours and ably delivered the first seminar on his Wenlock Weirdoes. Numerous quarry visits, along with preparatory and follow-up classroom sessions about the rocks and fossils seen at the site, were undertaken by school parties (from Reception Class to Year 11), as well as the general public and local interest groups. An impressive number of people have already visited the site, with public open days attracting around 80 visitors each time – hard work when they all want their finds identified, even if they are all *Atrypa*! Additionally a series of articles, leaflets and online eLearning resources have been produced, mainly aimed at teachers and students for use in connection with quarry visits, to assist with orientation and fossil identification, for example. The most eye-catching elements of the website are the 360° panoramic views of the site and the virtual fly-through the geology of the quarry and the Malverns (see the Whitman's Hill pages at <**http://www.EarthHeritageTrust.org/**>). The next challenge for this project is to secure additional funding to enable the visits programme to continue for the remainder of the lease.

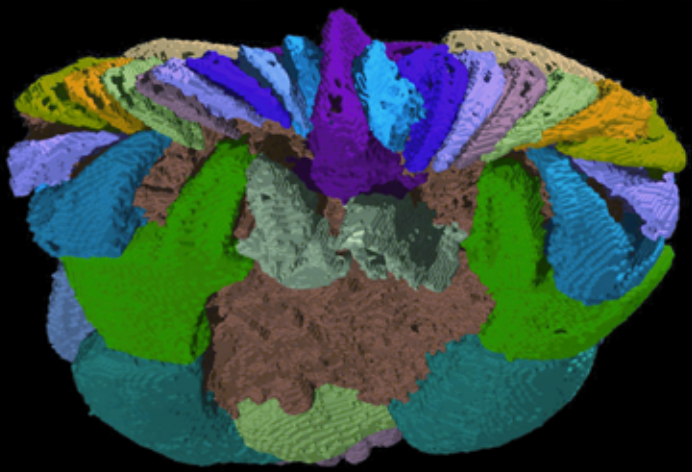
Whilst self-employed contract work has its obvious pitfalls, and in this sector the pay is quite poor, another positive aspect of this job is that it has been possible to work primarily from home, often with the option to choose what hours are worked, as long as the work is completed. This relative freedom has enabled me to fit in visits to local schools and science clubs to run sessions of palaeontological and geological activities, as well as undertaking my own palaeontological research. I was also recently invited to devise and deliver a series of adult evening classes in Palaeontology at the University of Worcester, which were well attended and received.

In summary, in the areas of geoconservation and geoeducation there are often employment opportunities and the (frequently) short-term project-based nature of the contracts means the work changes quite frequently, keeping you fresh and always gaining new skills. There is even the opportunity to design your own job if you can come up with a project the funders like!

Abigail Brown

Young women – the future of Palaeontology (photograph by Nigel Collins)

COMPUTER AIDED VISUALISATION IN PALAEONTOLOGY



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Sylvester-Bradley REPORTS

Crystallography and Chemistry of Fossil Craniids

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Electron backscatter diffraction (EBSD) provides crystallographic data from a sample without the need to remove individual crystallites as with other crystallographic techniques such as TEM. In recent years the potential of this technique has been recognised within the field of Biomineralisation and has provided important information concerning the crystallography of invertebrate skeletons and shells (Cusack *et al*., *in press*; Dalbeck *et al*., 2006; England *et al*., 2007; Schmahl *et al*., 2004).

The aim of this project was to apply EBSD to the shells of both modern and fossil Craniid brachiopods in order to determine and compare their detailed crystallographic structure. By using this novel technique we can investigate the crystallography of shells from the same subphylum ranging from the Ordovician to the present day. This data is invaluable not only to the study of early biomineral systems, but when combined with chemical data can also provide information concerning diagenesis, a process that is not yet fully understood. Chemical data was obtained by electron probe microanalysis (EPMA).

The dorsal valve of the Craniid shell is composed of two layers: a thin outer primary layer of acicular calcite, and an inner secondary layer of calcite semi nacre, which grows by screw dislocation (Williams and Wright, 1970). This shell structure has been identified in both extant and extinct species (Williams and Wright, 1970).

For this study two extant (*Novocrania huttoni* and *Novocrania anomala*) and three extinct (*Petrocrania scabiosa*, *Crania craniolaris* and *Crania quadrata*) species were analysed. In modern specimens of both *N. huttoni* and *N. anomala* the calcite *c*-axis lies parallel to the laminae that form the semi nacre (England *et al*., 2007). From analysis of the three fossil specimens, results obtained from an Ordovician specimen of *P. scabiosa* are of particular interest. In *P. scabiosa* the original crystallographic structure has been preserved and is identical to that of modern day craniids, in that the calcite *c*-axis is orientated parallel to the laminae (Figures 1 & 2).

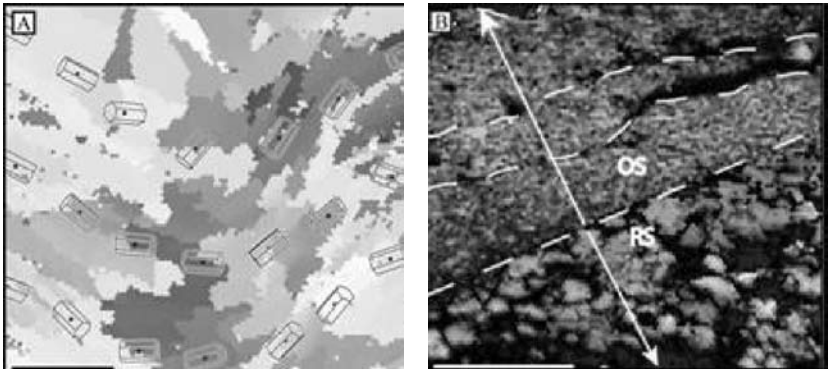

Figure 1. EBSD data of (A) Novocrania huttoni and (B) Petrocrania scabiosa.
A: Crystallographic map of the secondary layer of N. huttoni with outer surface of shell beyond top of image. Hexagonal calcite unit cell superimposed on image of N. huttoni laminae indicating that the c-axis is parallel to the laminae and therefore parallel with the shell surface in an undulating manner; scale bar = 15 µm.
B: EBSD index intensity map of polished section of P. scabiosa indicating areas of excellent preservation of original structure (OS) and those where diagenetic alteration has replaced the original ultrastructure (RS) with large calcite crystals; scale bar = 80 µm.

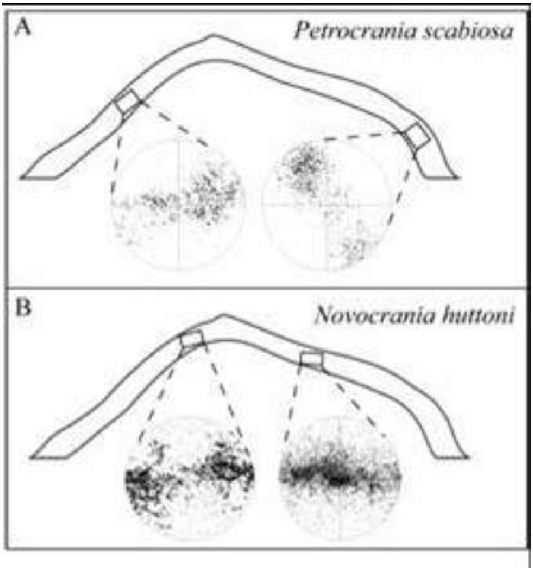

Figure 2. Schematic representation of section of P. scabiosa (A) and N. huttoni (B) dorsal valves indicating areas of EBSD analyses with corresponding pole figures, indicating crystallographic orientation of calcite crystals in reference to the {0001} plane of calcite. In all cases, the c-axis of calcite is parallel to the shell surface.

These results suggest that the crystallography of modern day Craniid brachiopods is the same as that of Ordovician Craniids.

Electron microprobe data indicates that all the fossil specimens studied have undergone diagenesis. However, while the original crystallography has been preserved in *P. scabiosa*, the original crystallography has been lost in *C. craniolaris* and *C. quadrata*. Further study into the different conditions under which these fossil Craniid specimens were preserved may provide valuable information on the mechanisms of carbonate diagenesis.

Acknowledgements

I would like to thank the Palaeontological Association for the Sylvester-Bradley Award which allowed me to carry out this study. I would also like to acknowledge the late Sir Alwyn Williams who collected the fossil specimens.

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Pennsylvanian intramontane ecosystems of central Europe

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Pennsylvanian coal-bearing strata contain remains of the earliest rain forests to evolve on our planet. Studied for more than 200 years, these 'Coal Forests' represent one of the best-understood terrestrial ecosystems in the entire Phanerozoic (DiMichele *et al.* 2001). Fossil remains are preserved right across the palaeotropics from central USA in the west to the Urals in the east (Falcon-Lang *et al.* 2006). Still poorly known are the communities that existed in intramontane environments within the Variscan Mountains that ran parallel to the tropical zone (Falcon-Lang & Bashforth 2005). Here I report how I used Sylvester-Bradley funds to investigate intramontane palaeoecology at a cluster of sites in the Czech Republic and former East Germany.

This work is ongoing and is being carried out in collaboration with Stanislav Oplustil of Charles University, Prague, my Ph.D. student, Arden Bashforth, and others.

The Pennsylvanian deposits in the study area infill a series of palaeovalleys that cut into regional basement. Given that fluvial sediments show extremely variable drainage patterns, both south into Austria and northwest through Germany, it is probable that the region comprised an area of considerable palaeotopography (Oplustil 2005). In our work we mainly focused on the deposits of the Kladno-Rakovnik Basin in the Czech Republic, as well as sediments in the Erzgebirge Basin of southern Germany (Shneider & Gaitzch 2004). The latter basin represents a valley-system that connected intramontane depocentres to the open seaway in the Variscan foredeep, and therefore might be expected to contain fossil communities that are transitional from montane settings further south.

In the Kladno-Rakovnik Basin, eleven sites were visited and fossil plant distribution recorded in a sedimentary facies context. Only two are described in this brief summary. One especially interesting locality is the Mirosov-Janov Quarry, and adjacent Hradek Quarry. Here, Duckmantian units of the Kladno Formation comprise 15–20 m thick conglomeratic units, interpreted as alluvial fan deposits. Plant impressions, preserved in localized mudstone laminae, were examined in collections at the National Museum, Prague. Arden Bashforth also made additional new collections, and systematic descriptive work, as well as quantitative analysis of palaeoecology, is underway. Although drawn from the same major plant groups that characterized lowland wetland deposits, the assemblages show distinct dominance–diversity characteristics, and likely represent upland floras.

Another interesting site examined is the Kaznejov Kaolin Mine where alluvial channel facies belonging to the Cantabrian Tynec Formation (Oplustil *et al.* 2005) contain abundant silicified tree-trunks, up to 2 m in diameter, and locally 17 m in length. Trees are allochthonous in trough cross-bedded sandstone. Given their taphonomic context, they were likely transported from extrabasinal forests (Falcon-Lang & Bashforth 2005). Samples of these trees were thin-sectioned, and wood anatomical studies are currently under way. Most conform to the general *Dadoxylon*-type but in some cases it may be possible to distinguish cordaitalean woods from those of conifers (Noll *et al.* 2005). Plant impressions in mud plugs within some channels were also collected, and Bashforth will examine these in the course of his doctoral research.

Within the Erzgebirge Basin of the former East Germany, outcrops were examined along the Mulde River, in the vicinity of the Carnsdorf Bridge (Schneider and Gaitzch 2004). The catastrophic floods that hit central Europe in recent times have produced moderately good exposures. Fossil plants collections comprising adpressions and a few permineralized wood fragments were made at a number of sub-localities along the river, and systematic work is under way to compare them at the species-level with coeval deposits, downstream in the coastal plain facies of northern Europe, and upstream in the intramontane basins described above.

