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The Palaeontology Newsletter

Contents

Reminder: The deadline for copy for Issue no. 105 is 5th October 2020.

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Editorial

Despite the ongoing global pandemic this remains a bumper issue. A letter from our president **Charles Wellman** (p.40) summarizes the effects of the COVID-19 virus on the Association and the Annual Meeting in particular. Readers are also urged to check the Future Meetings of Other Bodies section for postponements and cancellations of other palaeontological conferences. Due to related technical issues our book review section is absent this issue, but will return so please check out the books available to review and contact **Tom Challands** if you wish to contribute to a future issue.

Otherwise the *Newsletter* has been relatively unaffected, and you will find the usual selection of features. **Jan Zalasiewicz** uses his column to review our current understanding of Snowball Earth and our cartoonist **Holly Jones** has outdone herself this time – supplementing her epic news cartoon (see **Susannah Lydon**'s piece on the latest *Spinosaurus* findings) with her re-drawing of Raup's famous morphospace which serves as the centrepiece of a new column entitled "Palaeontology's Greatest Ever Graphs" (this first contribution is written by **Katie Collins**). **Yara Haridy**, **Christina Shears-Ozeki** and **Camilla Souto** are this issue's palaeontologists abroad, and give their accounts of life in Germany, Japan and the USA, respectively. Meanwhile, **April Wright** continues her Bayesian Phylogenetics series with tips on managing data and taxa.

Elsewhere there are updates on our Exceptional Lecturer (courtesy of **Stephan Lautenschlager**) and mentorship (courtesy of **Fiona Gill** and **Thomas Clements**) schemes, and **Fernanda Castano** delivers this issue's Legends of Rock piece on the 'father of Argentinan palaeontology', Florentino Ameghino. Behind the Scenes at the Museum travels to the Australian outback, where **Michelle Johnston** shows us around Kronosaurus Korner, and our Careers Q & A features the familiar face of **Mark Bell**, who recounts his transition from palaeontology to statistics. Unfortunately, this issue also features a number of obituaries, for **Françoise Bigey** (by Jean-Loup d'Hondt and Patrick Wyse Jackson), **Jenny Clack** (by Michael Coates), **Roger Cooper** (by Ian Percival) and **Charles Hepworth Holland** (by George Sevastopulo and Patrick Wyse Jackson).

Finally, the Association continues to address our field's many diversity issues. Especially prevalent at the moment is our lack of racial diversity, brought into sharp focus by the ongoing protests in the wake of the killing of George Floyd. The next issue will contain updates on the actions the Association is taking in that regard, and this one has our regular Spotlight on Diversity piece. The topic this time is a non-visible aspect of diversity (minority languages), penned by **Emma Dunne** and **Nussaïbah Raja-Schoob**, and there's a special interview by our Diversity Officer **Rachel Warnock** of Puerto Rican palaeontologist **Stephanie Plaza-Torres**. I will finish by highlighting the various Council vacancies that are coming up at the end of the year (p.26). If you would like to contribute to making Council more diverse please do consider self-nominating and feel free to ask me any questions you may have – my Twitter DMs are always open: @GraemeTLloyd.

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Association Business

Annual Meeting 2020

Notification is given of the 64th Annual General Meeting

Because of the current coronavirus pandemic the exact format of the Annual General Meeting has not yet been fixed, but it will be held virtually on Thursday 17th December 2020. Council will inform the membership via e-mail when this becomes known.

AGENDA

1. Apologies for absence
2. Minutes of the 63rd AGM, University of Valencia
3. Trustees Annual Report for 2019
4. Accounts and Balance Sheet for 2019
5. Election of Council and vote of thanks to retiring members
6. Report on Council Awards
7. Annual address

DRAFT AGM MINUTES 2019

Minutes of the Annual General Meeting held on Thursday 19th December 2019 at the University of Valencia, Spain.

1. Apologies for absence. None.

2. Minutes. The minutes of the 2018 AGM were agreed a true record by unanimous vote.

3. Trustees Annual Report for 2018. The report was agreed by unanimous vote of the meeting.

4. Accounts and Balance Sheet for 2018. The accounts were agreed by unanimous vote of the meeting.

5. Election of Council and vote of thanks to retiring members.

5.1 Prof. C.H. Wellman extended a vote of thanks to the following members of Council who were retiring from their positions this year: Dr C.J. Buttler, Dr B.H. Lomax, Dr L.M.E. McCobb, Dr A.R.T. Spencer, Dr D.P.G. Bond, Dr A.M. Dunhill, Prof. A.S. Gale and Ms Z.E. Hughes.

5.2 The following members were elected to serve on Council: President: Prof. C.H. Wellman, President-Elect: Dr P.J. Orr, Vice-Presidents: Dr F.L. Gill and Prof. T.R.A. Vandenbroucke, Treasurer: Dr P. Winrow, Secretary: Dr C.T.S. Little; Editor-in-Chief: Dr B.H. Lomax; Editor Trustees: Prof. N.J. Butterfield and Prof. M.A. Purnell, Newsletter Editor: Dr G.T. Lloyd, Book Review Editor: Dr T.J. Challands, Publicity Officer: Dr S.J. Lydon, Education Officer: Dr M.E. McNamara, Outreach Officer: Ms Z.E. Hughes, Internet Officer: Dr R.J. Garwood, Meetings Coordinator: Dr U. Balthasar, Diversity Officer: Dr R.C.M. Warnock, Ordinary Members: Dr T. Clements, Dr L. Hide, Dr S. Giles and Dr T.H.P. Harvey.

5.3 Dr R. Sansom and colleagues will organize the Annual Meeting in 2020 at the University of Manchester, UK. [See note above regarding the AGM and the coronavirus pandemic.]

6. Association Awards. The following awards were announced:

6.1 The Lapworth Medal was awarded to Prof. D.E.G. Briggs (Yale University).

6.2 The President's Medal was awarded to Dr M.D. Sutton (Imperial College London).

6.3 The Hodson Award was presented to Dr S. Danise (Università degli Studi di Firenze).

6.4 The Mary Anning Award was presented to Dr H. Hagdorn (Ingelfingen, Germany).

6.5 The Gertrude Elles Award for public engagement was presented to Ms E. Wallace (The University of Manchester/iCRAG).

6.6 Research Grants were awarded to: Dr N. Brocklehurst, University of Oxford, *Patterns of extinction and survival in early terrestrial herbivores*; Dr L.A. Riedman, University of California, Santa Barbara, *Eukaryotic evolution in heterogeneous Proterozoic seas*; and Dr E.A. Sperling, Stanford University, *Harnessing the power of the Metabolic Index for palaeontological studies*.

6.7 Under the Small Grants Scheme, the following awards were announced: the Whittington Award to Dr E.M. Dunne, University of Birmingham, *Harnessing the power of 'dark data' for enhancing estimates of tetrapod diversity*; the Callomon Award to Mr R. Smith, University of Portsmouth, *A new and unique Kem Kem beds (mid Cretaceous) locality near the oasis of Tarda, south eastern Morocco*; Stan Wood Awards to Ms R.F. Bennion, University of Liège, *Disparity and niche partitioning in toothed cetaceans from the early Miocene of Peru*, and Ms C. Shears-Ozeki, Kyoto University, *Bone modification of the Mesozoic marine vertebrates of south England*; and Sylvester-Bradley Awards to Ms N. Machida, West Virginia University, *The importance of environmental factors in driving paedomorphic evolution in the suborder Phacopina*, Dr N. Robin, University College Cork, *Investigating the enigmatic Devonian arthropod* Oxyuropoda, and Mr J.O. Shaw, Yale University, *Elucidating connections between the Cambrian Explosion and Great Ordovician Biodiversification Event*.

6.8 Undergraduate Research Bursaries were awarded to: Mr T. Mackay-Champion, University of Oxford, supervised by Prof. R.B.J. Benson, *Anatomy of Hylonomus, the earliest amniote, based on high-resolution synchrotron tomography*; Mr J. Lovegrove, University of Bristol, supervised by Prof. M.J. Benton, *Investigating the Palaeotopography and Variations in Ecology of Rhaetian Bristol using the Westbury Formation bone bed*; Mr A.R.D. Payne, University of York, supervised by Dr K.E. Davis, *What happened to* Pseudosuchia*? Exploring the effects of past environmental change on a once diverse clade*; Ms L. Southan, University of Birmingham, supervised by Dr S.E. Greene, *Testing the biogenicity of ancient stromatolites using magnetic susceptibility*; Mr R. Carter, Imperial College London, supervised by Dr M.D. Sutton, *Analysing an exceptionally-preserved Silurian asterozoan*; and Mr H. Berks, University of Bristol, supervised by Dr J. Vinther, *A new Early Cambrian arthropod – a description and phylogenetic analysis*.

6.9 Engagement Grants were awarded to Dr C.D. Dean for *Fossil fact or fiction? Einstein's Garden palaeontology stall at Green Man Festival, 2019*; Ms Y. Haridy for *Velociraptor puppet workshops*; and Dr E.A. Hide for *Mary Anning's specimens and archives in the Sedgwick Museum*.

6.10 The 2019 Best Paper Awards were presented to Dr S.W. Evers and Prof. R.B.J. Benson, for their paper entitled 'A new phylogenetic hypothesis of turtles with implications for the timing and number of evolutionary transitions to marine lifestyles in the group' (*Palaeontology*), and to Dr W.J. Foster and colleagues for 'Early Triassic benthic invertebrates from the Great Bank of Guizhou, South China: systematic palaeontology and palaeobiology' (*Papers in Palaeontology*).

6.11 The President's Prize was presented to Dr J. Luque (Yale University).

6.12 The Council Poster Prize was presented to Dr E.M. Dunne (University of Birmingham).

7. Annual Address. A talk entitled 'Not just skin deep: probing the secrets of fossil melanin using taphonomic experiments and analytical chemistry' was given by Dr Maria E. McNamara (University College Cork).

Trustees Annual Report 2019

The Trustees present their report with the financial statements of the charity for the year ended 31st December 2019. The Trustees have adopted the provisions of *Accounting and Reporting by Charities: Statement of Recommended Practice* applicable to charities preparing their accounts in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (FRS 102) (effective 1st January 2019).

1. OBJECTIVES AND ACTIVITIES

1.1 Aims and objectives: 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. In order to meet these objectives, the Association continues to increase its range and investment in public outreach and other charitable activities, whilst continuing to support research, publications, and student and speaker attendance at national and international meetings including our flagship Annual Meeting.

1.2 Grants-in-aid for meetings and workshops: The Association provided funds to support the following meetings and workshops: From molecules to macroevolution symposium, SVP 2019 (Prof. Derek E.G. Briggs, Yale University); 67th and 68th SVPCA (awards to Dr Martin Munt, Dinosaur Isle Museum and Dr Susannah C.R. Maidment, Natural History Museum, London).

1.3 Public meetings: Two public meetings were held in 2019, and the Association extends its thanks to the organizers and host institutions of these meetings.

63rd Annual Meeting. The Association's Annual Meeting is its flagship meeting and this year was held on 15–21 December at the University of Valencia. Dr C. Martínez-Pérez, together with local support from colleagues and PhD students, organized the meeting, which included a symposium on 'Virtual Palaeontology' and comprised a programme of internationally recognized speakers. There were 325 attendees. The Annual Address was entitled 'Not just skin deep: probing the secrets of fossil melanin using taphonomic experiments and analytical chemistry' and was given by Dr Maria E. McNamara (University College Cork). The President's Prize for best oral presentation by an early-career researcher was awarded to Dr J. Luque (Yale University). The Council Poster Prize for

best poster presentation by an early-career researcher was presented to Dr E.M. Dunne (University of Birmingham).

Progressive Palaeontology. This is an annual, open meeting for research students in Palaeontology and allied sciences to present their work to an audience of their peers. The 2019 meeting was organized by Mr L.E. Meade and a team of other students, and held at the University of Birmingham on 6–8 June. There were 95 attendees.

1.4 Publications: The journals *Palaeontology* and *Papers in Palaeontology* are produced by Wiley. During 2019, the following volumes were published: *Palaeontology* volume 62, comprising six issues; and *Papers in Palaeontology* volume 5, comprising four issues. Council thanks Mr N. Stroud for assistance with the typesetting and production of the *Palaeontology Newsletter*.

1.5 Research Grants: A total of 13 applications for Palaeontological Association Research Grants were received. Three were recommended for funding in 2019, totalling £19,883, and were awarded to: Dr N. Brocklehurst (University of Oxford), 'Patterns of extinction and survival in early terrestrial herbivores'; Dr L.A. Riedman (University of California, Santa Barbara), 'Eukaryotic evolution in heterogeneous Proterozoic seas'; and Dr E.A. Sperling (Stanford University), 'Harnessing the power of the Metabolic Index for palaeontological studies'.

1.6 Small Grants Scheme: The scheme received 22 applications. Seven were recommended for funding in 2019, totalling £10,063.30. Small grants were awarded as follows: Dr E. M. Dunne (University of Birmingham) received the Whittington Award; Mr R. Smith (University of Portsmouth) received the Callomon Award; Ms R.F. Bennion (University of Liège) and Ms C. Shears-Ozeki (Kyoto University) received Stan Wood Awards; Ms N. Machida (West Virginia University), Dr N. Robin (University College Cork) and Mr J.O. Shaw (Yale University) received Sylvester-Bradley Awards.

1.7 Undergraduate Research Bursary Scheme: The scheme attracted 18 applications, of which six were recommended for funding in 2019, totalling £13,792.80. The awardees were as follows: Mr T. Mackay-Champion, University of Oxford, supervised by Prof. R.B.J. Benson; Mr J. Lovegrove, University of Bristol, supervised by Prof. M.J. Benton; Mr A.R.D. Payne, University of York, supervised by Dr K.E. Davis; Ms L. Southan, University of Birmingham, supervised by Dr S. E. Greene; Mr R. Carter, Imperial College, supervised by Dr M.D. Sutton; and Mr H. Berks, University of Bristol, supervised by Dr J. Vinther.

1.8 Publicity, outreach and engagement: The Association continues to promote Palaeontology and its allied sciences to print/online media, radio and television. The Association is a major financial supporter of the Lyme Regis Fossil Festival and the Yorkshire Fossil Festival. The Association developed new displays and activities for the public on the theme of fossilization, organized and staffed by members of Council and student members; Association members also delivered public lectures at the festivals. The Association launched a YouTube channel showcasing diverse aspects of palaeontology to the broader public. The Public Engagement Group (PEG), consisting of the Outreach Officer, Education Officer, Publicity Officer, Executive Officer, President and the Treasurer, decided on expenditure of the group budget (£30,000 for 2019), supporting recurring festival activities, Engagement Grants and commissioned projects.

1.9 Engagement Grants: The scheme received a total of six applications in 2019, of which three were recommended for funding, totalling £12,536. These were awarded to Dr C.D. Dean for 'Fossil

fact or fiction? Einstein's Garden palaeontology stall at Green Man Festival, 2019'; Ms Y. Haridy for 'Velociraptor puppet workshops'; and Dr E.A. Hide for 'Mary Anning's specimens and archives in the Sedgwick Museum'.

1.10 Diversity Group: The Diversity Officer and Diversity Group (DG) are responsible for realizing the recommendations from the Diversity Study completed by Parigen Ltd in 2018. One of these was to revise the medals and awards nominations and selection procedures. To investigate alternative best practices, the DG collected evidence and reached out to other scientific organizations. In response the DG updated the nominations and awards procedures, and is committed to re-evaluating these. In 2019 the Association launched the Carer's Bursary with a £250 maximum per individual to support those with caring responsibilities to attend Association meetings. The award recognizes the challenges faced by carers in obtaining equal access to the opportunities linked to scientific meetings. This year the Association supported two individuals with these bursaries. The organizers of the Annual Meeting and Progressive Palaeontology also made efforts to ensure these events were diverse and inclusive. A panel on diversity issues was hosted at the Annual Meeting and a guide to organizing inclusive meetings was published by the Progressive Palaeontology organizers. Throughout the year the DG commissioned articles promoting diversity and inclusion for the *Newsletter*, including a Special Report on gender bias in publishing in palaeontology.

1.11 Palaeontological Association Exceptional Lecturer scheme: The first Palaeontological Association Exceptional Lecturer, Dr S. Lautenschlager, gave six lectures in 2019/2020, at the Swedish Museum of Natural History, the Geological Society of London, University College Cork and the Universities of Plymouth, Cambridge and Oxford. Dr A.J. Hetherington was selected in a competitive process to be the Palaeontological Association Exceptional Lecturer for the academic year 2020/2021.

1.12 Online activities: The online activities of the Association continue to expand with greater emphasis on social media (Facebook, Twitter). The Association continues to be the sole host for the online-only journal *Palaeontologia Electronica*, as well as continuing to host websites for other societies (The Palaeontographical Society, International Organisation of Palaeobotany), palaeontological online resources (EDNA fossil insect database, the Kent Fossil Database, SPIERS Software), palaeontological networking sites (European Coalfield Conservation Opportunities) and online outreach projects (Palaeontology [Online]). The listserver PaleoNet also continues to be hosted. The Association continues to run its Internet activities on cloud-based services provided by AWS located on EU-based servers. At the end of 2019 members of the PalAss Facebook group numbered 1,697 and the @ThePalAss Twitter account had 6,025 followers. During 2019 a new Association Facebook page was implemented to allow for easier updates to members. The page is linked to the Facebook group and had 256 followers at the end of 2019.

1.13 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 presented to Prof. Derek E.G. Briggs (Yale University). The President's Medal, awarded to a palaeontologist within 15 to 25 years of their PhD in recognition of outstanding contributions in their earlier career, coupled with an expectation that they will continue to contribute significantly to the subject in their further work, was presented to Dr Mark D. Sutton (Imperial College London). The Hodson Award, for a palaeontologist within ten years of award of their PhD who has made an outstanding contribution to the science through a portfolio of original published research, was awarded to Dr Silvia Danise (Università degli Studi di Firenze).

The Mary Anning Award, for an outstanding contribution by an amateur palaeontologist, was made to Dr Hans Hagdorn (Muschelkalkmuseum Hagdorn, Ingelfingen). The Gertrude Elles Award for high-quality, amateur or institutional, public engagement projects that promote palaeontology was awarded to Ms Elspeth Wallace (The University of Manchester/iCRAG). The 2019 Best Paper Awards in *Palaeontology* and *Papers in Palaeontology* were given respectively to Dr S.W. Evers and Prof. R.B.J. Benson for their paper entitled 'A new phylogenetic hypothesis of turtles with implications for the timing and number of evolutionary transitions to marine lifestyles in the group', **62(1)**, 93–134; and Dr W.J. Foster and colleagues for their paper 'Early Triassic benthic invertebrates from the Great Bank of Guizhou, South China: systematic palaeontology and palaeobiology', **5(4)**, 613–656. Council also awards undergraduate prizes to outstanding students in university departments worldwide where Palaeontology is taught beyond Level 1; a total of 19 were awarded throughout the year.

1.14 Forthcoming plans: The Association will continue to make substantial donations from General and Designated funds to promote the charitable aims of the Association. Resources will be made available to continue a similar programme of grants, meetings, outreach and public engagement activities. The 2020 Progressive Palaeontology conference will take place virtually due to the coronavirus pandemic. For the same reason the 64th Annual Meeting planned to be held in December 2020 at The University of Manchester will now also take place virtually. Volume 63 of *Palaeontology* and volume 6 of *Papers in Palaeontology* will be published; however, as announced at the AGM in 2019, paper copies will cease to be printed and publishing will move to online-only. The *Field Guide to Fossils of the Kimmeridge Clay Formation* is in production with publication expected in 2020. As of 2020, the Association will begin collecting diversity and equality data annually, supporting diversity and inclusion. Each year the membership will be asked to fill out an anonymous survey and given the opportunity to provide feedback. This provides a way to measure the impact of DG initiatives and to highlight critical areas for improvement. In addition, the DG has launched a survey to identify key areas for improvement at the Association's events.

1.15 Public benefit: The Trustees confirm that they have referred to the Charity Commission's guidance on public benefit when reviewing the charity's aims and objectives, in planning future activities and setting the grant-making policy for the year.

2. ACHIEVEMENTS AND PERFORMANCE

2.1 Meetings support: During 2019, the Association agreed to support a total of six palaeontological meetings, symposia or workshops worldwide (held in Australia, Spain and the UK). In addition, our Postgraduate Travel Grant scheme supported 12 postgraduate students to present their work at international conferences: Ms Valentina Brandolese (University of Ferrara), Ms Lucile Crete (Bournemouth University), Mr Panagiotis Kampouridis (Eberhard-Karls University Tübingen), Mr Romain Gougeon (University of Saskatchewan), Mr Calian Hazell (Northumbria University), Mr Pablo Sebastián Milla Carmona (University of Buenos Aires), Ms Maria Eugenia Pereyra (Facultad de Ciencias Naturales y Museo La Plata), Mr Hans Püschel (University of Edinburgh), Mr Miky Lova Tantely Raveloson (University of Antananarivo), Ms Lauren Sewell (Bournemouth University), Ms Amy Shore (University of Edinburgh) and Ms Danae Thivaiou (National and Kapodistrian University of Athens). The Association's support enabled the worldwide dissemination of research to the benefit of the global palaeontological community.

2.2 Publications: During 2019, 269 papers were submitted to either *Palaeontology* or *Papers in Palaeontology*. Of these, 127 (47 %) were considered to be within scope by the Editorial Board and 70 (26 %) were subsequently accepted following peer review; a further 29 papers are still awaiting submission of a revised manuscript before a final decision is made. A total of 97 papers were published online. The number of downloads of articles via Wiley Online Library was 14 % higher in 2019 relative to 2018 for *Palaeontology* and less than 1 % higher for *Papers in Palaeontology*. The Association continues to support data archiving by sponsoring Dryad data records; 75 papers published online in 2019 had associated data files in Dryad, representing 77 % of all papers published (18 % more than 2018). Authors were also encouraged to use alternative data repositories if they wished, and some took this option instead. The Association published two books in 2019: *Fossils from the Lias of the Yorkshire Coast* edited by Prof. Alan R. Lord and *Trilobites, Dinosaurs and Mammoths* by palaeoartist Mr J. McKay.

2.3 Support for research: In 2019 the Association agreed to fund the research activities of 16 early-career researchers based in five countries (Belgium, Ireland, Japan, the UK and the USA). Apart from directly benefiting the career development of the individuals concerned, the Association's funds continue to enable more palaeontological research to be undertaken worldwide than would otherwise be the case. Overall, the number of grants funded in 2019 decreased from 2018 (from 22 to 16). Compared to 2018, applications for Research Grants decreased from 20 to 13, and thus the success rate increased from 15 % to 23 %. The applications to the Small Grants Scheme increased (from 14 to 22), and the success rate consequently decreased from 64 % to 32 %. Applications to the Undergraduate Research Bursary Scheme increased slightly in 2019 compared to 2018 (from 17 to 18) and the success rate decreased to 33 %.

2.4 Mentoring scheme for early career palaeontologists: In 2017 the Association established a mentoring scheme to assist palaeontologists at the start of their academic careers. Priority areas were identified and in the first instance the focus was on the transition from postdoctoral positions to permanent jobs. Other transition points such as late stage PhD to postdoctoral positions and mid-career to senior leadership roles will be considered later. Twenty-three palaeontologists in permanent positions offered to act as mentors and so far ten postdoctoral palaeontologists have taken part in the scheme. The Palaeontological Association mentoring scheme is via direct mentoring, via e-mail, video call or other forms of communication. In 2019 feedback was sought from all mentors and mentees about the scheme. Four responses were returned in total, two each from mentors and mentees. Three of the four responses were extremely positive and the fourth, from a mentor, was neutral.