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A reappraisal of the phylogeny of early dinosaurs

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The origin and initial diversification of the dinosaurs are still poorly understood despite the immense focus on dinosaur palaeobiology during the last 30 years. New discoveries of relatively complete material over the past 20 years (*e.g.*, Sereno *et al.* 1993) have added much to our knowledge of basal dinosaurs, yet there is still considerable debate about how these forms fit into the phylogeny of dinosaurs and their closest relatives. Because of this uncertainty of relationships, there are precious little data available to test hypotheses about the initial divergences and diversifications of the main dinosaur clades of Ornithischia, Sauropodomorpha, and Theropoda.

Although additional data in the form of new specimens and taxa are always welcome, it appears that a large part of the chaos surrounding basal dinosaur relationships is methodological. There has been no shortage of phylogenetic analyses of basal dinosaurs over the past 15 years, and many share common weaknesses that may in part prevent the academic community from reaching a consensus. Most published basal dinosaur analyses have only utilized one or two closely related outgroups to polarize their characters, whereas a much deeper sampling of Archosauria is needed to understand the distribution of character-states throughout the clade, especially because many of these non-dinosaurian archosaurs were contemporaries of basal dinosaurs, and fragmentary specimens could be confused with basal dinosaur material. Additionally, nearly all analyses have excluded more fragmentary taxa of basal dinosaurs, even though it is clear that even highly-incomplete fossils can impact the topology of a phylogenetic tree.

New discoveries in the last several years have also necessitated a re-evaluation of basal dinosaurs. Dzik (2003) described the peculiar basal dinosauriform *Silesaurus opolensis* from the Upper Triassic of Poland. The discovery that many alleged Triassic ornithischian taxa cannot actually be considered ornithischians or dinosaurs (Irmis *et al.* 2006a) has led my colleagues and me to re-evaluate all proposed Triassic dinosaur records in North America (Nesbitt *et al.* in press). This comprehensive study has resulted in several important conclusions. First, several character-states previously used to diagnose the Dinosauria or clades within it were found to have a wider distribution among the Archosauria. Using a revised group of robust synapomorphies for identifying Triassic dinosaur taxa, we have determined that many of the purported Triassic dinosaur specimens are not diagnostic, or are chimaeras of dinosaur and non-dinosaur material. The revised record suggests that there are no confirmed occurrences of sauropodomorphs or ornithischians in the Triassic of North America.

My colleagues and I are also studying new material from the Hayden Quarry, a new locality that is near both the Ghost Ranch *Ceolophysis* Quarry and the Snyder Quarry in northern New Mexico (U.S.A.). Preliminary excavations have already yielded associated remains of a basal dinosauriform, several basal dinosaurs, and coelophysoid theropods. The Hayden Quarry is the only site in the world where basal dinosauriforms, basal dinosaurs, and theropods are found in direct association (Irmis *et al.* 2006b).

The author (left) and Sterling Nesbitt (right) excavate early dinosaurs at the Hayden Quarry in northern New Mexico (photo by A. Turner).

To incorporate the new discoveries outlined above and to address the weaknesses of previous phylogenetic hypotheses, I am working on a new phylogenetic framework based on a specimen-level analysis of early dinosaurs and related taxa as part of my PhD dissertation. With this phylogeny, I will be able to evaluate questions about biostratigraphy, evolutionary timing, biogeography and adaptation. For example, did a key adaptation or set of adaptations contribute to the success of the Dinosauria as a clade? What is the tempo and mode of early

dinosaur diversification? What hypotheses might explain the heterogeneous distribution of the major clades of dinosaurs (*i.e.*, ornithischians, sauropodomorphs, and theropods) during the Late Triassic, and can a particular geographic origin be postulated for the group?

The Sylvester-Bradley award allowed me to travel to various European collections to collect data for my phylogenetic analysis, as well as to compare the anatomy of known basal dinosaurs and relatives with the new discoveries from the Hayden Quarry. During my four week research trip, I visited the Natural History Museum (London), Humboldt Museum für Naturkunde (Berlin), Staatliches Museum für Naturkunde (Stuttgart), Institut für Geologie und Paläontologie (Tübingen), and Instytut Paleobiologii PAN (Warsaw). This visit complemented other visits to South America; I have now examined most of the basal dinosaur material in museum collections worldwide.

Although data analysis is still ongoing, preliminary results suggest that the new taxa from the Hayden Quarry do not belong to endemic North American clades. Rather, their closest relatives may be taxa that were previously known only from Argentina. Some material from the Hayden Quarry appears to be most closely related to the dinosauriform *Silesaurus* from Poland. These geographic connections suggest that the early biogeography of dinosaurs is not nearly as simple as the fossil record would lead us to believe. Publications of these results are currently in preparation, and will include a preliminary phylogenetic analysis that utilizes important data from my Sylvester-Bradley funded research trip.

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Geometric morphometric analysis of variation in Sphenodon 'sub-fossil' material

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The Tuatara, or *Sphenodon*, is a curious terrestrial reptile currently restricted to approximately 30 New Zealand offshore islands (Gans, 1983; Daugherty *et al*., 1990; Parkinson, 2000). It possesses a combination of characters not found in any other extant taxa; acrodont teeth, a posteriorly extended dentary, and an enlarged palatal tooth row, and represents the last living member of the Rhynchocephalia (*sensu* Gauthier *et al*., 1988), a group of lepidosaurian reptiles that attained a global distribution during the Mesozoic (*e.g.* Whiteside, 1986; Sues and Reisz, 1995; Evans *et al*., 2001; Jones, 2006a). Recent research has shown that the group, was more morphologically diverse than previously assumed and occupied a variety of palaeoecological niches (*e.g.* Evans, 1980, 2003; Carroll and Wild, 2004; Apesteguía and Novas, 2003; Jones, 2004, 2006abc; Reynoso, 1996, 2005).

As with other fossil taxa, extinct rhynchocephalians are diagnosed on the basis of morphological characters (*e.g.* Evans *et al*., 2001; Reynoso, 2005), and within group phylogenetic analyses rely exclusively on these (*e.g.* Whiteside, 1986; Reynoso, 1996). However, it can be difficult to assess taxonomically relevant morphological variation when sample sizes are small, prompting the need for a survey of the variation present in a sample of modern *Sphenodon*. Unfortunately, collections in the UK rarely include more than three *Sphenodon* skeletons, and frequently less than two. Juvenile/subadult material is especially hard to come by. Specimens are also often articulated and mounted for display, which can inhibit both examination and imaging. Moreover, most of the material lacks locality data and may be damaged from years of use (or misuse) in teaching collections.

The situation in New Zealand is rather different. Modern material is regularly donated to museum collections by conservation workers following chance encounters of dead individuals on the populated islands. Furthermore, a number of localities across mainland New Zealand have yielded assemblages of Holocene and Pleistocene 'subfossils' referable to *Sphenodon* (Crook, 1975). Recurrent excavations for bird fossils, in particular, have resulted in the recovery of *Sphenodon* material (*e.g.* Millener, 1981; Worthy and Grant-Mackie, 2003). This has led to extensive and carefully registered (but relatively unsurveyed) collections of *Sphenodon* bones in several institutions.

The Sylvester-Bradley Award allowed me to travel to New Zealand to visit these collections, including those on loan to Dr Jennie Hay (Massey University, Auckland Campus) for ancient DNA analysis. In each collection I was able to examine large samples of bones first hand, and compiled a photo library of as many specimens as possible. This included a reasonable size (growth?) series for nearly every major cranial element. Morphological variation was observed, both within and between assemblages. Specimens from the same locality were often very different from one another, making it difficult to demonstrate any geographic signal.

Of course we do not know how many 'species' might be represented in the 'subfossil' material, although it does not appear to be very different from modern material. Worthy and Grant-

Mackie (2003) were unable to find significant osteological differences between the two extant species, *Sphenodon punctatus* and the rarer *S. guntheri*. Given the variation I observed between different *S. punctatus* specimens, this is not surprising. Nevertheless, my examination of material at Te Papa museum did reveal one surprising character shared by the three available adult specimens of *S. guntheri*, but not *S. punctatus*. I plan to check this in *S. guntheri* material at the Natural History Museum before getting excited.

My main objective was to quantify the shape variation found in the dentary and maxilla, a task currently under way using TPSdig (Rohlf, 1998) and Morphologika (O'Higgins and Jones, 1999). The maxilla and dentary were chosen because they are usually the most abundant elements preserved, often used as the holotypes for fossil taxa (*e.g.* Evans *et al*., 2001; Reynoso, 2005), are of functional interest (Reynoso, 2005; Jones, 2006c), provide many suitable features for landmarking, and can be orientated in a consistent fashion. My morphological findings will be compared to those from genetic analyses (allozyme and mt DNA) that suggest the existence of a south to north genetic cline between the different island populations of *Sphenodon* (Daugherty *et al*., 1990; Hay *et al*., 2003, 2004).

There was an unexpected bonus to my trip. Whilst visiting Te Papa, I was granted access to the Miocene '*Sphenodon*' material from the Manuherikia Group, first reported by Worthy *et al*., (2002), and will contribute to a formal description. Confirmation of its rhynchocephalian affinity bridges the substantial gap between Pleistocene fossil material in New Zealand (Worthy and Grant-Mackie, 2003) and the Late Cretaceous (Campanian–Maastrichtian) rhynchocephalian material of South America (Martinelli and Forasiepi, 2004).

Part of the extensive Millener collection housed in the Geology Department at University of Auckland

The award also gave me the opportunity to observe living *Sphenodon* both in captivity (Orana Wildlife Park, University of Victoria, Southern Encounter Aquarium and Kiwi House) and in the wild (Matui/Somes Island). Although appearing superficially like some lizards, their behaviour is different. They generally do little else but play statues, unless there is the prospect of food, in which case they become far more animated and can act aggressively toward one another with movements

that are somewhat 'robotic'. Given the long isolation and harsh climate, it is unclear how much the behaviour and lifestyle of the modern *Sphenodon* reflects that of its fossil relatives (Gans, 1983). Even so, it is sadly the only living example available to us and one more than can be said for plesiosaurs (barring Nessie of course).

A selection of 'subfossil' Sphenodon *dentaries registered at University of Auckland. Scale bar = 50mm.*

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High resolution isotopic curves and palaeotemperature through the Permian/Triassic extinction

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There has been much discussion in recent issues of the *Newsletter* of a more integrated, 'outside the box' approach to solving fundamental palaeontological questions. Nowhere has this idea been more relevant that in the understanding of mass extinctions which by their very definition are extreme interactions between palaeontology, geology and geochemistry, and in some cases

even cosmology! As such it seems prudent that a multidisciplinary approach be taken to attempt to decipher them.

The end-Permian mass extinction was the greatest such event of the Phanerozoic, with the loss of between 80% and 90% of marine species (*e.g.* Benton and Twitchett 2003). The exact course of the extinction is still very hotly debated. The Siberian trap eruptions, meteorite impacts, global anoxia and mass methane hydrate release have all been cited as possible extinction mechanisms. There appears to be good evidence for negative anomalies in $\delta^{13}C$ and $\delta^{18}O$ (*e.g.* Kidder and Worsley 2004 and refs therein), which have been reported, for example, in Austria and especially just across the border in the Italian Dolomites (*e.g.* Magaritz *et al.* 1988, Horacek *et al.* 2007). The $\delta^{18}O$ anomaly is thought to relate to a rise in temperature of 5-6°C, which has also been linked to several of the proposed extinction mechanisms. This estimated palaeotemperature change was derived from $\delta^{18}O$ isotope studies from bulk marine carbonates in the Austrian Alps (Magaritz and Holser, 1991, Kidder and Worsley 2004). However the $\delta^{18}O$ ratio of bulk marine carbonates is easily influenced by other factors, including changes in lithology and diagenesis (Heydari *et al.* 2001) rather than just climate, and thus may be very unreliable for use in palaeotemperature calculations.