2.5 Outreach, education and public engagement: During 2019, the Association supported two major fossil festivals in the UK, in Lyme Regis and Scarborough, which attracted an estimated 10,000 and 3,000 members of the public, respectively. The PEG developed a suite of novel activities based around the theme of adaptation for the Association stand at the festivals including: the 'Wheel of Misfortune'; exploring themes of organismal response to cataclysmic and gradual environmental and biotic change; 'How Fit are You', a card game based on Top Trumps; and 'Design-your-own-chimera', involving assembling and drawing novel arthropod 'species' from assorted heads, limbs, tails and body shapes. Palaeoartist Mr J. McKay provided watercolour interpretations of the children's drawings. In addition, workshops were delivered by Association volunteers to 133 children from five year classes of a primary school as part of the Lyme Regis Fossil Festival schools'

day, and to 135 primary school children from five schools as part of the Yorkshire Fossil Festival schools' day. Association volunteers took part in a careers fair, 'Jobs that Rock', during the Yorkshire Fossil Festival, with a stand in the exhibition area and as part of a panel. The Association also took part in the Geological Society Careers and Industry Day at Imperial College London with a stand in the exhibition area. During 2019, PEG awarded three Engagement Grants (see 1.9). Continued use of social media, in particular the Association's Twitter and Facebook accounts, has enabled the rapid and regular dissemination of research news, including of new publications, meetings and other information, to a growing audience (see section 1.12). The PEG launched a new YouTube channel (accessible at <**https://www.youtube.com/channel/UCVedLnMZg6RiZ8W6RY5QNFg**>) late in 2019. The channel currently hosts short videos featuring Council members speaking about exciting elements of their research, including trilobites, fossil colour, mass extinctions, fossil plants and fossil fish. It is hoped that members will contribute to the channel in 2020.

3. FINANCIAL REVIEW

3.1 Reserves: As of 31st December 2019, the Association holds reserves of £783,352 in General Funds, which 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 to be produced, and the award of research grants and Grants-in-aid. They also act as a buffer to enable the normal programme to be followed in years in which expenditure exceeds income, and allow new initiatives to be pursued. The Association holds £130,612 in Designated Funds, which contribute interest towards the funding of the Sylvester-Bradley, Hodson, Callomon, Whittington and Stan Wood Awards and towards the Jones-Fenleigh Fund. Total funds carried forward to 2020 totalled £913,964.

3.2 Reserves policy: The Association maintains a minimum of General Fund reserves at a level sufficient to fund at least one year's expenditure, based on a three-year average of expenditure, in addition to Designated Fund reserves. This policy is reviewed and approved annually by the Trustees.

3.3 Summary of expenditure: Total charitable expenditure, through grants to support research, scientific meetings and workshops in 2019 was £432,957. Governance costs were £25,063. Total resources expended were £491,679. The Association continues its membership of the International Palaeontological Association and remains a Tier 1 sponsor of *Palaeontologia Electronica*, and the *Treatise on Invertebrate Paleontology*.

4. STRUCTURE, GOVERNANCE AND MANAGEMENT

4.1 Nature of the governing document: The Palaeontological Association was originally formed on 27th February 1957 as an unincorporated association, which was established as a registered charity (number 276369) on 21st August 1978. At an Extraordinary General Meeting on 16th March 2016, the membership voted in favour of the Association becoming a charitable incorporated organisation (CIO) under the Charities Act 2011. All contracts and assets were transferred to the new organization on 1st January 2017. As a CIO the charity is an independent legal entity and, in the unlikely event of its being wound up, the members (including the Trustees) will have no liability for any outstanding contractual debts that the CIO cannot meet. However, the Trustees will continue to have the normal trustee liability for negligence or fraudulence in managing the charity's affairs. The charitable objectives of the Association remain unchanged. The change in legal status means that there has been a different registration number (1168330) and constitution since 2017. The governing

document of the Palaeontological Association is the Constitution adopted at the AGM on Thursday 15th December 2016.

4.2 Management: The Association is managed by a Council of up to 20 Trustees, which is led by the President. The Association employs an Executive Officer and a Publications Officer who serve on Council but are not Trustees. The Trustees are elected by vote of the Membership at the Annual General Meeting, following guidelines laid down in the Constitution.

4.3 Membership: Membership on 31st December 2019 totalled 1,177 (1,189 at end 2017). Of these, 581 were Ordinary Members, 192 Retired Members, 20 Honorary Members, 356 Student Members and 28 Institutional Members. There were 38 institutional subscribers to *Papers in Palaeontology*. Wiley also separately manage further institutional subscribers and arrange online access to publications for them on behalf of the Association.

4.4 Risk: The Trustees consider that the Association is in a sound financial position. Membership numbers and revenues from publications remain strong.

5. REFERENCE AND ADMINISTRATION

5.1 Name and Charity Number: The Palaeontological Association is a Charity registered in England and Wales, Charity Number 1168330.

5.2 Address: The registered office and contact address of the Association is The Palaeontological Association, Alport House, 35 Old Elvet, Durham DH1 3HN, UK.

5.3 Trustees: The following members were elected at the AGM on 15th December 2018 to serve as Trustees in 2019:

Prof. C. H. Wellman	President
Dr C. J Buttler	Vice President
Prof. T. R. A. Vandenbroucke	Vice President
Dr C. T. S. Little	Secretary
Dr P. Winrow	Treasurer
Dr B. H. Lomax	Editor Trustee
Prof. M. A. Purnell	Editor Trustee
Dr A. R. T. Spencer	Internet Officer
Dr G. T. Lloyd	Newsletter Editor
Dr T. J. Challands	Book Review Editor
Dr L. M. E. McCobb	Outreach Officer
Dr M. E. McNamara	Education Officer
Dr S. J. Lydon	Publicity Officer
Dr R. C. M. Warnock	Diversity Officer
Dr U. Balthasar	Meetings Coordinator
Dr D. P. G. Bond	Ordinary Member
Dr A. M. Dunhill	Ordinary Member
Prof. A. S. Gale	Ordinary Member
Ms. Z. E. Hughes	Ordinary Member

5.4 Professional services: The Association's Bankers are NatWest, Sheffield City Centre, 42 High Street, Sheffield S1 2GE. The Association's Independent Examiner is Ms M. R. Corfield ACA ACMA, Corfield Accountancy Ltd., Chartered Accountants, Myrick House, Hendomen, Montgomery, Powys, SY15 6EZ. The Association's investment portfolio is managed by Quilter Cheviot Investment Management, 1 Kingsway, London WC2B 6XD.

EVENTS SINCE THE END OF THE YEAR

Information relating to events since the end of the year is given in the notes to the financial statements.

Approved by order of the Board of Trustees on 19th June 2020.

Independent Examiner's Report to the Trustees of The Palaeontological Association

I report to the trustees on my examination of the accounts of the above charity for the year ended 31st December 2019 set out on pages 14 to 22.

As the charity's trustees, you are responsible for the preparation of the accounts in accordance with the requirements of the Charities Act 2011 ("the Act").

I report in respect of my examination of the charity's accounts carried out under section 145 of the 2011 Act and in carrying out my examination, I have followed all the applicable Directions given by the Charity Commission under section 145(5)(b) of the Act.

The charity's gross income exceeded £250,000 and I am qualified to undertake the examination by being a qualified member of the Institute of Chartered Accountants in England and Wales (ICAEW) and the Chartered Institute of Management Accountants (CIMA), which are two of the listed bodies.

I have completed my examination. I confirm that no material matters have come to my attention in connection with the examination which give me cause to believe that in, any material respect:

- the accounting records were not kept in accordance with section 130 of the Charities Act; or
- the accounts did not accord with the accounting records; or
- the accounts did not comply with the applicable requirements concerning the form and content of accounts set out in the Charities (Accounts and Reports) Regulations 2008 other than any requirement that the accounts give a 'true and fair' view which is not a matter considered as part of an independent examination.

I have no concerns and have come across no other matters in connection with the examination to which attention should be drawn in this report in order to enable a proper understanding of the accounts to be reached.

Ms M. R. Corfield ACA ACMA
Corfield Accountancy Limited
Chartered Accountants
Myrick House
Hendomen
Montgomery
Powys SY15 6EZ

Date: 19th June 2019

THE PALAEONTOLOGICAL ASSOCIATION

Statement of Financial Activities for the Year Ended 31 December 2019

	Notes	Unrestricted funds £	Designated funds £	31.12.19 Total funds £	31.12.18 Total funds £
INCOME AND ENDOWMENTS FROM					
Donations and legacies		55,148	6,423	61,571	62,552
Charitable activities					
Public Meetings		53,301	—	53,301	48,536
Publications		320,107	—	320,107	318,458
Investment income	**2**	12,588	2,155	14,743	14,625
Total		441,144	8,578	449,722	444,171
EXPENDITURE ON					
Raising funds	**3**	36,459	—	36,459	39,680
Charitable activities					
Public Meetings		73,364	—	73,364	72,542
Grants & Awards		55,356	10,138	65,494	65,866
Administration		51,479	—	51,479	55,756
Publications		239,820	—	239,820	195,332
Governance Costs		25,063	—	25,063	44,557
Total		481,541	10,138	491,679	473,733
Net gains/(losses) on investments		94,878	—	94,878	(27,037)
NET INCOME/(EXPENDITURE)		54,481	(1,560)	52,921	(56,599)
RECONCILIATION OF FUNDS					
Total funds brought forward		728,871	132,172	861,043	917,642
TOTAL FUNDS CARRIED FORWARD		783,352	130,612	913,964	861,043

CONTINUING OPERATIONS

All income and expenditure has arisen from continuing activities.

The notes form part of these financial statements.

THE PALAEONTOLOGICAL ASSOCIATION

Balance Sheet
At 31 December 2019

	Notes	Unrestricted funds £	Designated funds £	31.12.19 Total funds £	31.12.18 Total funds £
FIXED ASSETS					
Investments	**6**	558,383	130,612	688,995	625,469
CURRENT ASSETS					
Debtors	**7**	175,564	—	175,564	189,454
Cash at bank		90,743	—	90,743	91,305
		266,307	—	266,307	280,759
CREDITORS					
Amounts falling due within one year	**8**	(41,338)	—	(41,338)	(45,185)
NET CURRENT ASSETS		224,969	—	224,969	235,574
TOTAL ASSETS LESS CURRENT LIABILITIES		783,352	130,612	913,964	861,043
NET ASSETS		783,352	130,612	913,064	861,043
FUNDS					
Unrestricted funds	**9**			913,064	861,043
TOTAL FUNDS				913,064	861,043

The notes form part of these financial statements.

The financial statements were approved by the Board of Trustees and authorized for issue on 19th June 2019.

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements for the Year Ended 31 December 2019

1. ACCOUNTING POLICIES

Basis of preparing the financial statements

The financial statements of the charity, which is a public benefit entity under FRS 102, have been prepared in accordance with the Charities SORP (FRS 102) 'Accounting and Reporting by Charities: Statement of Recommended Practice applicable to charities preparing their accounts in accordance with the Financial Reporting Standard applicable in the UK and Republic of Ireland (FRS 102) (effective 1 January 2019)', Financial Reporting Standard 102 'The Financial Reporting Standard applicable in the UK and Republic of Ireland' and the Companies Act 2006. The financial statements have been prepared under the historical cost convention with the exception of investments which are included at market value, as modified by the revaluation of certain assets.

Income

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

All income is recognized in the Statement of Financial Activities once the charity has entitlement to the funds, it is probable that the income will be received and the amount can be measured reliably.

Expenditure

Liabilities are recognized as expenditure as soon as there is a legal or constructive obligation committing the charity to that expenditure, it is probable that a transfer of economic benefits will be required in settlement and the amount of the obligation can be measured reliably. Expenditure is accounted for on an accruals basis and has been classified under headings that aggregate all cost related to the category. Where costs cannot be directly attributed to particular headings they have been allocated to activities on a basis consistent with the use of resources.

Allocation and apportionment of costs

Administrative costs have been allocated to the various cost headings based on estimates of the time and costs spent thereon.

Taxation

The charity is exempt from corporation tax on its charitable activities.

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.

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

1. ACCOUNTING POLICIES – continued

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 delegates annually to attend the Symposium of Vertebrate Palaeontology and Comparative Anatomy (SVPCA).
- Hodson Fund: Awards made in recognition of the palaeontological achievements of a researcher within ten years of the award of their PhD.
- Callomon Fund: Grants made to permit palaeontological research with a strong fieldwork element.
- Whittington Fund: Grants made to permit palaeontological research with an element of study in museum collections.
- Stan Wood Fund: Grants in the area of vertebrate palaeontology ideally involving fieldwork, due to generous donations in memory of the Scottish fossil collector Mr Stan Wood.

2. INVESTMENT INCOME

	31.12.19 £	31.12.18 £
Deposit account interest	274	99
Investment Income	14,469	14,526
	14,743	14,625

3. RAISING FUNDS

	31.12.19 £	31.12.18 £
Voluntary Income Costs: Administration	**32,759**	**35,481**
Investment Management Costs: Stockbroker Fees	3,700	4,199
	36,459	39,680

4. TRUSTEES' REMUNERATION AND BENEFITS

There were no Trustees' remuneration or other benefits for the year ended 31 December 2019 nor for the year ended 31 December 2018.

Trustees' expenses

The total travelling expenses reimbursed to 19 Members of Council (2018:19) was £12,308 (2018: £16,810).

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

5. STAFF COSTS

Analysis of Staff Costs and Remuneration

	£ 2019	£ 2018
Salaries	85,753	81,750
Social Security Costs	6,467	5,975
Pension Costs	8,575	8,175
Total	100,795	95,900

The average monthly number of employees during the year was as follows:

	2019	2018
Publications	1	1
Administration	1	1
	2	2

No employees received emoluments in excess of £60,000.

6. FIXED ASSET INVESTMENTS

Investments are initially recognized at their transaction value and subsequently measured at their fair value as at the balance sheet date. The statement of financial activities includes the net gains and losses arising on revaluation and disposals throughout the year.

7. DEBTORS: AMOUNTS FALLING DUE WITHIN ONE YEAR

	31.12.19 £	31.12.18 £
Sundry Debtors	175,564	189,454

8. CREDITORS: AMOUNTS FALLING DUE WITHIN ONE YEAR

	31.12.19 £	31.12.18 £
Trade creditors	19,734	27,945
Subscriptions in advance	21,604	17,240
	41,338	45,185

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

9. MOVEMENT IN FUNDS

	At 1.1.19 £	Net movement in funds £	At 31.12.19 £
Unrestricted funds			
General fund	728,871	54,481	783,352
Sylvester-Bradley	21,073	(3,465)	17,608
Jones-Fenleigh	27,503	873	28,376
Hodson	294	1	295
Callomon	3,368	(935)	2,433
Whittington	12,974	2,849	15,823
Stan Wood	66,960	(883)	66,077
TOTAL FUNDS	861,043	52,921	913,964

Net movement in funds included in the above are as follows:

	Incoming resources £	Resources expended £	Gains and losses £	Movement in funds £
Unrestricted funds				
General fund	441,144	(481,541)	94,878	54,481
Sylvester-Bradley	836	(4,301)	—	(3,465)
Jones-Fenleigh	873	—	—	873
Hodson	1	—	—	1
Callomon	365	(1,300)	—	(935)
Whittington	4,349	(1,500)	—	2,849
Stan Wood	2,154	(3,037)	—	(883)
TOTAL FUNDS	449,722	(491,679)	94,878	52.921

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

9. MOVEMENT IN FUNDS — *continued*…

Comparatives for movement in funds:

	At 1.1.18 £	Net movement in funds £	At 31.12.18 £
Unrestricted Funds			
General fund	776,624	(47,753)	728,871
Sylvester-Bradley	26,394	(5,321)	21,073
Jones-Fenleigh	27,713	(210)	27,503
Hodson	1,719	(1,425)	294
Callomon	4,519	(1,151)	3,368
Whittington	13,974	(1,000)	12,974
Stan Wood	66,699	261	66,960
TOTAL FUNDS	917,642	(56,599)	861,043

Comparative net movement in funds included in the above are as follows:

	Incoming resources £	Resources expended £	Gains and losses £	Movement in funds £
Unrestricted funds				
General fund	439,541	(460,257)	(27,037)	(47,753)
Sylvester-Bradley	652	(5,973)	—	(5,321)
Jones-Fenleigh	1,370	(1,580)	—	(210)
Hodson	1	(1,426)	—	(1,425)
Callomon	349	(1,500)	—	(1,151)
Whittington	500	(1,500)	—	(1,000)
Stan Wood	1,758	(1,497)	—	261
TOTAL FUNDS	444,171	(473,733)	(27,037)	(56,599)

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

9. MOVEMENT IN FUNDS — *continued*…

A current year 12 months and prior year 12 months combined position is as follows:

	At 1.1.18 £	Net movement in funds £	At 31.12.19 £
Unrestricted funds			
General fund	776,624	6,728	783,352
Sylvester-Bradley	26,394	(8,786)	17,608
Jones-Fenleigh	27,713	663	28,376
Hodson	1,719	(1,424)	295
Callomon	4,519	(2,086)	2,433
Whittington	13,974	1,849	15,823
Stan Wood	66,699	(622)	66,077
TOTAL FUNDS	917,642	(3,678)	913,964

A current year 12 months and prior year 12 months combined net movement in funds included in the above are as follows:

	Incoming resources £	Resources expended £	Gains and losses £	Movement in funds £
Unrestricted funds				
General fund	880,685	(941,798)	67,841	6,728
Sylvester-Bradley	1,488	(10,274)	—	(8,786)
Jones-Fenleigh	2,243	(1,580)	—	663
Hodson	2	(1,426)	—	(1,424)
Callomon	714	(2,800)	—	(2,086)
Whittington	4,849	(3,000)	—	1,849
Stan Wood	3,912	(4,534)	—	(622)
TOTAL FUNDS	893,893	(965,412)	67,841	(3,678)

THE PALAEONTOLOGICAL ASSOCIATION

Notes to the Financial Statements – *continued* for the Year Ended 31 December 2019

10. RELATED PARTY DISCLOSURES

There were no related party transactions for the year ended 31 December 2019.

11. INVESTMENT GAINS AND LOSSES

All gains and losses are taken to the Statement of Financial Activities as they arise. Realized gains and losses on investments are calculated as the difference between sales proceeds and their opening carrying value or their purchase value if acquired subsequent to the first day of the financial year.

Unrealized gains and losses are calculated as the difference between the fair value at the year end and their carrying value. Realized and unrealized investment gains and losses are combined in the Statement of Financial Activities.

Investment Gains/Losses	31st December 2019	31st December 2018
	£	£
Realized Gain/(Loss)	2,803	(518)
Unrealized Gain/(Loss)	92,075	(26,519)
Total per Statement of Financial Activities	94,878	(27,037)

12. INVESTMENT PORTFOLIO 2019

See pages 24–25.

13. POST BALANCE SHEET EVENTS

Since 31st December 2019, the pandemic related to COVID-19 has impacted the Association's investments and its activities during 2020. As at 31st March 2020, the fair value of the Association's fixed asset investments had reduced to £587,902 (a reduction of £101,095 (15 %)) compared to the year ended 31st December 2019.

The ongoing extent of the COVID-19 outbreak and its impact on the Stock Market remains unclear at this time, although positive signs have been seen in two of the charity's investment funds (COIF) where a 9 % loss in value for the first quarter of 2020 had regained its 31st December 2019 valuation level by early June 2020. Due to the continued uncertainty, these subsequent changes in the fair value of the Association's fixed asset investments and impact on the Association's activities are therefore not reflected in the financial statements as at 31st December 2019.

The Trustees are monitoring the situation and are taking account of the pandemic in making decisions that impact the Association's financial health including, but not limited to, expenditure on conferences which may be cancelled due to travel restrictions and replacement of the Association's flagship Annual Meeting with a virtual event.

Detailed Statement of Financial Activities for the Year Ended 31 December 2019

	31.12.19 Unrestricted funds £	31.12.18 Total funds £
INCOME AND ENDOWMENTS		
Donations and legacies		
Donations	8,140	7,462
Subscriptions	53,431	55,090
	61,571	62,552
Investment income		
Deposit account interest	274	99
Investment Income	14,469	14,526
	14,743	14,625
Charitable activities		
Scientific Journals	309,605	314,201
Special Papers	573	828
Newsletter	80	243
Field Guides	9,129	2,944
Distribution	720	242
Scientific Meetings	53,301	48,536
	373,408	366,994
Total incoming resources	**449,722**	**444,171**
EXPENDITURE		
Raising donations and legacies		
Administration	32,759	35,481
Investment management costs		
Stockbroker Fees	3,700	4,199
Charitable activities		
Scientific Journals	67,050	56,630
Field Guides	25,622	—
Newsletters	18,990	18,265
Marketing	297	632
Publication Costs	82,544	81,825
Editorial Costs	45,317	37,980
Public Meetings & Costs	73,364	72,542
Grants & Awards	37,534	53,772
Research Grants	27,960	12,094
Administration	51,479	55,756
Consultancy	2,800	17,609
	432,957	407,105
Support costs		
Governance costs		
Trustees' expenses	12,308	16,810
Accountancy and legal fees	595	595
Administration	9,360	9,543
	22,263	26,948
Total resources expended	**491,679**	**473,733**
Net income before gains and losses	**(41,957)**	**(29,562)**
Realized recognized gains and losses		
Realized gains/(losses) on fixed asset investments	94,878	(27,037)
Net income	**52,921**	**(56,599)**

This page does not form part of the statutory financial statements.

Palaeontological Association year ended 31st December 2019.