The Permian–Triassic sections in the Italian Dolomites have also been the site of many extensive brachiopod studies (*e.g.* Posenato 2001) which have recovered many well-preserved specimens. Brachiopod shells, due to their low magnesium calcite mineral composition, are remarkably resistant to diagenetic alteration, and as a result their shells retain the biogeochemical records of climate and environmental conditions over their lifetime (Bojar *et al.* 2004). This has been successfully utilised in several Palaeozoic studies not only to produce palaeotemperature estimates but also to assess seasonal affects (*e.g.* Bojar *et al.* 2004 and refs therein).

The funds from the Sylvester-Bradley award allowed me, in the Summer of 2006, to undertake a two-week field season in the mountains of the Italian Dolomites and study four sections which span the Permian–Triassic boundary. At each locality I undertook sedimentary logging at a bed-by-bed scale and took bulk rock samples at every ten centimetres which equated to just over 230 samples. Also from the beds that straddle the boundary I sampled multiple brachiopod fossils above and below the boundary. In the lab each brachiopod was cut longitudinally and micro-sampled for $\delta^{13}C$, $\delta^{18}O$ isotopes. The bulk rock samples were prepared in a similar way. They were all analysed on a multiflow mass spectrometer. Thin sections were cut of both the brachiopods and the bulk rock for both petrography and cathodoluminescent microscopy. This combined dataset of both bulk sediment samples and brachiopod fossils will allow me to locate precisely the bulk rock $\delta^{18}O$ isotope anomaly and, through the use of unaltered brachiopod shells, to produce a precise temperature at the time of this excursion itself.

The bulk rock results show a comparable anomaly in $\delta^{18}O$ at a similar position to those seen elsewhere in the Dolomites, especially the curve recorded by Broglio Loriga and Cassinis (1992) from the Tesero section. However, through the bed-by-bed sampling I conducted, I have unprecedented detail of the anomaly itself. Initial petrographic investigations of the rock samples collected suggest that, as previously reported, these limestones show extensive recrystallisation and some dolomitization. However, interestingly, the brachiopod shells appear to be largely unaltered, and appear to show internal lineations which are consistent with primary

growth lines, although more research is being undertaken to clarify this. In addition, the internal isotopic variations across the shell appear to be comparable with those seen in modern brachiopods (Auclair *et al.* 2003), which suggests a primary palaeotemperature signal is recorded. Using the samples collected in the Italian Dolomites it will be possible to produce a new, more accurate palaeotemperature estimate for this crucial time period in earth history.

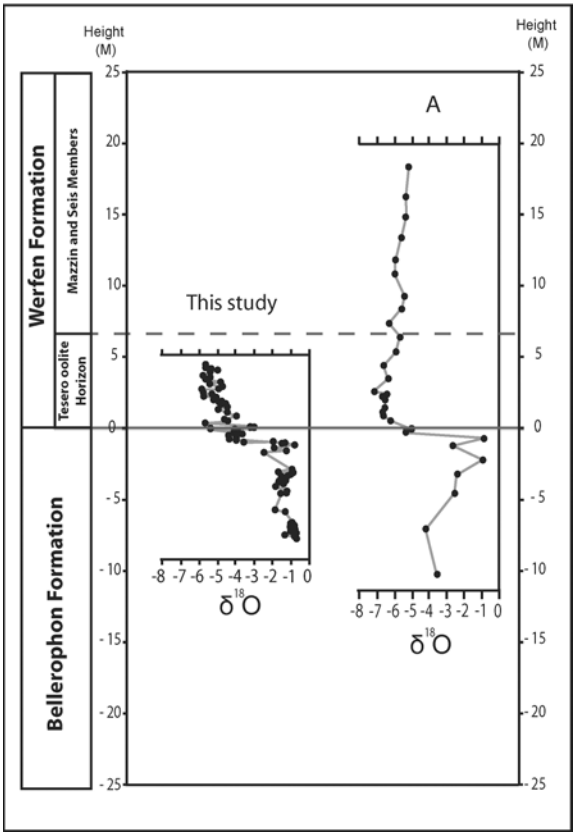

Figure 1. Comparison of $\delta^{18}O$ results from bulk carbonate between this study and the previous study (A) of Magaritz and Holser (1991).

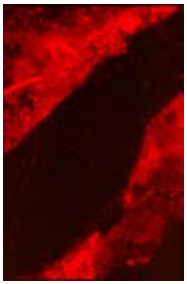

Figure 2. Cathodoluminescent photomicrograph showing a cross-section through a well-preserved brachiopod (dark) in a more altered matrix (light).

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Cenozoic evolution of radiolarian silica economy

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The history of the silica cycle is a fascinating example of how the biological and inorganic earth systems have coevolved. Polycystine Radiolaria are major players in the marine silica cycle, constructing beautifully intricate shells of opaline silica that can be preserved in the fossil record. It has been known for some time that fossil radiolarian shells from the early Cenozoic are much lighter than those from the more recent past, but it has remained unclear what caused this weight change: does it represent a secular trend in body size, as has been documented for numerous other plankton groups where it has been related to Cenozoic climate change? Or is

it due to a more economical use of silica, perhaps as a result of increased competition from diatoms? It was in pursuit of these questions that I gratefully accepted one of last year's Sylvester-Bradley Awards to consult the Ocean Drilling Program Micropaleontology Reference Center (MRC) and the radiolarian expertise of David Lazarus at Berlin's Museum für Naturkunde, as part of my MSc research at Bristol University, supervised by Daniela Schmidt.

In Berlin, David and I developed a measurement protocol employing a digital imaging system, which allowed us to quantify both the size of radiolarians and how much silica they use. We selected slides from the MRC and constructed a Cenozoic time-series of radiolarian size and silica economy from over 5,000 measurements. The preliminary results of this study give a strong indication of how and why radiolarian shells are lighter today than they were 65 million years ago.

The Cenozoic record of radiolarian silica use shows a peak in the Late Eocene and a sharp drop from the Late Eocene to the Early Oligocene. This record, however, is a conflation of two quite distinct signals – body size and silica economy – which most likely track responses to separate selection pressures.

The body size record displays a high degree of variability but shows a marked peak in the Late Eocene and a sharp decrease into the Early Oligocene. Unlike other oceanic microfossils, size change through time in radiolarians does not appear to be closely correlated to change in climate. The variability in the signal may be due to size changes within distinct faunal provinces, perhaps due to directly size-related ecological factors, which require further research at spatial and temporal scales beyond the resolution of this study.

The records of shell thickness and pore area, in contrast, describe a remarkably clear and steady trend of increasing silica economy. This gradual evolutionary transition from forms with thick shells and little pore area to forms with much thinner walls and far greater pore area is most probably a result of declining concentrations of DSi through the increased use of silica by diatoms. The correspondence between the expansion of the diatoms and the evolution of radiolarian silica efficiency is underlined by a marked increase in silica economy from the Late Eocene to the Early Oligocene, which corresponds to a coeval expansion of diatom silica use and opal sedimentation. The evolution and expansion of grasslands may have further modulated silica supply to the oceans. The radiolarian evolution of silica economy through the Cenozoic thus reflects the much larger-scale Phanerozoic trend of increasing biological control over the biogeochemical silica cycle through the rise of diatoms, and possibly grasses.

Palaeobiogeography of Cambro-Ordovician conodont faunas across Laurentia

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From their origin in the Late Cambrian, euconodonts are cosmopolitan in their palaeo-biogeographic distribution, but this soon breaks down into a strongly developed global provincialism by the Floian (Early Ordovician). The long-established view of this provincialism comprises two provinces: a high latitude, cold water North Atlantic Province (NATP), and a low

latitude, warm water North American Midcontinent Province (NAMP) (Sweet *et al.*1959). Recent work has also established the retention of cosmopolitanism in deep, cold water conodont faunas within Ordovician oceans (Zhen & Percival 2003). However, the focus of previous work has been at an inter-continental scale, and little attention has been paid to biogeographic patterns and processes within these primitive vertebrates at the scale of a single continent.

This lack of detailed biogeographic investigation of conodont biogeography is principally due to the lack of sufficient published work. However, unpublished collections do exist, with extensive coverage across Laurentia through the time interval that encompasses the transition from Late Cambrian cosmopolitanism to late Early Ordovician provincialism, and these collections were visited in March 2006, with the aid of Sylvester-Bradley funding. Studies on palaeobiogeography are necessarily limited by the need to ensure that the taxonomy is consistent, and this is particularly true of conodont faunas where incomplete apparatus reconstructions at some localities may artificially bias species diversity and geographic distribution. The research aimed to increase significantly the sampled coverage of Laurentian conodont faunas for multivariate analysis beyond that of the published dataset, and hence to increase the biogeographic resolution, whilst maintaining the taxonomic consistency, which is not always possible when using published sources only.

The data collection was based on a study of the two largest collections of Cambrian–Early Ordovician conodonts in the USA – the large unpublished conodont collections of the US Geological Survey (Reston, VA) and those of Prof. R. L. Ethington (University of Missouri, Columbia, MO), which include numerous unpublished PhD collections. Whilst in the USA, well-documented faunas from important stratigraphic reference sections were examined, including those from the Beekmantown Group, the Kinblade and West Spring Creek formations of Oklahoma, the Epler Formation of Pennsylvania and New Jersey, and the Jefferson City Dolomite of Missouri. The unpublished collection data were then integrated with the new data from NW Scotland and Greenland, and with well-published Newfoundland faunas.

The combined data were used to analyse the distribution of conodont taxa across Laurentia through the time interval from Late Cambrian to early Middle Ordovician to assess the amount of endemism along the Laurentian margin. Any separate biomes recognised may be largely dependent upon the major facies extents and their interaction with the deeper ocean faunas and climatic barriers. This was undertaken using multivariate analysis of presence/absence data matrices. It was decided that abundance data would not be incorporated because the data associated with the conodont collections did not allow the possible effects of hydrodynamic sorting to be excluded. However, an indication of the relative abundance of taxa within the fauna was used to indicate if endemic species were a very rare component or not. Following this, it was ascertained whether intra-continental endemism becomes established during this interval, paralleling that which occurs on a larger scale. The faunas were then quantitatively compared in a spatial and temporal framework using a series of time slices ranging in age from Late Cambrian to early Middle Ordovician. For each time slice, the extra conodont collections gave a greater number of biogeographical data points for use in the multivariate analysis than would otherwise have been possible. The cluster analysis was carried out using PAST (Hammer *et al.* 2001); Raup-Crick, Dice and Jaccard similarity coefficients were used, with paired linkages, as this best suited the presence/absence data.

Results from the time slices show that very little endemism is present within faunas of *Rossodus manitouensis* Biozone (Tremadocian) compared to time slices higher in the Lower Ordovician (*Oepikodus communis* Biozone, Floian, late Early Ordovician). By the Floian (478 Ma), the dendrogram (Figure 1) contains two well-supported clusters. The first is centred on the eastern part of Laurentia, comprising Scotland, Greenland, Newfoundland and New York, and is distinct from a second cluster centred on the southern and western parts of the margin (Texas, Georgia, Nevada and Mexico). Out of the 92 species included in the analysis in the *communis* Biozone time slice, 14% are endemic to East Laurentia, providing good support for the recognition of two separate subprovinces (north-east and south-west) in the Laurentian Province of the Tropical Domain (Shallow Sea Realm) *sensu* Zhen & Percival (2003). There is little evidence for a geographical barrier between the two regions, and at this preliminary stage it is suggested that the provinciality may be controlled by a climatic barrier, water temperature, ocean currents and/or upwelling zones. Work is ongoing to characterise further the initiation and causal mechanisms of Early Ordovician conodont endemism in Laurentia.