Nominal	Holding	Cost (bought pre 2019) £	Value end 2018 £
£10,000	UK 4.5% Gilt 07/03/19 GBP 0.01	10,046.50	10,210.00
£18,000	UK 4.75% Stock 07/03/20 GBP 100	18,145.87	19,112.00
49,685.81	COIF Charities Fixed Interest Fund	65,807.52	66,246.09
9,730.085	M&G Securities Limited Optimal Income J GBP Dis		
7,500	Royal London Unit Trust Mngrs Sterling Credit Z GBP NAV		
700	Pimco Global Advisors Irl Ltd Global Inv Grade Cred		
1,425	BP Ord 25c shares	5,047.35	7,067.00
600	Royal Dutch Shell B shares	4,422.42	14,040.00
600	BHP Billiton $0.5 shares	4,341.48	9,910.00
180	CRH ord EUR 0.32	4,426.82	3,728.00
1,400	Smith(DS) ord GBP 0.10	4,569.69	4,190.00
370	Halma ord GBP 0.10	3,871.71	5,046.80
130	Halma ord GBP 0.10	1,360.33	1,773.20
437	IMI Ord 25p shares	4,267.00	4,125.00
350	Experian Ord 10C	2,870.79	6,667.50
70	Experian Ord 10C	574.16	1,333.50
200	Diageo Ord GBP 0.28	3,884.00	5,590.00
100	Diageo Ord GBP 0.28	1,942.00	2,795.00
200	Persimmon Ord 10p	2,258.00	3,860.00
70	Reckitt Benckiser Group ord GBP 0.10	5,325.75	4,209.00
150	Unilever PLC Ord GBP 0.031111	2,163.11	6,163.00
150	Unilever PLC Ord GBP 0.031111	2,163.11	6,163.00
120	Astrazeneca Ord 25c	5,749.41	7,047.53
50	Astrazeneca Ord 25c	2,395.59	2,936.47
450	Glaxo Smithkline Ordinary 25p shares	7,083.98	6,710.00
2,500	Tesco ord GBP0.05		
300	Relx Olc GBP 0.1444	4,438.20	4,850.00
300	Compass Group Plc ord GBP0.1105		
175	Carnival Plc Ord USD 1.66	3,996.49	6,585.00
1,000	BT Group Ordinary 5p shares	3,446.05	2,381.00
2,277	Vodaphone Group Ord USD 0.11428571	3,434.00	3,482.00
641	National Grid Ord GBP 0.12431289	3,648.26	4,899.00
2,250	Barclays 25p Ord shares	4,867.00	3,387.00
1,465	HSBC Holdings Ordinary 0.5 US Dollar shares	4,534.00	9,477.00
982	Great Portland Estates Ord GBP0.15263157894	8,503.00	6,472.00
6,000	Mercantile Investment Tst Plc(The) ord GBP0.025	10,171.60	10,530.00
300	Findlay Park Partners US Smaller Companies	4,347.16	25,315.76
125	Findlay Park Partners US Smaller Companies	1,811.31	10,548.24
2,525	Ishares S&P 500 GBP	18,161.79	49,354.14
300	Ishares S&P 500 GBP	2,157.84	5,863.86
4250	Fidelity EUR Value Ordinary 25P shares	4,059.07	8,798.00
30	Roche Hldgs Ag Genusscheine Nvp	3,335.33	5,829.00
6,600	Thesis Unit Trust Mngmt Ltd TM Crux European GBP Dis	7,140.00	12,699.00
9,000	Baillie Gifford & Co Japanese Income Growth W4 Dis	11,977.02	11,052.00
1,007	Eastspring Investments SICAV Japan Dynamic FGDY GBP	7,837.74	8,854.00
26	Veritas Funds Plc Veritas Asian D GBP Inc	8,182.27	14,924.00
900	JPMorgan Am UK Ltd Emerging Markets I Instl	5,043.10	7,313.00
650	RIT Capital Partners Ordinary £1 shares	4,903.90	12,415.00
800	BH Global Ltd ord GBP	10,226.25	11,860.00
4,400	Invesco Fund Managers Targeted Y Acc	9,770.33	9,538.00
37	Marshall Wace UCITS Funds Plc MW Tops UCITS G GBP	4,849.70	4,990.00
4,443	Aberdeen Investment Property Trust B	4,681.00	5,386.00
9,000	Charities Property Fund Income	11,043.28	11,711.00
1,021.54	COIF Charities Investment Fund Acc Units	59,678.69	158,032.03
	Total	388,960.96	625,469.12

Schedule of Investments (Note 12 to the Accounts).

Proceeds (sold in 2019) £	Cost (bought in 2019) £	Gain realised during 2019 £	Value end 2019 £	Gain unrealised during 2019 £
10,000.00		-210.00		
			18,403.00	-709.00
			68,342.83	2,096.74
	10,060.08		10,130.00	69.92
	10,474.20		10,680.00	205.80
	9,620.07		9,828.00	207.93
			6,720.00	-347.00
			13,473.00	-567.00
			10,661.00	751.00
			5,476.00	1,748.00
			5,379.00	1,189.00
			7,829.00	2,782.20
2,145.25		372.05		
4,191.66		66.66		
			8,932.00	2,264.50
1,412.43		78.93		
			6,401.00	811.00
3,082.56		287.56		
			5,390.00	1,530.00
			4,290.00	81.00
			6,526.00	363.00
6,465.16		302.16		
			9,128.00	2,080.47
3,192.65		256.18		
			8,006.00	1,296.00
	5,953.09		6,380.00	426.91
			5,717.00	867.00
	5,399.53		5,670.00	270.47
6,332.31		-252.69		
2,034.57		-346.43		
2,846.11		-635.89		
			6,053.00	1,154.00
			4,042.00	655.00
			8,671.00	-806.00
7,250.71		778.71		
			15,720.00	5,190.00
			31,034.00	5,718.24
11,628.82		1,080.58		
			61,414.00	12,059.86
7,005.08		1,141.22		
			11,050.00	2,252.00
			7,345.00	1,516.00
			14,993.00	2,294.00
			12,519.00	1,467.00
			10,056.00	1,202.00
			18,585.00	3,661.00
			9,351.00	2,038.00
			13,748.00	1,333.00
			12,140.00	280.00
			9,860.00	322.00
			5,223.00	233.00
5,269.33		-116.67		
			11,592.00	-119.00
			192,239.12	34,207.09
72,856.64	41,506.97	2,802.38	688,996.95	92,075.12

Nominations for Council

At the AGM in December 2020, the following vacancies will occur on Council:

- Vice President
- Treasurer
- Chair of the Editorial Board
- Editor Trustee
- Newsletter Editor
- Book Review Editor
- Education Officer
- Meetings Coordinator
- Diversity Officer
- Ordinary Members (up to two vacancies) *

* These positions are dependent on Council members currently holding these posts moving to other Council posts.

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. Each nomination must be accompanied by the candidate's written agreement to stand for election, and a short personal statement (less than 200 words) describing their interests.

All potential Council Members are asked to consider the following:

> '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'.

Further information on the responsibilities of Trustees can be obtained by e-mailing <**secretary@palass.org**>.

The closing date for nominations is **1st September 2020**. They should be sent to the Secretary, Dr Crispin Little, in PDF format via e-mail: <**secretary@palass.org**>.

Council vacancies: 'job descriptions':

Vice-President (two-year term)

The Vice-President is one of the more loosely defined Council offices. Vice-Presidents are normally long-serving Council members who have previously held one of the other offices. They have no formal portfolio or duties other than to deputize for the President if and when required, but are present on Council to provide independent input on all matters, backed up by experience arising from their long service. They are also expected to lead or at least participate in important sub-committees, particularly those tasked with making recommendations for the awards of grants.

Treasurer (five-year term)

The Treasurer's main role is to oversee the financial management of the Association, providing an independent sounding board for financial matters and being the link between the Executive Officer and the Trustees on finance. The Executive Officer manages the day-to-day financial aspects of the Association (*e.g.* processing payments, collecting annual membership and conference fees, producing the annual accounts *etc.*), although the Treasurer is a cheque signatory and is called on to countersign larger payments. The Treasurer attends annual meetings with our investment managers, is a member of the Public Engagement Group, and regularly contributes to committees considering grant applications.

Editor Trustee (three-year term; for final year becomes Chair of the Editorial Board)

The Editor Trustees are on the Editorial Board of *Palaeontology* and *Papers in Palaeontology* and also serve on the PalAss Council. Their role is: to advise the Chair of the Editorial Board about policy issues that might arise in the running of the journals; to attend the annual review meeting with the publisher, Wiley; to advise the Chair about the suitability for peer-review of articles submitted to *Palaeontology* and *Papers in Palaeontology*; to select the article to be awarded Best Paper in each journal annually; and to hold a watching brief with respect to the management and well-being of the journals and inform Council of issues arising.

Chair of the Editorial Board (one-year term for most senior Editor Trustee)

The Chair of the Editorial Board:

- oversees the production of the Association's publications and provides vision and leadership for their future development, acts as line manager for the Publications Officer, and sets priorities and goals for the journals.
- selects and invites members onto the Editorial Board to ensure diversity balance, geographical coverage and disciplinary representation are achieved.
- vets the quality of papers being accepted for publication in *Palaeontology* and *Papers in Palaeontology*, acts as a member of the Editorial Board in the preliminary sift of all papers submitted, assigns papers of suitable quality to a science editor, and writes rejection letters to the rest.
- vets the recommendations made by the Editorial Board with respect to whether papers are fit and ready for publication in light of referees' reports received, and makes final decisions.
- firefights any issues arising from the publication process (*e.g.* disgruntled authors, referees or readers).

Newsletter Editor (three-year term)

Editing the *Palaeontology Newsletter* is an intensive role three times a year with relatively little in between apart from collating some content and attending Council meetings. The main responsibilities are approaching people and commissioning content, ensuring that permission for all reproduced images and content has been sourced, editing all content in the *Palaeontology* style, and reminding contributors of deadlines as necessary. The Newsletter Editor may volunteer to sit on one or more of the Association sub-committees to review grants and awards.

Book Review Editor (three-year term)

The main duty of the Book Review Editor is to provide a range of new and recently-published scientific book titles for members to review. Books available span all areas of palaeontological and evolutionary research and, as such, it is necessary to establish and maintain contact with a broad range of publishers, search for new titles and request review copies from publishers. For each *Palaeontology Newsletter*, a list of recently-acquired titles is prepared and, as requests come in from members to review the books, each copy must be sent to the prospective reviewer. Reviews recently received from members must be edited in time for each *Newsletter* deadline. It is often necessary to remind reviewers when their text is required so records must be kept monitoring movement of books and receipt of reviews. The Book Review Editor may volunteer to sit on one or more of the Association sub-committees to review grants and awards.

Education Officer (three-year term)

Together the Publicity Officer, Outreach Officer and Education Officer comprise the Public Engagement Group (PEG). These posts have responsibility for all the Palaeontological Association outreach activities. Currently they include organizing the Association's presence at Lyme Regis Fossil Festival and the Yorkshire Fossil Festival, coordinating the Engagement Grants, answering relevant enquiries, and initiating other activities that promote and develop palaeontological outreach and education for the Association. The members of PEG work closely together and their roles often overlap, but responsibilities specifically associated with the Education Officer post include leading the Association's educational activities, for example delivering dedicated activities at schools' days associated with fossil festivals and communication with ESTA. Members of PEG also work closely with the Diversity Group. The Education Officer may volunteer to sit on one or more of the Association sub-committees to review grants and awards.

Meetings Coordinator (three-year term)

The Meetings Coordinator ensures the Palaeontological Association is present at most of the major international meetings in the wider Earth Sciences domain, mainly by soliciting and/or organizing symposia that are hosted or sponsored by the Association, and via other initiatives. The Meetings Coordinator interacts with the Annual Meeting organizers regarding the topic of the symposium at the Annual Meeting, and with other conveners of Palaeontological Association-sponsored symposia to avoid overlaps and enhance the visibility of a wide range of palaeontological topics. The Meetings Coordinator also is responsible for the evaluation of applications to and the administration of the Association's Postgraduate Travel Fund. The Meetings Coordinator may volunteer to sit on one or more of the Association sub-committees to review grants and awards.

Diversity Officer (three-year term)

The Diversity Officer leads the Diversity Group in developing strategies to support and promote diversity in the Palaeontological Association and broader palaeontology community. The Diversity Officer should aim to identify issues and barriers that arise for under-represented groups and work with the Diversity Group on trying to provide solutions. The Officer will also liaise with the Public Engagement Group (PEG) with the aim of promoting palaeontology as a diverse and welcoming scientific community to a wider audience. The Officer should also promote the code of conduct and facilitate efforts to ensure it is being upheld at Palaeontological Association sponsored events. The Diversity Officer may volunteer to sit on one or more of the Association sub-committees to review grants and awards.

Ordinary Members (three-year terms)

Ordinary Members do not have a formal portfolio. They attend Council meetings and contribute to discussion, decision-making and future planning. They often participate in important sub-committees, such as those tasked with reviewing and making decisions upon grant applications.

Awards and Prizes

The Palaeontological Association recognizes excellence in our profession by the award of medals and other prizes. The Association sees its lists of medals and award winners as a record of the very best palaeontologists worldwide, at different career stages, and offering different kinds of contributions to the field. The Association stresses the importance of nominations and encourages all members to make nominations. Members considering making nominations should first read the Palaeontological Association 'Statement of Diversity' below.