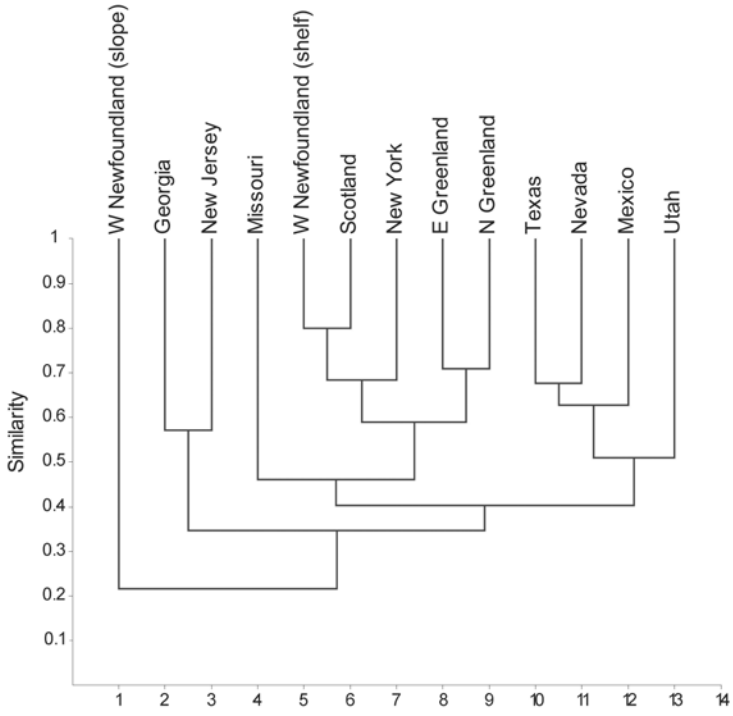

Figure 1. Dendrogram showing faunas from south to east Laurentia during the communis Biozone time slice. The tree shows a close clustering of localities from eastern Laurentia comprising Greenland, NW Scotland, Newfoundland and New York, in contrast to a southern and western group that includes Texas, Nevada, Utah and Mexico. The cluster analysis was carried out with Dice similarity coefficient and paired linkage using PAST (Hammer et al. *2001).*

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Chinese Permian pteridosperms: diversity and abundance

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Seed plants are represented by five extant groups that consist of cycads, *Ginkgo,* conifers, Gnetales and angiosperms, of which the first four are gymnosperms, or plants with naked seeds. The angiosperms are flowering plants that comprise the majority of the world's present-day flora and dominate most terrestrial biomes. Within seed plants, pteridosperms, also known as seed ferns, are a paraphyletic assemblage of extinct groups that play an important role in forming the backbone of seed plant evolution from which each of the extant groups has evolved. Pteridosperms are recognised as a highly morphologically divergent plexus of gymnosperms from which arose several more readily defined monophyletic groups (Hilton and Bateman, 2006). Pteridosperms themselves are generally regarded as plants with seeds attached to fern-like foliage. However, there are very few convincing examples recognised from the fossil record (Seyfullah, 2006). A clearer understanding of pteridosperms and resolution of their relationships should help clarify seed plant relationships, and in particular early gymnosperm evolution. The majority of information on Palaeozoic pteridosperms is geographically restricted to Europe and North America. These show a dramatic floristic turnover at the end of the Carboniferous and the regional demise of several previously important pteridosperm groups including lyginopterid pteridosperms. This has been linked with drying of habitats (*e.g.* Hilton and Cleal, 2003) brought about by climate change (*e.g.* Montañez *et al.* 2007).

Fossils of pteridosperms from the Permian of China, despite being poorly characterised in general, where known are remarkably similar to those from the Carboniferous of Euramerica. However, data on Permian pteridosperms from China are poorly known and often speculative accounts unsupported by photographic evidence. In order to assess the composition and diversity of Chinese Permian pteridosperms, work was undertaken in 2006, supported by a

Sylvester-Bradley Award, in collaboration with Prof Wang Shi-Jun (Institute of Botany, Chinese Academy of Sciences) and Prof Tian Baolin (China University of Mining and Technology), the recognised authorities on Palaeozoic permineralised plants from China.

Unfortunately, the first choice for fieldwork, collecting plants from south China's Guizhou Province, was impossible for logistical reason, but instead fieldwork concentrated on collecting permineralised fossil plants from Shanxi Province in North China. Specimens from this work are currently in preparation. By contrast, re-examination of previously collected coal ball material was more rewarding, and led to the identification of two pteridosperm taxa that are being currently studied to mark the completion of the project.

Prof Wang Shi-Jun collecting coalballs.

The first is a lyginopterid stem, and the second, a stem and petiole of a previously unrecognised species that is thought to be allied to the medullosan pteridosperms. The lyginopterid stem has a distinct sparganum cortex and a typical mixed protostele that consists of clusters of tracheids interspersed with parenchyma, with these features being consistent with those of the genus *Heterangium*. This occurrence is important as it confirms the presence of this genus in the Permian floras of China after its documented regional demise in Euramerica at the end of the Carboniferous. Other parts of the plant are at present unknown but current preparations of samples collected are expected to reveal more information on these.

The second taxon is known from a stem with attached petiole bases, and has a distinctive organisation that includes isolated bundles of vascular tissue positioned in a regular concentric pattern throughout the cortex. This organisation is similar to that observed in the medullosan pteridosperm stem *Sutcliffia* and associated/attached petioles of *Myeloxylon* that has been

previously described from Carboniferous anatomically preserved specimens from Euramerica. These specimens are currently in preparation to allow precise identifications to be made.

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Investigation of pristine planktonic foraminifera from Puerto Rico: Taxonomic and Geochemical analysis

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The Oligocene (~34–24 Ma) began with the development of a major ice sheet on Antarctica, yet the evolution of sea surface temperatures through the Oligocene is an enigma. Benthic foraminiferal isotope records suggest large swings in global ice volume and deep marine temperatures, but the impact of Antarctic ice volume fluctuations on the tropical surface ocean and biota are unknown. Documentation of how global climate was influenced by ice volume variations in the early cryosphere is vital in understanding the climate system, including deep ocean circulation, tropical temperature controls, and latitudinal heat transport. However, until now, studies have not been conducted with well-preserved material, hindering true temperature calculations.

While I was examining holotypes of Oligocene planktonic foraminifera at the Smithsonian National Museum of Natural History, I was amazed by the remarkable preservation of *Globigerina ampliapertura cancellata*, a species described by Pessagno (1963) from the Juana Diaz Formation, Puerto Rico. This specimen was transparent in the light microscope, with a clear surface ornamentation. Such excellent preservation of foraminifera is rare and appears to be restricted to clay-rich facies. The Juana Diaz Formation crops out in southern Puerto Rico and consists of shales and marls of Eocene and Oligocene age. So, to find these Oligocene foraminifera treasures, I set off for fieldwork in Puerto Rico.

Consultations with faculty at the University of Puerto Rico had confirmed that the localities detailed in Pessagno (1963) were accessible. The fieldwork was not without its adventures and hazards, the first of which occurred just outside San Juan, when the rental car rattled, splutted and the engine caught fire. Trying to reach Pessagno's outcrops in the field was also rather challenging. Road markings were different from 50 years ago, or covered by vegetation. But we were persistent. We trekked through tropical jungle and walked up rivers to locate the outcrops which proved rich in Oligocene planktonic foraminifera. Eighteen samples were collected from around the Ponce area; better yet, we sampled from a new road cutting. This 310 m long section (Figure 1) had unoxidised greenish grey clay just beneath the surface. Samples were washed in the field to confirm their age and preservation. The foraminifera are extremely diverse and well preserved, ranging from Oligocene Biozone O2 to O5 (~32 to 27.5 Ma).

Figure 1. The author (left) and Jorge Velez-Juarbe (University of Puerto Rico) feeling happy after sampling Oligocene outcrop in southern Puerto Rico.

The samples collected from Puerto Rico will provide insights into tropical planktonic foraminiferal diversity for the Oligocene Caribbean. Detailed Scanning Electron Microscope analyses are being performed at Rutgers University to determine wall structures and provide insights into the phylogeny of extinct species. This work will contribute to the Oligocene Atlas of Planktonic Foraminifera, part of the International Subcommission of Paleogene Stratigraphy. Following taxonomic studies, stable isotope and trace element analyses will be conducted to reconstruct sea surface temperatures for the Oligocene Caribbean.

I am very grateful to the Palaeontological Association Sylvester-Bradley Award for funding fieldwork in Puerto Rico. Thanks are extended to Jorge Velez-Juarbe for all his help in the field, to James Joyce, University of Puerto Rico, for providing geological maps, and to Paul Pearson for discussion.

Figure 2. Bridget Wade and Jorge Velez-Juarbe sampling Oligocene outcrop in southern Puerto Rico.

Figure 3. Meeting local flora face to face

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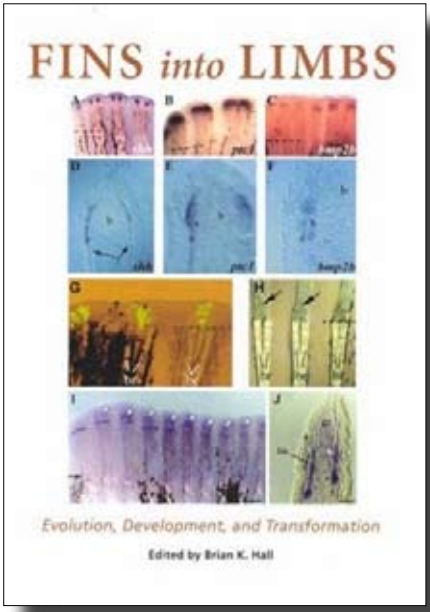
Book Reviews

Fins into Limbs: Evolution, Development, and Transformation

Brian K. Hall (ed.) (2006). The University of Chicago Press, Chicago. 344 pp. ISBN 978-0-226-31337-5 (paperback), $45.00US



The origin of limbs and digits and their relationships to fish fins has been a 'hot topic' in both developmental biology and palaeontology for a number of years now. This volume attempts to bring together much of the recent work in the area, but more than that, it also takes in studies of fins and limbs in much broader terms – anatomical, embryological, functional. By its very nature, therefore, its main relevance is to a subset of readers of the Palaeontological Association's *Newsletter*, namely, vertebrate palaeontologists. I will aim my review towards them by emphasising the palaeo content of the book, and try to assess how well it succeeds in its remit.

The book consists of 19 chapters covering fin and limb evolution, development and diversification in vertebrates, all written by acknowledged key contributors to the field. I have encountered various reactions to the volume at first hand, by a Palaeozoic vertebrate palaeontologist, an anatomist, and a developmental biologist, the latter two of whom spotted the review copy in my office. Both of these pounced on it as potentially useful for teaching and as a general reference work to the field, and went off to buy copies. The vertebrate palaeontologist, on the other hand, suggested that there was 'not much new' in it and wondered why he had bothered. The following may illustrate why these people reacted in this way.

The first section, by Bowler, provides an historical review of literature on limb evolution up to 1940, which is useful, but prefers to stick with the terminologies used at the time of the literature cited, rather than translating them into modern terms. Thus 'amphibian' is used to mean 'early tetrapod' (see below). The allotted time-frame misses most of the substantial output by W.K. Gregory and colleagues on the topic. Coates and Ruta provide a thoughtful and rigorous review of girdles and paired appendages among sarcopterygians, including the earliest known through to Carboniferous tetrapods, giving an introduction to the literature describing the most relevant taxa. Strangely, they do not include the curious isolated humerus from the Famennian of Red Hill, Pennsylvania, which has provided much food for thought about the possible function of near-tetrapod pectoral limbs (Shubin *et al.* 2004). They look at transformational scenarios, homoplasy, character distribution

and functional implications. We are still left with the apparently intractable problems of how come digits and whence the enlarged pelvic apparatus of tetrapods, so to that extent there is nothing really new here. However, this book is intended, afer all, as a review volume.

The chapter by Drucker and Summers gives an historical review of functional studies of fins and limbs, showing that too few studies have been made of fin functions. This is signficant for those of us working on tetrapodomorphs and early tetrapods, since there is very little for us to draw on for functional analyses of our taxa. For a palaeontologist, however, the chapter conspicuously lacks references to the extensive modern literature on functional morphology of extinct animals such as dinosaurs and pterosaurs.

The fourth chapter in this section, by Wagner and Larsson, gives a peroration on what evolutionary novelties actually are, genetically, that I was not sure was needed in this compilation, and then an account of the phylogenetic context of the fin–limb transition. To some extent, this overlaps with the chapter by Coates and Ruta, though covers more of the non-sarcopterygian fishes. After that, we get a useful review of the genetic control of fin *versus* limb development, which for me was helpful in providing a critique of the digital arch model of Shubin and Alberch (1986). As a model that could explain the digit numbers and distribution in Devonian tetrapods, this model was intuitively appealing, but at best now appears too simple. Some of this section of the chapter may prove rather difficult for non-specialists to follow easily, but provides access to much recent literature. The chapter concludes that tetrapod digits are indeed an evolutionary novelty.

The next section starts with a chapter by Tanaka and Tickle giving a more detailed account of the genetic control and patterning of the tetrapod limb, and contrasts between that and fin development in the zebra fish. This again provides a good introduction to the literature up to about 2002/2003, so will be useful for those teaching the subject. One gripe, that I am afraid is all too common in some circles, is to call everything except birds and mammals 'lower vertebrates'. It's time this 'scala naturae' thinking had been banished from our minds! Witten and Huysseune give a good explanatory chapter clarifying different kinds of skeletal tissues and structures, also helpful for explaining to students that not all bone is like that found in mammalian long bones. One omission from the perspective of a palaeontologist is the lack of mention of prismatic cartilage found in chondrichthyans, and often not recognised as fossil material by non-specialists. Cartilage in this chapter is treated essentially as a precursor for bone. The colour section of plates is inconveniently placed in the middle of this chapter, rather than between chapters. Weatherbee and Niswander consider mechanisms of chondrogenesis and osteogenesis in limbs mainly from the point of view of genetic and molecular control of processes, some of which overlaps with the previous chapter and is not so useful for palaeontologists, likewise the next chapter on apoptosis in fins and limbs by Zuzarte-Luis and Hurlé.

Archer and colleagues provide a review of joint formation and various types of joint, integrating information from fossils from agnathans to amniotes, and Farnum looks at postnatal growth, its control and cessation in a range of groups from fish to mammals. It deals mainly with histology, so may be useful for palaeontologists in some fields. The chapter on paired fin repair and regeneration, while interesting and treating a potentially medically important subject, has no figures at all, and the final chapter in this section treats tetrapod limb regeneration and is therefore mainly limited to urodeles.

The final section begins with a massive review of early tetrapod and Lissamphibian girdle and limb anatomy, so if you need access to a quick anatomical guide, this may provide one. However, it is probably rather detailed for the average reader, and provides no deep insights into the overall picture. I suspect this is the chapter that coloured my colleague's view. Much of the material is better covered by Coates and Ruta, who also place their material in a more modern framework. The chapter by Shapiro and colleagues gives an intriguing insight into patterns of limb reduction and loss in reptiles, treating manus and pes of each group to try to determine overall patterns. Generally speaking, reduction mirrors the order of development, but another important conclusion for palaeontologists is that reptiles, fossil and extant, have a great potential for enhancing understanding of digit development and loss. Polly provides a detailed anatomical review of the skeleton of terrestrial mammals, very useful as a resource for anatomists – both teachers and students – and the section on recently described fossil mammals is especially welcome for palaeontologists. The chapter by Gatesy and Middleton is, by contrast with most of the other chapters, an original study of limb proportions among flying vertebrates, using ternary diagrams to distinguish between bats, birds, and pterosaurs and their subgroups, and including fossil members. The groups fall out quite distinctly in all their analyses. One curiosity is the eerie conflation of the names of two fossil Early Carboniferous tetrapods: *Crassigyrinus*, arguably the largest, and *Casineria*, the smallest, into the new genus *Crassineria*. The real animal, *Casineria*, achieves its position by having disproportionately long hands and making it into a subset of one of their ternary diagrams. The chapter on digging and burrowing adaptations of the skeleton in tetrapods may help palaeontologists recognise such in the fossil record. Otherwise, such habits are really only deducible by inference in fossils, which therefore are not dealt with here. The chapter on aquatic adaptations in amniote limbs is disappointing as it deals mainly with the types of swimming motions that amniotes employ, anatomy being treated very superficially. I would have expected much more detail of the many aquatically adapted forms in the fossil record, especially with Mike Taylor as one of the authors. The final chapter, on sesamoid bones by Vickaryous and Olson, may conceivably be useful for a palaeontologist faced with oddities in the skeleton, and indeed a couple of fossil forms in which they have been found, the Permian amniote *Captorhinus* and the Triassic turtle *Proganochelys*, are mentioned.

As a volume, this publication suffers from a number of problems, some trivial, and some not so trivial. One trivial comment is the format of the book, a large American Letter size. Good for clarity, but with a soft cover, floppy and difficult to control on your knee as I was doing when I reviewed it. And it would be good for clarity if all the figures had been produced to the same standard. However, in several chapters the line graphics are fuzzy and pixelated, clearly having been reproduced from images submitted at too low a resolution or in an inappropriate file format.

Revealing from an historical point of view are the frontispieces chosen for the sections on *Evolution* and *Transformation*. Both are images produced by Gregory and Raven (1941). The first includes a hypothetical series between the pelvic fin skeleton of *Eusthenopteron* and the hind limb of the temnospondyl *Trematops*. Given how problematical their corresponding series of pectoral limbs is, one might be doubly sceptical of the pelvic series. The second image shows Gregory and Raven's idea of a 'prototetrapod'. This is interesting in itself if compared with what is now known from recently discovered near-tetrapod fossils. The old ideas seem to have got almost everything in the wrong order. So much for educated guesswork! One wonders about the appropriateness of these images in retrospect.

One emerging feature of the volume is the intriguing light it throws on the use of terminology. Chief among these, to an early tetrapod palaeontologist, is the varying use of the term 'tetrapod' or Tetrapoda. This is a controversial subject in my field, and the volume reflects the differing opinions. These vary from the use of Tetrapoda to include the total group (Crown plus Stem) as used by Coates and Ruta, to the more intuitive and broadly employed use to mean 'vertebrate with limbs and digits', as in most other chapters of the book. Coates and Ruta's arcane application of the term will be completely counterintuitive to most non-specialists, and includes stem group members that manifestly do not have limbs. There is in fact a perfectly suitable name for this inclusive grouping – Tetrapodomorpha – that predates the use of the term for the total group. At least this name may alert the non-specialist to the idea that it might not be equivalent to 'vertebrates with limbs and digits'. It is clear that most people outside the coterie of early tetrapod palaeontologists will continue to use the term tetrapod to mean just that – vertebrates with four feet. No one in this volume, happily, restricts the term to the Crown Group, which use excludes many creatures with limbs and digits.

A further complication arises with the term amphibian versus Amphibia, but in this case, only one chapter other than the first confuses the issue, that by Carroll and Holmes, who use the term 'amphibian' to mean all early tetrapods that are not amniotes. These authors do not accept the monophyly of modern Amphibia, so that their use of the term 'amphibian' is entirely as a paraphyletic grade group. Carroll is also alone among early tetrapod palaeontologists in insisting on retaining the name 'labyrinthodont' for all large fossil tetrapods, a term which not only encompasses a paraphyletic assemblage, but one which is actively obfuscating in linking totally disparate groups in people's minds. Another nomenclatural infelicity is the use of Teleostomi in the chapter by Wagner and Larsson, a term which they do not define, but which has been out of use for decades. As originally coined it included sarcopterygians to the exclusion of dipnoans, and actinoptergyians, while its counterpart, the Plagiostomi, included chondrichthyans, acanthodians, placoderms and dipnoans. Perhaps some editorial input on these inconsistencies would have been helpful.

The publisher has taken the irritating decision to place all the references at the end of the volume. You can see why a publisher might want to do this – they think you will be forced to buy the volume to get the references to any particular chapter – and it avoids duplication. This is a real annoyance for the reader. Not only do you have to turn to the back of the volume to look at the references, but the reverse procedure of finding in which chapter particular references were cited is near impossible.

Speaking of references, a trawl through the reference list reveals one of the main problems with this volume. It shows that there are very few included that date from more recently than 2003. There are a few from 2004, but those from 2005 and 2006 seem to be limited to those written by the authors themselves or their close collaborators (there is a single 2007 reference, an 'in press' publication by the editor). The date of publication given on the website is 2006, whereas the volume itself gives 2007, suggesting a possible delay from submission to actual publication, which may account for the deficits. However, this brings me to my main observation about the volume.

In the last couple of years, some key progress has been made both in the developmental biology of non-teleostean actinopterygians and chondrichthyans, and in the fossil record of near-tetrapods (*i.e.* non-limbed tetrapodomorphs), that the timing of this volume inevitably fails to capture. Some

beautiful work on skeletogenesis in chondrichthyans has recently shown similar processes at work to those that produce bone in osteichthyans (Eames *et al.* 2007). This is of great signficance for those trying to understand deep gnathostome relationships. Among actinopterygians, work on the genes controlling development of the fin skeleton in the paddlefish *Polyodon* has shown that some of the processes thought unique to tetrapods, in particular in the actions of Hoxa11-13 and Hoxd11-13, has shown them to operate in a comparable manner to those in the tetrapod limb (Davis *et al.* 2007). This is inferred to suggest that such actions have been lost in teleosts, rather than gained by tetrapods, further implying that tetrapod digits are not after all such a developmental novelty as previously supposed. This new work contrasts with the picture painted in the chapter by Wagner and Larsson. As for the fossil record, discovery of the amazing material of *Tiktaalik roseae* in the Frasnian of the Canadian Arctic, by Daeschler, Shubin and colleagues, has produced the most limb-like fin skeleton known so far, and has prompted revised assessments of the transition from the array of radials in *Tiktaalik* to digits (Daeshler *et al.* 2006, Shubin *et al.* 2006). In tune with Wagner and Larsson, however, the model of the digital arch suggested by Shubin and Alberch (1986) is not supported by the form of the fin skeleton of *Tiktaalik*.

The volume thus stands at something of a watershed in the history of the fin to limb transition. Great things are afoot, so to speak, in terms of new fossils and in developmental studies that should bring much-needed insights to the whole issue. For example, some soon to be published studies of lungfish fin development will add, like the *Polyodon* studies, further understanding of where digits really did come from. On the other hand, whereas the developmental side of the volume is in some senses out of date already, the anatomical reviews will stand for many years, and provide an easily accessible and pretty comprehensive source for teaching and research in limb morphology, mechanics and evolution.

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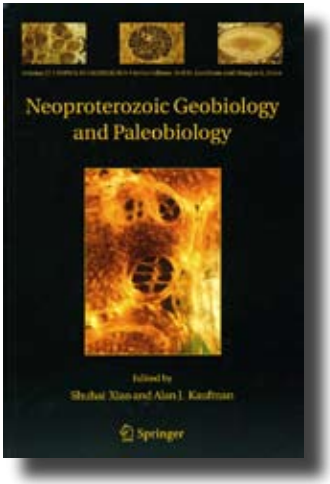
Neoproterozoic Geobiology and Paleobiology

Shuhai Xiao and Alan J. Kaufman (eds) (2006). Topics in Geobiology, Volume 27, Springer, Dordrecht. 300 pp. ISBN 978-1-4020-5201-9 (Hardback), €109.95.