Statement of Diversity

The Palaeontological Association has an Unconscious Bias document (available on the Association website), the recommendations of which will be adhered to at all times. All decision-making for Palaeontological Association awards and prizes will be carried out objectively and professionally. The Association is committed to making award and prize decisions purely on the basis of the merit of the individual(s). No nominee for awards or prizes will receive less favourable treatment on the grounds of: gender, marital status, sexual orientation, gender re-assignment, race, colour, nationality, ethnicity or national origins, religion or similar philosophical belief, spent criminal conviction, age or disability. Equally, all nominations will be assessed on equal terms, regardless of the sex, age and/or ethnicity of the nominee. Nominations will therefore be assessed and graded on their merits, in accordance with the criteria and the aims and objectives set for each award or medal. Due consideration will be given to any period away from science due to parental leave, illness and any other such career break. Nominators are reminded that neutral language (*e.g.* gender neutral) should be used in all nominations.

Palaeontological Association Awards/Medals selection procedures

The Palaeontological Association Council discusses Awards and Medals at the May Council meeting and votes to select awardees. The benefit of using Council to select awardees, rather than a dedicated awards committee, is that it draws on the wider experience of the entire Council. Voting is preceded by an introduction from the President that: (i) includes a diversity statement to remind Council of their responsibility in terms of fairness and diversity issues (including impact of non-standard careers *etc.*); (ii) outlines the remit and selection criteria for each award; and (iii) considers the impact of awardees in terms of increasing the diversity of recipients. Each award is considered in turn with every application considered except those that clearly fall outside of the remit. Each Council Member will vote by listing their three preferred candidates for each award in rank order. The candidate with the most votes as preferred candidate will be awarded the award/medal. If there are only two candidates and they are tied the President shall have the casting vote. If there are three or more candidates and there is a tie the vote will be recounted including the second

ranked candidate for all of the votes. If the vote remains a draw after second and third ranked candidates are considered the President will cast the deciding vote.

Lapworth Medal

The Lapworth Medal is the most prestigious honour bestowed by the Association to a palaeontologist who has made a highly significant contribution to the science of palaeontology by means of a substantial body of research and service to the scientific community. It is not normally awarded on the basis of a few good papers, but Council will look for breadth as well as depth in the contributions in choosing suitable candidates.

The candidate must be nominated by two members of the Association (proposer and seconder; names and contact details required). The nomination must consist of: (i) a two-page career summary (font-size 12); and (ii) a list of ten papers that demonstrate significance and breadth of research. The two-page career summary should outline the significant contribution to the science in terms of research and also other activities such as outreach, teaching, mentoring and administration (including that relevant to palaeontology at their home institutions, scientific societies and at higher levels, such as funding bodies and government advisory panels). We are looking for evidence of both depth and breadth in research with clearly identified achievements and breakthroughs. Relevant honours and awards may be mentioned. If a candidate has taken time out from their professional career for family or other purposes this should be highlighted. Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the Association website by the deadline.

The award will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to decide not to make an award in any particular year.

Nominations are invited by **31st March** each year.

President's Medal

The President's Medal is a mid-career award given by Council to a palaeontologist who has had between 15 and 25 years of full-time experience after their PhD (excluding periods of parental or other leave, but not excluding periods spent working in industry) in recognition of outstanding contributions to his/her earlier career, coupled with an expectation that they will continue to contribute significantly to the subject in their further work.

The candidate must be nominated by two members of the Association (proposer and seconder; names and contacts details required). The nomination must consist of: (i) a statement of when the PhD was awarded; (ii) a two-page career summary (font-size 12); and (iii) a list of ten papers that demonstrate significance and breadth of research. The two-page career summary should outline the significant contribution to the science in terms of research and also other activities such as outreach, teaching, mentoring and administration. We are looking for evidence of significance of research with clearly identified achievements and breakthroughs. If a candidate has taken time out

from their professional career for family of other purposes this should be highlighted. Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the Association website by the deadline.

The award will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to decide not to make an award in any particular year.

Nominations are invited by **31st March** each year.

Hodson Award

The Hodson Award is conferred on a palaeontologist who has had no more than ten years of full-time experience after their PhD (excluding periods of parental or other leave, but not excluding periods spent working in industry) and who has made a notable contribution to the science.

The candidate must be nominated by two members of the Association (proposer and seconder; names and contacts details required). The nomination must consist of: (i) a statement of when the PhD was awarded; (ii) a two-page career summary (font-size 12); and (iii) a list of ten papers that demonstrate significance and breadth of research. The two-page career summary should provide evidence of outstanding contribution in career so far. If a candidate has taken time out from their professional career for family or other purposes this should be highlighted. Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the Association website by the deadline.

Nominations will be considered by Council at its May meeting and awardees will be invited to a ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to decide not to make an award in any particular year.

Nominations are invited by **31st March** each year.

Mary Anning Award

The Mary Anning award is open to all those who are not professionally employed in 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 recognized journals.

The candidate must be nominated by two members of the Association (proposer and seconder; names and contacts details required). The nomination must consist of: (i) a statement confirming that the nominee is NOT professionally employed in palaeontology; and (ii) a one-page career summary (font-size 12). The one-page career summary should outline the nominee's contribution to palaeontology. This should include details of the sorts of activities pertaining to development of fossil collections, curation, care and maintenance of fossil collections, publications relating to these fossil collections, and evidence for outreach activities associated with these fossil collections. Nominations must be compiled into a PDF file of less than 10 MB and uploaded to the Association website by the deadline.

Nominations will be considered by Council at its May meeting. Awardees will be invited to a ceremony at the Annual Meeting in December, although the award may be presented at another time and place on request of the awardee. Awards will be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to decide not to make an award in any particular year.

Nominations are invited by **31st March** each year.

Gertrude Elles Award

The Gertrude Elles Award is to promote high-quality public engagement in the field of palaeontology. The award is made by Council for high-quality, amateur or institutional, public engagement projects that promote the discipline. Nominated projects can include museum displays and exhibitions, outreach programmes to schools and/or communities, art/science collaborations, digital initiatives, or any other programme that falls broadly under the heading of public engagement with palaeontology.

Nominations must consist of a one-page supporting case (font-size 12) and a portfolio of up to four images. The supporting case must outline:

- the aims of the project
- the nature of the target audience
- the available budget and funding sources
- visitor/audience members
- the results of project evaluation to demonstrate the quality and effectiveness of the project
- links to any digital components
- mechanisms for obtaining feedback

Self-nominations are permitted, and the nominators (names and contact details required) and proposed recipients do not need to be members of the Association. Nominations will be considered relative to the scale of the institution and the available project budget. The supporting case and the portfolio of images must be compiled into a PDF file of less than 10 MB and uploaded to the Association website by the deadline.

The award will be considered by Council at its May meeting and winners will be invited to the award ceremony at the Annual Meeting in December. Awards will also be announced in the *Newsletter*, on the Association website and through social media. Council reserves the right to decide not to make an award in any particular year.

Nominations are invited by **31st March** each year.

Honorary Life Membership

Honorary Life Membership recognizes individuals whom Council deems to have been significant benefactors and/or supporters of the Association. Recipients will receive free membership for life.

The candidate must be nominated by two members of the Association (proposer and seconder; names and contact details required). The nomination must consist of a one-page statement (font-

size 12) outlining nature of support for the Palaeontological Association. This should be uploaded to the Association website by the deadline.

The award will be considered by Council at its May meeting and announced at the AGM. The award will also be announced in the *Newsletter*, on the Association website and through social media.

Nominations are invited by **31st March** each year.

Annual Meeting President's Prize and Council Poster Prize

These prizes are awarded for the best talk and best poster at the Annual Meeting. All student members of the Palaeontological Association, and all members of the Association who are early-career researchers within one year of the award of a higher degree (PhD or MSc), excluding periods of parental or other leave, are eligible for consideration for these awards. Individuals may nominate themselves for consideration when submitting abstracts for the meeting. Each prize is announced immediately after the oral sessions at the end of the Annual Meeting.

Best Paper Awards

The aim of this award is to recognize papers published in either *Palaeontology* or *Papers in Palaeontology* and reward excellence in our field of science. The selection criteria are as follows: scientific breadth and impact; novelty of approach; and quality of writing and illustration. The awards are open to all authors irrespective of age and nationality; membership of the Association is not required. Frontiers reviews, rapid communications and regular research articles are all eligible. The selection procedure is that a list of all papers published in the year will be drawn up in October (when papers for the final part are allocated) and circulated around the science editors. The science editors are asked to nominate any papers that stand out, providing 2–3 sentences explaining their choices. The Chair of the Editorial Board will then draw up a shortlist of no more than five papers with supporting statements to circulate to the Editorial Board. The Editorial Board will then select winners by vote. Corresponding authors of winning papers will be offered 'Gold open access' paid for by the Association for one nominated paper submitted to *Palaeontology/Papers in Palaeontology* within the following 18 months (and subsequently accepted). In the case of joint authorship papers, the corresponding author can, by agreement, transfer the prize to one of the co-authors. The Chair of the Editorial Board will contact the winning authors and write short synopses for the *Newsletter*. An announcement of the awards will also be made at the AGM.

Undergraduate Prize Scheme

The Undergraduate Prize Scheme annually invites all university departments where a palaeontology course or module is taught after the first year as part of a degree programme to recommend one of their undergraduate students to receive this award. The award consists of a certificate and free membership of the Association for the rest of the year in question, plus the following calendar year. It provides electronic access to both of our journals, postal copies of the *Newsletter*, and all the other advantages of membership. Receipt of the award also looks good on a recipient's CV.

Departments may use any criterion for selection, though most prefer to use the scheme as an acknowledgement of best performance in a relevant exam or project. Only one nomination will be accepted from any one institution in each calendar year. The nominee must be an undergraduate student, not a postgraduate, when they are selected. Normally the award is made to a student in their penultimate year of study, but a final year candidate may be chosen if this is deemed more appropriate for the department in question.

Contact <**executive@palass.org**> with the nomination (name and e-mail address) and we will arrange to sign up the student as a member and send them a certificate. There is no deadline for this award.

Innovations in Palaeontology Lecture Series and the PalAss Exceptional Lecturer

The Innovations in Palaeontology Lecture Series, to be given by the **PalAss Exceptional Lecturer**, aims to promote palaeontology to the wider academic community and to recognize excellence in research among palaeontologists. The PalAss Exceptional Lecturer is selected in a competitive process. This scheme aims to:

- improve the dissemination of cutting-edge palaeontological research to the broader academic community;
- raise the profile of palaeontology within the Earth sciences and related fields;
- recognize outstanding research and science communication in palaeontology among members of the Association.

Format of the scheme:

- One PalAss Exceptional Lecturer will be selected each year in a competitive process.
- The PalAss Exceptional Lecturer will be expected to give five lectures at five different institutions over a nine-month period.
- The successful applicant will receive the Innovations in Palaeontology Lecture Series Grant, which will be administered by the home institution of the PalAss Exceptional Lecturer.
- The Innovations in Palaeontology Lecture Series Grant may only be used to pay the reasonable travel costs incurred by the PalAss Exceptional Lecturer to visit each of the host institutions (up to £2,000 for the total Innovations in Palaeontology Lecture Series with a maximum of £500 for any individual lecture). The host institutions will cover costs for accommodation (where necessary) and hospitality.
- Any academic institution (universities and/or museums) from any country can apply to participate in the Innovations in Palaeontology Lecture Series as a host institution.
- Any unused funds must be returned to PalAss after delivery of the final lecture. Should the PalAss Exceptional Lecturer move institutions within the timeframe of the lecture series, any unspent funds must remain available to the PalAss Exceptional Lecturer.
- Applications to be a PalAss Exceptional Lecturer will be strengthened if the applicant agrees to submit a paper as a review article for possible publication in *Palaeontology*.