This book developed from a Pardee keynote symposium ("Neoproterozoic Geobiology: Fossils, Clocks, Isotopes, and Rocks") held at the 2003 GSA Annual Meeting in Seattle (USA). The symposium aimed at bringing together sedimentologists, palaeontologists, geochemists, and earth system modellers "to present new data and models on the Neoproterozoic Earth, in order to better understand the relationship between tectonic, climatic, and biological change at the end of the Proterozoic Eon". The book, however, echoes with sceptical voices, some offering valid arguments questioning existing paradigms, and presents "a sample of views and visions among some of the growing numbers of Neoproterozoic workers".

No introduction is needed, and the theme of the book is set up immediately and with the correct question: why are fossils of eukaryotic heterotrophs so rare in the Palaeo- and Mesoproterozoic record, compared to Neoproterozoic? Indeed, convincing evidence exists for only one (of 14) heterotrophic clade during this time – the basidiomycet/ascomycet fungi (<1077 Ma); three more clades – the lobose and filose amoebae (<770 Ma) and the animals (<580 Ma) – appear during Neoproterozoic time. Susannah Porter is rightly sceptical as to the possible reasons for this phenomenon. Limited primary productivity and preservational bias are popular, very influential, hypotheses, but Porter is not persuaded. To a large extent the answer lies in whether the biodiversity of organic-walled vesicular microfossils, the acritarchs, can be resolved correctly; here, this is addressed by John Huntley and colleagues. It appears that the initial increase of morphological disparity preceded the taxonomic diversification of acritarchs by approximately 500 million years. Nearly half the morphological characters of this group appeared first during the early Mesoproterozoic (1500–1400 Ma); the first major taxonomic radiation, however, occurred in the pre-glacial Neoproterozoic (1000–720 Ma). Interestingly, the morphological history of Proterozoic macroalgae is somewhat similar to that of Proterozoic acritarchs; thus Shuhai Xiao and Lin Dong suggest external forcing of the morphological evolution of both acritarchs and macroalgae. There is another notable increase in acritarch and macroalgal morphological disparity during the early Ediacaran (635–550 Ma), which is coupled with a concurrent increase in thallus surface/volume ratio and maximum canopy height in benthic macroalgal communities. Among possible explanations, the authors mention that the elaboration of acritarch and macroalgal morphology may have been driven by top-down ecological forcing by animal grazing.

The depauperate fossil record of Neoproterozoic animals is addressed by David Bottjer and Matthew Clapham. The authors recognize four distinct ecological associations of the Ediacaran macroscopic organisms, but follow the traditional interpretation that these represent time-restricted assemblages. This is where the book takes a less sceptical tone… More welcome is a

critical review of Ediacaran trace fossils by Sören Jensen and colleagues. From the assumption that however strange the Ediacaran body fossils might be, the trace fossils at least provide a proxy for the presence of some sort of metazoan, it now looks as if the roster of genuine traces is much smaller than thought previously. The authors reiterate the absence of trace fossils prior to about 560 Ma – an important constraint for the emergence of a bilaterian bodyplan. With respect to the origin of bodyplans during the Ediacaran–Cambrian metazoan radiation, Doug Erwin provides an exemplary overview of the conserved developmental features among the Bilateria, culminating in a fascinating intellectual excursion that attempts to assemble these features into an urbilaterian ancestor. The discussion by Blair Hedges and colleagues is a reminder that the current large, and controversial, gaps in the Proterozoic fossil record will be reduced partially as more genomes are sequenced and analytical methods refined.

Galen Halverson elucidates the most interesting events and least understood intervals in the Neoproterozoic chronology. In a parallel vein, Frank Corsetti and Nathaniel Lorentz argue against the popular view that cap carbonates are reliable chronostratigraphic markers, and call for use of the terms Sturtian and Marinoan to be abandoned outside of Australia. One of the sensations of the final pages of the book has been the recognition of the importance of the Gaskiers diamictite, which, despite its incompatibility with the theoretical requirements of the current Snowball paradigm, does have a cap carbonate, albeit thin, that records negative $\delta^{13}C$ values.

Most contributions to this volume repay reading, despite the fact that the book fails to account for a significant chunk of information from the key Neoproterozoic successions of the Central Ural Mountains and the Siberian Craton, the former being crucial to correlation of the Varangian diamictites. For me, another key element absent from the book is a chapter written by a theoretical ecologist dealing with the problem of complexity and stability of Neoproterozoic ecosystems. This is one of the most intriguing and potentially fruitful challenges in palaeobiology, "necessary to understand how organismal ecology, diversity, biogeography and productivity interrelate to yield functioning ecosystems, and how such systems would have worked in the absence of eumetazoans" (Butterfield 2007, p.46).

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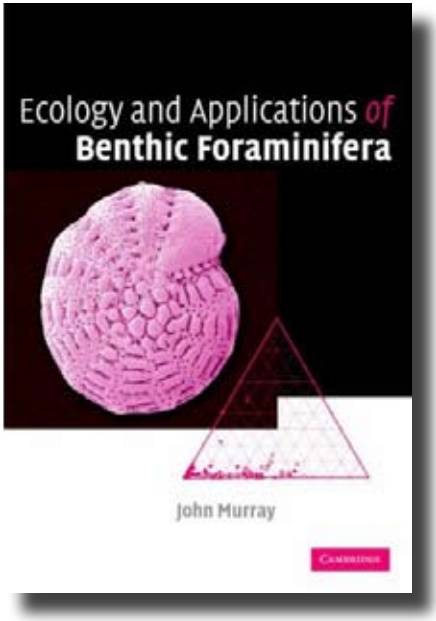
Ecology and applications of benthic foraminifera

John W. Murray (2006). Cambridge University Press, Cambridge, 426 pp. ISBN 978-0-521-82839-0, £80.00STG, $150.00US.

When I started to work with foraminifers, the first book I was given was John Murray's 1991 edition of "Ecology and Palaeoecology of Benthic Foraminifera". I have been looking forward to a new edition ever since I heard that John would use his retirement to write one. Since the last edition, the Web of Science has registered nearly 2,500 articles that consider benthic foraminifers/foraminifera,

highlighting how active the field is today. Including "applications of" in the title reflects how the scope of the field has changed over the last 15 years. Today benthic foraminifers are widely used as tools in palaeoceanographic studies, and by people dissolving them in acids (otherwise known as geochemists). Most of these have very limited understanding of the ecology of benthic foraminifers which influences tremendously their interpretation of palaeoproxies, and highlights the need for an updated version of this text.



The book starts with a detailed description of methods used in foraminiferal studies, ranging from field sampling via preparation of modern samples to statistics (Chapter 2). Though short, this part will be very helpful for novices in the field planning their first foray into sampling or data processing. The next 30 pages (Chapter 3) discuss aspects of biology and basic ecology, from cellular biology, via population dynamics, test design and function to ecology. Both chapters will assist those of us preparing a unit on benthic foraminiferal ecology in a lecture course, although nice illustrations would have made the chapter even more useful for teaching.

The book continues with a focus on the most important environments (Chapters 4–7) and discusses each individually. These environments range from marginal marine settings, such as lagoons and fjords, via shelf areas, warm water and cool water carbonate environments, to the deep sea (all discussed on a regional basis). The important species within these ecosystems are introduced, and their specific ecological demands discussed. Most importantly, these species are illustrated and the species names are always associated directly with the plate, making this information extremely easy to use. The abundance of these species in various ecosystems is plotted, and the new feature of this book – the web-based data files – makes this information readily available for research purposes. These web-based data files also contain literature references and the faunal reference list (including the name of the first describer as the author insists on); together these comprise nearly another book in itself.

The deep sea chapter includes the discussion on palaeoproxies. The relationship of standing stocks to organic carbon flux, the species relationship to water depth, current speed of the bottom water and specific deep sea currents are discussed for individual basins. Although this is very valuable to people studying these regions, a critical discussion of benthic foraminifera as palaeoproxies would have been a very important addition. Most applications of benthic foraminifera are in palaeoceanographic studies and are conducted mainly by geochemists. The profound ecological knowledge within this book, combined with proxy assessment, would have educated people better in the ecology of the carrier of palaeoclimate signals. The summary of living distributions (Chapter 8) covers, amongst other topics, reaction to environmental variability

such as salinity, temperature, oxygen, and predation, microdistribution in the three-dimensional space of the sediment column, as well as larger scale distribution patterns including biogeography and diversity. Chapter 9 discusses the formation of dead and fossil assemblages. Taphonomic processes – including great figures of erosional features, such as transport via currents, winds and bioturbation – are covered, as is time averaging. The book closes by considering potential applications (Chapter 10), ranging from biostratigraphy, via palaeoecology, palaeoceanography to environmental monitoring. The palaeoceanographic proxies part includes transfer functions for productivity, oxygen, and sea level changes. Unfortunately, the chapter does not discuss the link between ecology and chemical proxies in foraminiferal tests. The book concludes with a glossary, several indices and a highly valuable appendix on ecological data for dominant species.

The book will not make a good bed time read and is too specialised for undergraduate students to function as a textbook. It will, however, be very helpful for any PhD student starting to specialise in ecology of benthic foraminifers, and serve as an invaluable resource for researchers specialising in the field. The large number of case studies are full of data for people interested in these specific ecosystems. John's wish is that the book will be useful to readers. No doubt it will be.

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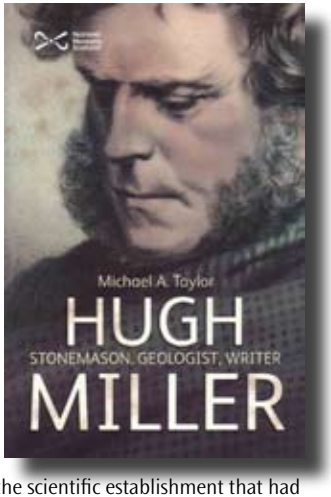
Hugh Miller: Stonemason, Geologist, Writer

Michael A. Taylor (2007). NMS Enterprises Limited – Publishing, Edinburgh. 176 pp. ISBN 978-1-905-26705-7 (paperback), £12.99STG.

This is an excellent, interesting and scholarly biography of Hugh Miller. The author has an enduring passion for Miller and his work, having previously published widely on Miller, and been instrumental in the curation of the Miller bicentenary exhibition in Edinburgh in 2002. Michael Taylor is Principal Curator of Vertebrate Palaeontology in the National Museums Scotland where much of Hugh Miller's collection is held. Thus this is a biography where the biographer has similar interests to those of his subject, and provides a sympathetic account of his life. Maybe I should declare a personal interest as an admirer of Hugh Miller and his work on the Old Red Sandstone.

The volume commences with a Foreword by Marion Allardyce McKenzie Johnston, a descendant of Miller who formally opened the refurbished Miller family home (a National Trust for Scotland property) in Cromarty in 2004. David Alston provides a Preface placing Miller in the local Cromarty context. It is good that Miller has descendants and a local community interested in his achievements, and is still lauded as a local hero. In reality, Miller was an important player in the development of geological science, and has a charity 'The Friends of Hugh Miller' devoted to his legacy to society.

Michael Taylor provides an introduction followed by 19 chapters that trace the life of Miller from cradle to grave. This was an extrordinary journey; son of a shipmaster lost at sea when he was five, his school education ended at 16 after a physical fight with his teacher over spelling. Despite being an 'unruly youth' he read avidly and had started writing by the time he was 18. Lack of formal schooling debarred the clever but bored (hated Latin) Hugh from universities of the day, and



he became a stone mason – a hard profession in the 1820s, involving poor lodging conditions, and the effects of stone dust that greatly damaged his lungs. Despite the hardship he continued to develop a keen eye for natural history, and continued his interest in writing. His first excursion into publishing, a book of poetry, was a financial disaster, but did introduce him indirectly to journalism with the *Inverness Courier*.

Back in Cromarty he became known for his interest in local history, and in 1835 he published 'Scenes and legends of the North of Scotland, or, The traditional history of Cromarty'. His interest in fossils started in 1820, finding ammonites on the shore at Eathie on the Black Isle. His geological interest continued largely as a hobby, and it was not until 1841 that 'The Old Red Sandstone', the book that made his geological reputation, was published. He was by that time in contact with the scientific establishment that had given him the encouragement and confidence to publish his findings.

From stone mason he had moved to banking, which clearly did not excite him, being far more interested in the fishes of the Old Red Sandstone of his native Cromarty. In 1840 he moved to Edinburgh to edit the *Witness* newspaper, and became deeply involved in the 'Disruption' of the Church of Scotland and the formation of the Free Church. His editorial work was clearly both tiring and stressful; Mike Taylor tells us that he regularly wrote 10,000 words a week! He did have holidays, and spent most time in geological travel, as on the Free Church yacht *Betsey*, the story of which (Miller 1858, Taylor 2003) is excellent reading, and makes the privations of modern field investigation seem negligible.

Hugh was increasingly afflicted with poor health from 1854, generally interpreted as lung disease (silicosis) resulting from his time as a mason. He was prone to infections that laid him low for long periods. His wife, Lydia, suffered from arthritis, and family life cannot have been easy. However the tragic end was not foreseen; Hugh Miller shot himself during the night of 23rd December 1856. Many words have been written trying to explain his suicide, but we will never know the true reason or reasons for his action. However, Michael Taylor debunks some of the wilder flights of fancy and brings refreshing reason to the discussion.

The overall impression of Miller the man reveals a highly talented naturalist, writer and observer of mankind. He had strong principles and did not feel comfortable in the company of the landed classes he had criticised over the clearances, treatment of servants and church patronage. He enjoyed academic debate, but could not stand the tittle-tattle of polite dinner parties. His legacy to geology was his ability to communicate the developing science of geology, particularly palaeontology, to Victorian society through his prose.

This book is well researched and a pleasure to read. The illustrations of places, people and specimens help the reader visualise the nineteenth century world of Hugh Miller. A minor quibble might be that more use could have been made in illustrating items personal to Hugh Miller, and a reproduction of a letter to show his characteristic handwriting would have been of interest. The

many quotations from Miller's work are skilfully combined with Taylor's text. A list of sources, dates of Miller's major works, index, and a glossary to explain some of the Scots words used by Miller are all useful additions. The author describes his book as 'a brief informal biography,' to me it is much more; this book effectively brings to life the complex character of Hugh Miller, further cementing his reputation as one of the most influential geologists of the nineteenth century.

This book is excellent value; acknowledgement is given in the Foreword to an anonymous benefactor who made publication possible. I also thank this person for their generosity, but the main accolade for this excellent book must go to Michael Taylor.

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Horns and Beaks: Ceratopsian and Ornithopod Dinosaurs

Kenneth Carpenter (2007). Indiana University Press, Bloomington and Indianapolis. 369pp. ISBN 0-253-34817-X, $49.95 (hardback).

Horns and Beaks is the fifth and final multi-authored Indiana University Press volume on the different dinosaur groups: its predecessors were *The Armored Dinosaurs* (2001), *Mesozoic Vertebrate Life* (2001), *The Carnivorous Dinosaurs* (2005) and *Thunder-Lizards* (2005). I am slightly embarrassed to note that I reviewed all of them (see *Palass Newsletter* **49**: 101–103, **50**: 91–93, **61**: 113–117 and **62**: 122–126). While books on theropods and sauropods might have a fair amount of appeal to non-specialists, it is difficult to imagine that ornithopods – regarded by many people (including dinosaur specialists) as 'the boring ones' – would have the same mass-market appeal, nor, it would seem, is there enough new research to fill a volume of a few hundred pages. This might explain why the volume covers the rather more charismatic ceratopsians as well: at least, in the past, palaeontologists have written books devoted to them alone. Well, one book anyway (Dodson 1996). As with the previous volumes, some colour plates featuring life restorations or photos of some of the more impressive species might have been included to liven things up a bit. As it stands the volume is drab and dull, and black and white throughout.

Taxonomic coverage is not equal in the volume, with there being twice as many papers on ornithopods as there are on ceratopsians, and five of the ten ornithopod papers are on hadrosaurids (or their close relatives). Pachycephalosaurs – which are more closely related to ceratopsians than ornithopods are – are unfortunately not represented at all, but their rarity means that few people get to work on them. Heterodontosaurids, which have traditionally been classified as basal ornithopods, are discussed briefly in one paper, but are otherwise absent from the volume.

The volume kicks off with a reinterpretation of the world's oldest iguanodontian ornithopod, *Callovosaurus leedsi*, from the Middle Jurassic Oxford Clay of England. José Ignacio Ruiz-Omeñaca

and colleagues show that this taxon is valid (rather than a *nomen dubium*), and that it is a dryosaurid (rather than an indeterminate iguanodontian). While their reasoning seems fairly sound, *Callovosaurus* is known only from a femur, and suggested identifications have bounced back and forth over the years; indeed a dryosaurid identification was hinted at by Gilmore in 1909 and favoured by Galton in the 1970s. One cannot help but feel that proposed identifications will never be secure until we have good, associated skeletons. And, yes, I do realize the inherent irony in my saying that, given the focus of my own academic work.

In a well-illustrated paper, Peter Galton describes and reviews the dental morphology of all the ornithischians known from the Morrison Formation (he therefore covers thyreophorans and heterodontosaurids as well as ornithopods). *Nanosaurus rex* – the type species for *Othnielia* – is argued to be non-diagnostic, with previous views on its status as a valid taxon being based on a referred specimen that is the holotype of *Laosaurus consors*. This is not the type species of *Laosaurus* (that honour goes to the *nomen dubium L. celer*), so *L. consors* is now awarded its own generic name, *Othnielosaurus*. This is the first of four new genera coined in this volume.

Two papers review and revise the long-accepted taxonomy of iguanodontians. Kathleen Brill and Kenneth Carpenter show that the skull which, since about 1894, has been masquerading as that of the well-known Morrison Formation ornithopod *Camptosaurus*, was based predominantly on that of a referred specimen which now seems to represent a new taxon. The original *Camptosaurus* skull, reconstructed here for the first time, is inferred to be more triangular, with a sloping snout and larger antorbital fenestra, than the subrectangular, more robust skull usually illustrated for this taxon. Interestingly, the new-look *Camptosaurus* skull is superficially like that of a dryosaurid. The more robust skull usually illustrated as that of *Camptosaurus* is based on the 'Garden of the Gods' specimen given to Othniel Marsh by James Kerr in 1886. Its rugose snout tip, horn-like jugal process and other features show that it is quite distinct from *Camptosaurus* and other iguanodontians, and it is made the type of the new taxon *Theiophytalia*. The authors also reconstruct '*Iguanodon' lakotaensis*: heralded back in 1989 as 'the first indisputable remains of *Iguanodon* from North America', it is apparently no such thing and represents another new taxon.

The second paper revising iguanodontians is Greg Paul's brief renaming of the Isle of Wight's *Iguanodon atherfieldensis*. It is poorly known outside the dinosaur research community that, following Charig and Chapman's (1998) suggestion and subsequent endorsement by the ICZN, the name *Iguanodon* is no longer tied to *Iguanodon anglicus* (the taxon named for the Hastings Beds Group teeth described by Gideon Mantell). The type species is now the robust iguanodontian first described from the coal mines of Belgium, *Iguanodon bernissartensis*. While this idea has its merits, the problem is that any other iguanodontian that is not a demonstrable close relative of *I. bernissartensis* can now no longer be called *Iguanodon*: this includes Mantell's iguanodontian bones and teeth from the Hastings Beds Group of East Sussex, as well as most of the species referred to *Iguanodon* during the 19th and 20th centuries.

As is all too clear if you stand next to the mounted skeletons of the two taxa in the dinosaur display at the Natural History Museum, *I. atherfieldensis* – one of the best known species referred to the genus – is a very different beast from *I. bernissartensis*. At least some phylogenetic analyses have found the two to occupy different positions on the cladogram, rather than to fall together as a monophyletic *Iguanodon*. Paul takes all of this to its logical conclusion and now

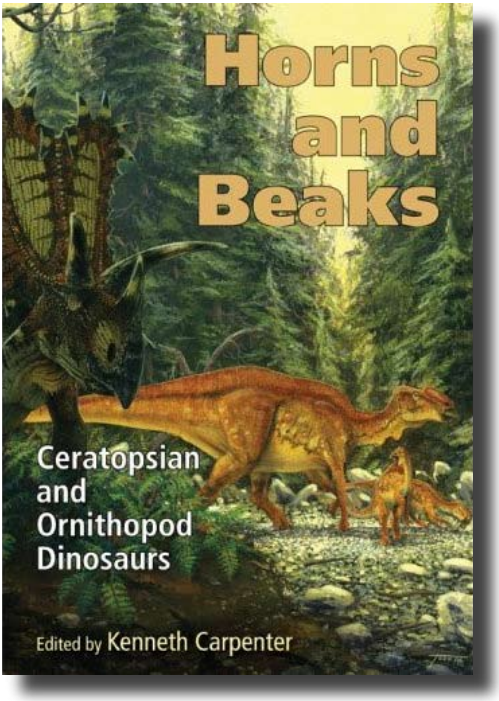
gives *I. atherfieldensis* its own generic name: *Mantellisaurus*. We know this isn't a new idea as Paul is on record as saying as long ago as 1991 that he planned to give a new generic name to *I. bernissartensis*, back before it became the type species of the genus. I wish that a different new name had been proposed: it's appropriate to give Gideon Mantell (and/or his wife Mary) credit for a role in the discovery of the British iguanodontian taxa, but Mantell is not really linked with *Mantellisaurus*. This taxon was described from the Isle of Wight by Reginald Hooley in 1925, 73 years after Mantell had died, and it comes from strata more than 10 Ma younger than those that yielded the iguanodontian material described by Mantell.

There's another problem: Paul's reconstruction of *Mantellisaurus* is not based on Hooley's Isle of Wight holotype, but on a referred specimen from Bernissart, and this looks about as different from *Mantellisaurus* as *I. bernissartensis* does. In contrast to the *Mantellisaurus* holotype, the referred Bernissart specimen is long-skulled, has proportionally longer arms and an entirely different sort of pelvis. It's probably another taxon. It highlights the fact that one must concentrate on holotypes when redefining taxa.

Another new iguanodontian, *Cedrorestes crichtoni* from the Cedar Mountain Formation of Utah, is named by David Gilpin and colleagues. I don't see the value in naming this taxon after Michael Crichton: the *Jurassic Park* books and films have surely been given enough accolade already by vertebrate palaeontologists (two taxa, *Tianchiasaurus nedegoapeferima* and *Coloborhynchus spielbergi*, honour, respectively, the actors and director of the first *Jurassic Park* movie) and, nope, no indication from the acknowledgments that Crichton provided funding that assisted in the specimen's discovery or excavation. Is *Cedrorestes* really a valid taxon? It looks highly similar to *Planicoxa*, a Cedar Mountain Formation iguanodontian named in 2001.

It follows that several papers in the volume are devoted to hadrosaurids, given that they are one of the most taxonomically abundant, geographically widespread and best known of dinosaur groups. *Brachylophosaurus* looks set to become one of the best-understood of hadrosaurids, and two papers are devoted to it here. Albert Prieto-Marquez provides a new description of the postcranial osteology. Several small skeletal elements, usually absent in hadrosaurid skeletons due (presumably) to post-mortem loss, are reported here for the first time. In the second paper, Nate Murphy and colleagues briefly describe 'Leonardo', a mummified brachylophosaur from the Judith River Formation of Montana. This is perhaps the most complete and exquisite hadrosaurid specimen yet discovered: it preserves rhamphothecae, a soft-tissue frill, a scaly integument and gastric contents. For those who have been following the debate over hadrosaurid neck shape, 'Leonardo' is reported to preserve a dorsoventrally deep neck. Although the authors do not seem to emphasize (or even mention) it, this is hopefully only the preliminary version of what will be a much more comprehensive analysis of the specimen.