Eligibility and selection process of the PalAss Exceptional Lecturer:

- Eligible candidates will have a PhD in palaeontology or a related field.
- Applicants can reside in any country, but must be members of the Association.
- Candidates must self-nominate.
- To self-nominate, a two-page CV, full list of publications, and statement of motivation (max. 300 words) must be submitted via the Association's webpage as a single PDF format file (max. 8 MB). In addition, a 60 second video summary (in MP4 format; max. size 30 MB) of a proposed seminar topic must be submitted via the Association's webpage.
- The PalAss Exceptional Lecturer will be chosen based on the career track record, including research impact (relative to their career stage) and oratorical skills.

Selection of host institutions:

- Institutions interested in participating in the Innovations in Palaeontology Lecture Series should apply via the PalAss webpage and suggest a timeframe within which the lecture should be given.
- The PalAss Exceptional Lecturer will receive the list of potential host institutions after the 1st May deadline, and will choose their preferred hosts and liaise directly with them. Applications after the 1st if May will be considered depending on the remaining availability.

Expectations for host institutions:

- Each lecture must be widely advertised across the host institution. We particularly encourage advertisement of the Innovations in Palaeontology Lecture Series on social media.
- Host institutions are expected to pay for hospitality and offer a meal in a social environment to the PalAss Exceptional Lecturer.
- If the PalAss Exceptional Lecturer has to travel more than three hours to the host institution or cannot return home at a reasonable time, the host institution must offer at least one night of accommodation.

Deadlines each year:

- 1st September: Deadline for nominations for the PalAss Exceptional Lecturer.
- December: The PalAss Exceptional Lecturer will be announced at the Annual Meeting.
- March: The call for host institutions to participate in the Innovations in Palaeontology Lecture Series will be published in the *Newsletter*.
- 1st May: Deadline for applications from host institutions.
- September – May: delivery of lectures.

GRANTS

Palaeontological Association grants are offered to encourage research, education and outreach through different means. Undergraduates, early-career researchers, and otherwise unfunded persons are given special encouragement to apply. All of these awards and grants are core to the charitable aims of the Palaeontological Association. A full list of the Association's grants may be found on the Association's website (<**www.palass.org**>). Those with deadlines in the next six months are detailed below.

Grants-in-aid: meetings, workshops and short courses

The Association is happy to receive applications for grants from the organizers of scientific meetings, workshops and short courses that lie conformably with its charitable purpose, which is to promote research in palaeontology and its allied sciences. The Association will consider applications up to £2,000. Application must be made in good time (at least nine months before the start of the event) by the scientific organizer(s) of the meeting using the online application form. Such requests will be considered by Council at the May and October Council Meetings each year. 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/workshop/short course literature and other media. Enquiries may be made to the Secretary (e-mail <**secretary@palass.org**>).

Applications should be made through online submission via the appropriate page on the Association's website, for which you will need the following information:

- Title of meeting / workshop / short course
- Date and Place proposed
- Name, position and affiliation of the organizer(s)
- Brief description (not more than ten lines) of the rationale behind the meetin / workshop / short course
- Anticipated number of attendees
- Amount requested (also whether the request is for a loan or a grant)
- Other sources of funding applied for
- Specific use to which requested funds will be put

Note: If funds are requested to support one or more keynote speakers, then full details of their names, affiliations and titles of presentations should be included. The application will be strengthened if the keynote speaker agrees to submit their paper as a review article for possible publication in *Palaeontology*.

The deadlines are **1st March** and **1st September** each year.

Engagement Grants

Awards are made to encourage educational outreach, public engagement, and related initiatives in palaeontological themes. Normally, the budget for an individual grant would be less than £5,000 GBP. However, under exceptional circumstances, a budget of up to £8,000 GBP for an individual application will be considered. Grants can support either stand-alone complete projects, or they can be 'proof of concept' case studies that have their own outcomes but that form the groundwork for a larger bid elsewhere.

Applications for salary costs are permitted, providing a full justification is given, but if awarded all legal and financial liability will lie with the applicant (see 'Categories of expenditure for which the Palaeontological Association does not provide support' on the Association website).

Proposals must fit with the charitable aims of the Association.

Preference is given to applications for a single purpose (rather than top-ups of grants for existing projects). We particularly encourage applications with an innovative aspect, such as engaging with new media, and especially cases that will disseminate good practice.

The principal applicant must be a member of the Association. Preference will normally be given to candidates who have not previously won an award.

Proposals will be ranked on the following criteria:

- Fit to the charitable aims of the Association
- Imaginative quality, innovation, and likely spread and impact of the proposal
- Feasibility, value for money and cost effectiveness
- Track record of the investigator in engagement and education initiatives

At the end of the award period a final report (including receipted accounts) will be submitted for review by the Trustees or, where appropriate, external referees. Appropriate parts of the final report will be published in the Association *Newsletter*. Any publicity associated with the activity must mention the support of the Association.

For more information please e-mail the Association's Outreach Officer at <**outreach@palass.org**>.

The application deadline is **1st September** and funds will normally be available from 1st November each year. In rare cases where rapid access to funds is critical, applications submitted outside the normal deadlines may be considered. The awards will be announced at the Annual General Meeting.

Small Grants Scheme

The Association offers multiple awards each year, in honour of four donors, to fund palaeontological research, travel and fieldwork; these are integrated together under the Small Grants Scheme. These grants are open to any member of the Association, although preference is given to students, early-career researchers, and members of the Association who are retired.

Sylvester-Bradley Awards: Multiple awards of up to £1,500 each, for palaeontological research.

Callomon Award: An award of up to £1,500 for a project which is normally field-based.

Whittington Award: An award of up to £1,500 for a project which is normally based on museum collections.

Stan Wood Award: An award of up to £1,500 for projects in vertebrate palaeontology, and ideally involving fieldwork and fossil collecting.

There is one application form and Council will decide on the allocation of the awards based upon the nature of the project made in the application.

Applications should be made through online submission via the appropriate page on the Association's website, and will comprise:

- An account of project aims and objectives, and expected outcomes
- A breakdown and justification of the proposed expenditure
- A curriculum vitae
- Two references: one reviewing the project, and one personal reference for the applicant
- A summary suitable for the non-specialist, which will be published in the *Newsletter* when an award is made

Successful applicants will be required to produce a final project report that will be published in the *Newsletter*, and are asked to consider the Association's meetings and publications as media for conveying the research results.

Further details and a full list of terms and conditions for the Small Grants Scheme can be found on the appropriate page of the Association's website. Enquiries may be made to the Secretary (e-mail <**secretary@palass.org**>).

The deadline is **1st November** each year. The awards will be announced at the AGM, and funds will normally be available from 1st January.

Undergraduate Research Bursaries

The Palaeontological Association Undergraduate Research Bursaries are aimed at giving undergraduate students the opportunity to acquire research skills and experience that will significantly transform their academic career. The bursaries will support projects co-designed by students and their supervisor(s) that give students registered for an undergraduate degree their first experience of undertaking a palaeontological research project. The bursaries provide a stipend for the student of £305 per week for up to eight weeks. The scheme is not intended to fund students to undertake routine work for the supervisor(s) and the Association expects the supervisor(s) to provide significant personal mentoring of successful student applicants.

Applications should be made by the principal supervisor through online submission via the appropriate page on the Association's website, and will include:

- Details of the principal supervisor making the application, and other members of the supervisory team

- Details and academic track record of the named student
- An account of the project aims, methods and expected outcomes
- A project plan including details of supervision
- Ethics statement
- A referee statement in support of the named student

After completion of the work, successful **students** are required to produce a short report of the findings suitable for publication in the *Newsletter*. This report should be submitted by e-mail to <**palass@palass.org**> within eight weeks of the stated end date of the project. Successful candidates are requested to prioritize the Association's meetings and publications as media for conveying the research results.

Further details, including eligibility criteria for supervisors and students, and a full list of terms and conditions for the Undergraduate Research Bursaries scheme, can be found on the appropriate page of the Association's website. Enquiries may be made to the Secretary (<**secretary@palass.org**>).

The deadline is **1st February** each year. Successful applicants will be notified by the end of March and funds will normally be available from 1st June. A full list of awards will be announced at the Annual General Meeting.

news

A letter from the President concerning the Association's response to COVID-19

Dear Palaeontological Association membership,

We are witnessing unprecedented times due to the COVID-19 pandemic and this has of course impacted the Palaeontological Association. I am writing to explain these impacts and how we are addressing them.

Firstly, I am very pleased to announce that Council continues to function efficiently and is communicating through a variety of electronic media. On Wednesday 6th May we held our first remote Council meeting. This was a great success and business was conducted unhindered and in a similar fashion to our usual 'physical' meetings in London. Thus, much of the Association's business that can carry on at present will carry on. Organizing our communication strategy was no small task and I would like to thank those facilitating it: Internet Officer (Russell Garwood), Executive Officer (Jo Hellawell) and Secretary (Cris Little) in particular.

At the Council meeting we were able to continue with the business of Council such as making decisions on grant applications, voting for awards and medals, continuing current projects (*e.g.* updating the Constitution) and the vital work of our sub-committees: the Public Engagement Group and Diversity Group. My thanks to the entire Council for making this happen.

Our publications team encountered some problems on initially entering lockdown that largely emanated from large-scale issues affecting our publishing company Wiley. The team worked tirelessly to resolve these problems and I am delighted to say that publications continue unimpeded. On 20th May we held a virtual meeting with Wiley that was very encouraging. My sincere thanks to our Publications Officer (Sally Thomas), Chair of the Editorial Board (Barry Lomax) and the entire Editorial Board for their tireless work. Likewise, thanks to our Newsletter Editor (Graeme Lloyd) for his hard work that ensured the production of this *Newsletter*.

Travel restrictions have been a particularly troublesome consequence of the pandemic. Very early on the decision was taken to run our *Progressive Palaeontology* conference as a virtual meeting. Bethany Allen and her team did an amazing job of reorganizing the meeting accordingly. I am delighted to say that interest in the conference did not wane following this format change. Indeed, we had more delegates register than attended the meeting last year. Bethany and her team must be applauded for this fantastic effort organizing *Progressive Palaeontology*, which was held from 11th to 13th June, and was a huge success. Thanks must again also go to our 'internet team' (Russell Garwood and Alan Spencer) who have liaised closely with Bethany to ensure that we had the technology to run such a large virtual conference.

At the May Council meeting we also made the regrettable decision that our Annual Meeting in December will have to be run as a virtual meeting. Rob Sansom has agreed that the Manchester

Annual Meeting will be postponed to December 2021 and subsequent meetings will also step back a year: Cork (2022) and Cambridge (2023). This was not an easy decision to make, but was one that could not be delayed further due to time and financial constraints regarding organization. However, I think it is a wise decision considering present uncertainty. We will closely monitor *Progressive Palaeontology* and other virtual scientific meetings around the world and take the best from them to ensure that our first virtual Annual Meeting will be a great success. The meeting will run from 16th to 18th December 2020. Please put these dates in your diary, as I hope you will all 'attend' and enjoy our first Virtual Annual Meeting. There are, of course, ramifications for not having a physical meeting. For example, we have had to re-think the way in which we will run our AGM. But we do know that this will be held virtually on Thursday 17th December. More details will follow.

We are now actively searching for a team to organize the 'Virtual PalAss Annual Meeting 2020'. We anticipate that the conference will be led by an individual who will gather an organizing committee that will take responsibility for organizing and running the conference. More details of this role are provided in the advertisement directly following this section (*page 48*).

At present global finance has taken a large hit and is relatively unstable. Our Treasurer (Paul Winrow) and Executive Officer (Jo Hellawell) have been closely monitoring the Association finances. They reported back to Council at the May meeting that our financial situation remains good, with our investment managers carefully handling our portfolio and making some agile and sound financial decisions. On 22nd May the three of us held a virtual meeting with the investment managers that was reassuring and where we also confirmed that we will move our portfolio into their Global Income and Growth Fund for Charities. My thanks to Paul and Jo for keeping a very close eye on our financial health.