In another contribution on hadrosaurids, Michael Brett-Surman and Jonathan Wagner review variation within the appendicular anatomy of lambeosaurines and hadrosaurines. They repeatedly make the point that it is difficult to draw clear lines of demarcation between the character states of hadrosaurines and lambeosaurines: instead, the two groups seem to merge into one another. That doesn't mean that the two groups aren't clades, but it does mean that it is difficult to be sure about the taxonomic affiliations of isolated elements. Some anatomical terminology is a bit confused in this article: in one paragraph, the authors discuss the morphology of the short,



divergent fifth finger, but wrongly refer to it as digit IV (p. 145). I don't know whether to blame the authors however, as the editing throughout the book is a bit shaky (read on). Given the huge amount of morphological data reviewed in this paper, I was surprised to find that it lacked a discussion section, or any sort of tabulation of which features were found to be useful in distinguishing the two clades, and which not. Additional papers in the volume cover palaeopathologies in hadrosaurids and the history of hadrosaurid nomenclature.

Moving finally to the ceratopsian section of the book, Christopher Ott describes the first material of the rare basal neoceratopsian *Leptoceratops* from the Hell Creek Formation. This not only provides new morphological information on this taxon, but also demonstrates that it occurred alongside *Triceratops* and *Edmontosaurus* in coastal plain habitats: it can no longer be inferred to have been restricted to piedmont and/or alluvial plain habitats where *Triceratops* was rare. Andy Farke's review of *Torosaurus latus* is excellent, with much new information on the morphology of this animal. It seems to have exhibited a curious degree of variation, with individuals differing in the shape and form of the nasal horn, the curvature and length of the brow horns, the length and shape of the frill and, most peculiarly, in the absence or presence of the postfrontal fontanelle. Intraspecific variation in the latter feature has been noted before, and might prove to be really interesting *if* we knew what the function of this bizarre structure was. It might be reasonable to guess that it's something to do with CNS cooling, but maybe this can't apply if some individuals lack the fontanelle. As has been reported elsewhere in ceratopsids, epoccipitals are sometimes present and sometimes absent. Were they really absent in life in some individuals (or imperceptibly fused to the frill edges), or did they just drop off during decomposition?

Thomas Lehman provides a lengthy and interesting look at the palaeobiology of *Chasmosaurus mariscalensis* based on his analysis of an assemblage of multiple specimens from Texas. His conclusions on growth rates (which posit relatively slow growth and long life) are rather different from the views recently championed by other dinosaur workers. One area that needs further analysis concerns lifestyle and habitat choice in these dinosaurs, as Lehman joins the list of authors who have noted the repeated association of chasmosaurines with swamp and marsh habitats. Were these animals really semi-amphibious animals of wetlands? Intuitively, this seems unlikely, but I'm not sure why. Incidentally, *C. mariscalensis* was recently made the type of a new genus, *Agujaceratops* Lucas *et al*., 2006. This proposal of generic status may have occurred while Lehman's paper was in

press as he does not comment on it; that's a shame as I'd like to know what he thinks of it.

One of the most interesting ideas about ceratopsian palaeobiology is that horns were lost and resorbed during the ontogeny of some horned dinosaur taxa. Another is that the various accessory fenestrae sometimes present in ceratopsid frills result from intraspecific fighting. Darren Tanke and Andy Farke provide a good, comprehensive, review of these subjects among others. Why ceratopsids exhibited bone resorption remains uncertain but, to be fair, it was only recently discovered that this occurs at all. Accessory fenestrations in ceratopsid frills are, the authors argue, most likely a mechanical response to the distribution of stress patterns, but circular lesions and other concavities seen on the skulls of these dinosaurs remain unexplained. As seems increasingly the case, it is probably not going to be possible to go further on this subject until we understand why such structures occur in living animals, and this remains an area of relatively little research. Having said that, I note that the authors do not comment on some of the modern phenomena that cause cranial pitting in extant tetrapods, such as helminth parasites.

In the last paper of the volume, Kenneth Carpenter reviews Marsh's early views on ceratopsians. After receiving *Triceratops* horns from George Cannon in 1887, Marsh at first thought he had a new species of giant long-horned bison. Shortly afterwards, he regarded *Triceratops* bones from the Denver area as belonging to stegosaurs. Carpenter describes how, rather than bungling his original identifications in a rush to get the fossils into print, Marsh's conclusions were sensible based on what was known at the time, and also reflected uncertainties about the ages of the respective strata.

The standard of editing in this volume is not excellent and I get the impression that the absence or presence of typos was controlled largely by the authors: in some cases, problems seem to been have introduced, rather than eliminated, by the editing. For example, use throughout Farke's *Torosaurus* paper of the binomial *Triceratops porosus* [sic] for *T. prorsus* suggests that whoever edited the paper had crocodiles on their mind at the time.

As with the previous dinosaur volumes in this IUP series, *Horns and Beaks* cannot be said, unfortunately, to include any ground-breaking papers that are essential reading for non-specialists, nor any that are of general interest to those outside the dinosaur community. But as a dinosaur specialist and enthusiast, I found it an interesting compilation and, given the need to keep up to date with changing taxonomic allocations and the naming of new taxa, I regard it as an essential volume on ornithopods and ceratopsians.

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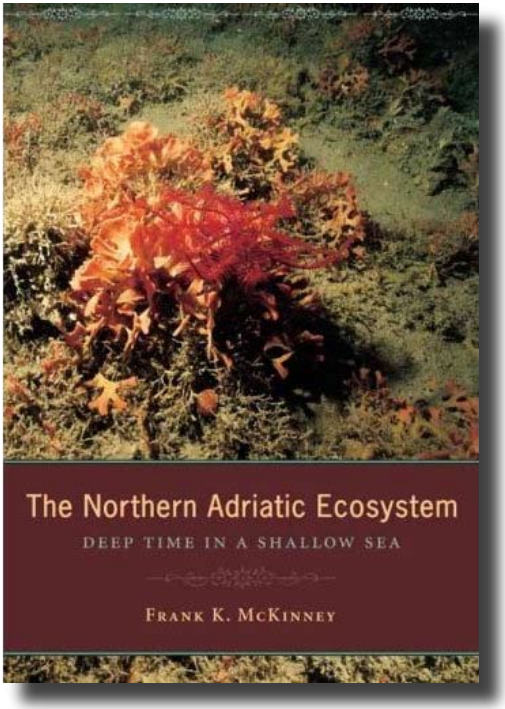
The northern Adriatic ecosystem: Deep time in a shallow sea

Frank K. McKinney (2007). Columbia University Press, New York.
ISBN 9780231132428 (hardback) $60.00.



In this remarkable book, author Ken McKinney presents an ingenious way to model palaeontological hypotheses of benthic marine ecosystem changes with modern communities. He compares a series of grand ecological events which took place over hundreds of millions of years across the globe with the contemporary ecosystems found on a muddy patch of seafloor not much more than 100 kilometres wide. Surprisingly, this abstract construct works very well. This book not only provides new ideas about ecosystem changes through "deep time", it is itself a model of a philosophical and methodological approach to palaeoecology.

The northern extension of the Adriatic Sea between the east coast of Italy and the west coast of the Balkans is a shallow epeiric ramp where waters of the Mediterranean extend on to part of the Po River plain. It is no deeper than 100 metres, and usually much more shallow, so the modern sea is a product of eustatic flooding after the last glacial maximum some 6,000 to 18,000 years ago. For such a small body of water it has a wide range of physical and chemical sub-environments, producing many distinctive ecological systems among the benthic flora and fauna. It is in this biological variety that the author sees parallels with the dramatic changes in marine communities during the Phanerozoic.

Bottom-dwelling communities in the northern Adriatic Sea are complex in all the predictable ways, but they show a distinct and simple gradient from primarily epifaunal filter-feeders in the east to primarily infaunal faunas in the west. The thesis of this book is that this ecological change in space in this particular epeiric sea is analogous to the similar ecological change in time from the Paleozoic to our Modern benthic ecosystems. With this ecological gradient laid out before us in a modern and accessible sea, we should be able to sort out the biological and physical factors behind the modern spatial pattern and see if they can be applied to the historical evidence. This is not strictly to "test hypotheses concerning the shift" as is claimed on the book jacket, but it is creating a conceptual model for those changes which can be tested for plausibility. Here is where I must give the reader a Spoiler Alert because the author has strong evidence for one particular causal mechanism for the northern Adriatic ecological gradient which does indeed fit the fossil record beautifully. Read no further if you would rather have the book unfold like a suspense novel before you.

This contemporary-spatial and ancient-temporal ecological comparison is an elegant idea, but it requires a book-length development of the evidence before it can be seriously considered. If this book were a novel, it would have a very exciting first chapter where the history of benthic marine communities is told and the ideas about what caused the "long-term ecological changes" are explained almost like characters. The middle chapters, though, are slow-going as the physical framework of the northern Adriatic Sea is described in painful but necessary detail. This includes the basic geography of this shallow body, the tectonic history of the Adriatic, the physical oceanography, nutrient levels and cycling, pelagic biology, and the origin and distribution of the bottom sediments. I must admit to nodding off during the salinity distribution explanation, and glazing over in the midst of the chlorophyll *a* annual cycle, but I knew the reward for such slogging was coming soon.

Chapter Seven begins the detailed description of the benthic communities in the northern Adriatic Sea, and here our palaeontological interest levels perk up again. There is a biologist hero here: Aristocle Vatova (1897–1992), who worked out of the Marine Research Station at Rovinj, which is now in Croatia, in the 1930s. He made hundreds of grab samples throughout the northern and middle Adriatic, producing a superb dataset of benthic diversity which has still not been equalled. McKinney shows the fine texture in this information, updating it with later studies, including his own, and constructing from it a broad trophic analysis. It is here that the epibenthic–endobenthic gradient appears.

But would such a benthic gradient survive fossilization? Another detailed assessment follows to sort out this survivability into the rock record. Using Bambachian megaguilds and measures of skeletalization, McKinney warms our palaeontological hearts by demonstrating that while much is lost, basic ecological patterns are preserved in the record, especially the epibenthos–endobenthos dominance within communities. The benthic marine fossil record of such faunas is not so bad.

Finally, the last chapter is titled "paleontological implications" – what controls the benthic community distribution in the northern Adriatic Sea? Can it provide a plausible model for the Paleozoic–Modern changes in community organization? Now all the oceanographic and biological details are assembled for the grand analysis, complete with Bambachian megaguilds and Principal Components Analysis of the datasets. Is it simply water depth which controls community distribution? No. Sediment type or accumulation? No. Predators or bioturbation? Not directly, at least. Nutrient levels? Bingo. The regions of the Adriatic dominated by infauna have the highest nutrient levels. These are the communities in the "freshened, eutrophic water on the western side", the area that receives high amounts of nutrients from the discharge of the Po River. The epifauna–infauna gradient is coincident with the nutrient gradient.

The nutrient controls on this ecosystem spatial gradient match wonderfully with a hypothesis made by Dick Bambach in 1999 (Energetics in the global marine fauna: A connection between terrestrial diversification and change in the marine biosphere. *Geobios* **32**: 131–144) that nutrient changes in the world's oceans drove ecological changes which resulted in a switch from epibenthic to endobenthic dominance. Its simplest correlate is that increased aquatic nutrient levels from expanding land plant biomass increased the value of deposit-feeding and produced an increase in the diversity and efficiency of predators on benthic fauna, thus the change from epibenthos to endobenthos domination. A palaeontological idea supported by neontological observations.

This story is a splendid model for modern palaeoecology. Ken McKinney could produce this monograph because he combined three attributes of modern palaeontology: a strong knowledge of the fossil record, a thorough understanding of the theoretical models of our discipline, and the skills of a marine biologist. Few of us can master all three, but we can all work towards this kind of conceptual synthesis. This book also succeeds, of course, because Ken is a superb writer with a spare, efficient, and interesting prose.

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