In terms of our members, we recognize that this time period will have affected people in different and disproportionate ways, and that this may have longer term consequences for individuals' welfare and careers. Going forward we aim to identify ways of mitigating the effects of the pandemic in our grant and award evaluation procedures and in providing better support to our diverse membership.

In these turbulent times I hope I have brought some clarity regarding Association operations, and even some good news concerning our ability to carry on. Please stay safe – and I hope the Association, through its various activities, will continue to feed your palaeontological curiosity and facilitate our palaeontological research – though I too look forward to the day when we can get back into the field, visit collections and meet up with colleagues at conferences.

Charles Wellman
President

Palaeontology in the news

The faintest whiff of a new spin on aquatic dinosaurs never fails to excite the media, as well as the wider dinosaur fandom. While mid-20th century notions of sauropods and other large dinosaurs as water beasts have been soundly discredited (with one or two vocal dissenters – discussed in previous articles), new evidence that advances the argument for aquatic behaviour always raises interest. And, of course, there is nothing in palaeontology that grabs the attention of the media more than a big theropod story. The combination of the two in the latest study on *Spinosaurus* has re-energized the aquatic dinosaur circus.

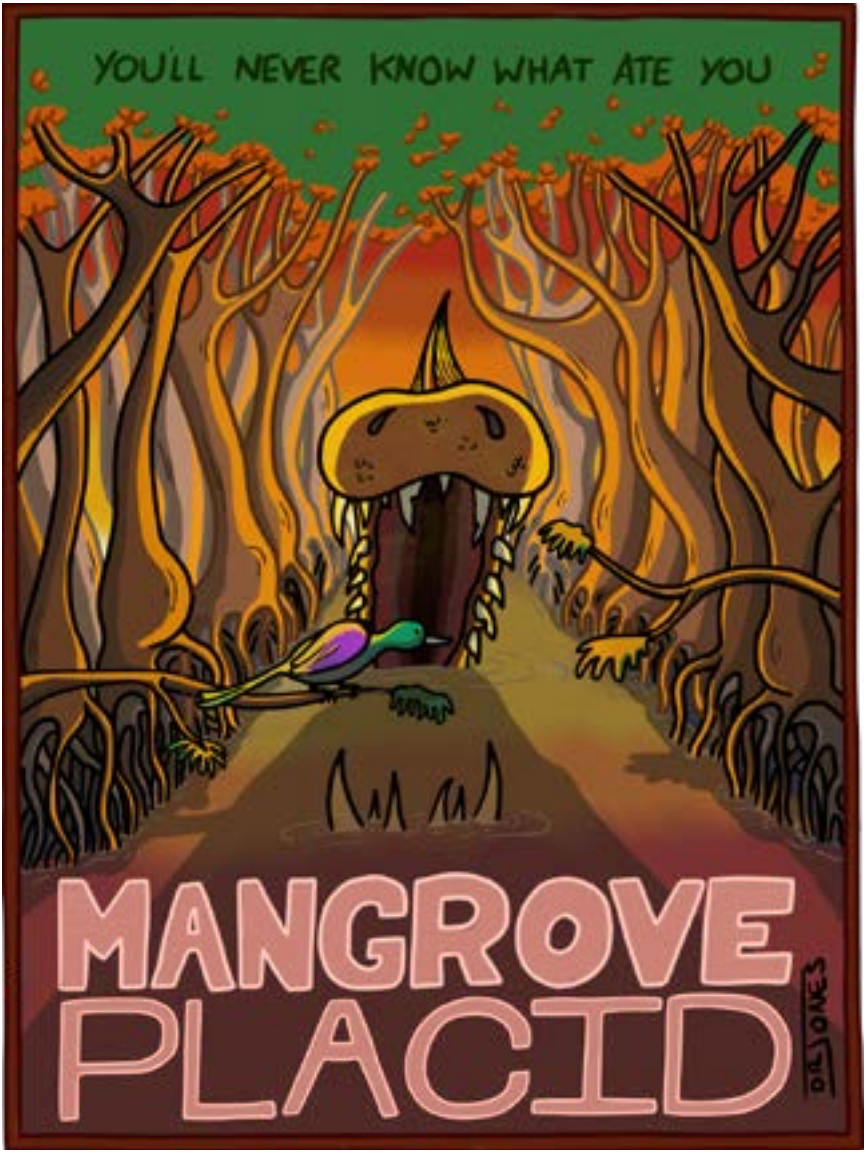
A new paper, published in *Nature* on 29th April 2020 by Nizar Ibrahim (University of Detroit Mercy) and colleagues, presented "unambiguous evidence for an aquatic propulsive structure in a dinosaur", based on a nearly complete, partially articulated tail collected from the Late Cretaceous Kem Kem beds of south-eastern Morocco. *Spinosaurus aegyptiacus* had a tall, reinforced tail built for swimming. Just picture it: a huge, predatory theropod swimming like a newt. Experimental work using a flow-tank demonstrated that the tail would produce similar propulsion (and with similar efficiency) to modern aquatic animals, backing up the interpretations based on morphology alone.

Spinosaurus already had a colourful back-story. The original specimen was discovered in the Cenomanian Bahariya Formation in western Egypt in 1912, by Richard Markgraf, a former Cairo hotel pianist turned fossil collector. He was working for German palaeontologist Ernst Stromer, who published his description based on this specimen in 1915. This holotype was then destroyed by the British bombing of Munich in 1944. More material was subsequently described from the mid-nineties onwards, from Algeria, Tunisia and Morocco, giving a more rounded picture of *Spinosaurus* anatomy and its palaeobiology.

Controversy over the degree to which *Spinosaurus* was aquatic is not new, however. The crocodile-like skull, with well-spaced, conical teeth, was already widely interpreted as that of a piscivore, and isotope analysis of its teeth suggested a semi-aquatic lifestyle. Ibrahim had already published a paper with colleagues in 2014, establishing a subadult specimen from the Moroccan Kem Kem beds as the neotype. This paper described a scaled-down pelvic girdle and diminutive hind-limbs which, in combination with an elongate trunk and long neck, made a semi-aquatic interpretation more sensible. The new 2020 paper stated that the tail described was found in close association with, and belongs to, this neotype specimen.

There had previously been some push-back against the 2014 semi-aquatic interpretation, with a modelling paper by Donald Henderson in 2018 suggesting that *Spinosaurus's* buoyancy would be an issue for an aquatic hunter, and that its centre of gravity would be much closer to the hips, and therefore much more in keeping with firmly terrestrial theropods, than was proposed by Ibrahim and colleagues in 2014.

Spinosaurus also has a well-established reputation in popular culture, as the one dinosaur that could beat *Tyrannosaurus* in a fight. This plot line in Jurassic Park III depicted *Spinosaurus* as a typical Hollywood theropod – albeit one with a fancy sail – which swiftly despatched the *Tyrannosaurus* that had been harassing the puny humans. There is also a gripping scene where *Spinosaurus* attacks a boat, so associations between *Spinosaurus* and water were already firmly established in the dinosaur fan world, if not backed up by any actual anatomical features in the movie.



<http://www.ratbotcomics.com/>

My guess is that the debate about the aquatic hypothesis for *Spinosaurus* still has plenty of life left in it within the media, because the one thing people love is a whopping great Cretaceous killing machine, especially one with novelty value. There was, however, one thing that I found quite interesting about media coverage when the story broke. *Nature* published two palaeontology papers that day. The other one, by David Krause (Denver Museum of Nature and Science) and colleagues, described *Adalatherium hui*, a Late Cretaceous animal that is almost (but not quite) a mammal, from Madagascar. Described as the most complete specimen of a Gondwanan Mesozoic mammaliaform, this hefty Mesozoic beast tells a tale of 20 million years of insular evolution on Madagascar. The embargo on both *Nature* papers lifted at 4pm on 29th April and Twitter went into a *Spinosaurus* frenzy. But the PM programme on BBC Radio 4, that bastion of establishment news coverage in the UK, ran that evening with a piece on the mammaliaform story instead. Somewhere out there, there's a news editor who knows that it's not all about the dinosaurs…

Susannah Lydon
Publicity Officer

A year as the Palaeontological Association Exceptional Lecturer

The Innovations in Palaeontology Lecture Series was introduced for the first time in 2019 to promote palaeontology to the wider academic community and to recognize excellence in research among palaeontologists. This lecture series is delivered by the Palaeontological Association Exceptional Lecturer and I was honoured to have been selected as the inaugural Exceptional Lecturer for this scheme.

Photo courtesy of Stephan Lautenschlager.

In my application, I had proposed to present my work on using digital visualization and analysis techniques to study the function and behaviour of fossil organisms and to reconstruct "lost worlds". My initial fear that no-one actually wanted to hear me talk about digital dinosaurs, and that I would end up with maybe one invitation, was unfounded. I was invited to speak at six different institutions and two more visits may have been possible, had the coronavirus outbreak not thrown a spanner in the works.

I started the lecture series in September 2019 at the Naturhistoriska Riksmuseet, the Swedish Museum of Natural History, in Stockholm. The audience consisted of a mix of researchers, museum curators and students from different disciplines across palaeontology, Earth sciences, biology and zoology and the lecture was well-received. My second stop at the Oxford University Museum of Natural History had a very different audience. Tied in with the Oxford Science and Ideas Festival, the lecture on how to digitally reconstruct the brain anatomy of dinosaurs and other extinct

animals had attracted a good number of interested amateurs and members of the public of all ages. Following the lecture, I was presented with a range of excellent questions – especially from younger members of the audience (aged between 5 and 15). I had to answer questions on whether dinosaur brains showed indications for seasonal migration, about the sensory capabilities of the infamous *Tyrannosaurus rex* and how accurately fossil animals can be reconstructed using computer technology. Clearly a set of challenging and critical questions that could have come from an academic audience.

Further visits to the University of Cambridge, the University of Plymouth and University College Cork followed. Here, audiences were again mostly composed of academics and I was pleasantly surprised to see chemists, engineers and geophysicists among the audience who used similar analytical methods but for different research applications and who shared their knowledge and experience with me. The lecture series concluded with two public talks at the Geological Society in London in February 2020 as part of the Society's Year of Life lectures.

Overall, the first Innovations in Palaeontology Lecture Series was a great success. Approximately 600 people from all backgrounds and across all ages have attended the lectures and the responses were positive and encouraging throughout. The lectures and the subsequent questions and conversation resulted in a lot of interesting discussions and a few new research collaborations have been made.

I would like to thank the Palaeontological Association for providing this opportunity and heartfelt thanks to the hosts and host institutions who looked after me during my visits. I hope the Innovations in Palaeontology Lecture Series and the Palaeontological Association Exceptional Lecturer become an integral part of the Association's awards scheme and I am looking forward to all the exciting topics this series will bring in the future.

Stephan Lautenschlager
University of Birmingham

Jean Baptiste Lamarck Medal of the EGU

The 2020 Jean Baptiste Lamarck Medal of the European Geosciences Union (EGU) has been awarded to former PalAss President Prof. Mike Benton FRS in recognition of his outstanding contributions to vertebrate palaeontology, to palaeobiology and to macroevolution across times of extreme environmental change. The medal was established by EGU's Stratigraphy, Sedimentology and Palaeontology Division in recognition of the scientific achievements of Jean Baptiste Lamarck and is awarded each year to scientists who have made an exceptional contribution, alternating between the three subdivisions. Mike began his career with studies on the evolution of reptiles in the Palaeozoic and Mesozoic, and was interested in answering fundamental questions about the evolution of life and how environmental changes impacted evolution. Mike has since published

Image © The Royal Society.

fundamental contributions on phylogeny and on co-evolution of life and the environment, with a focus on specific time intervals of rapid climate change at the Permian–Triassic transition. He is a creative researcher and a motivating university teacher; his textbook *Vertebrate Palaeontology* has been extremely successful, now published in its fourth edition, and a second edition of his *Introduction to Paleobiology and the Fossil Record*, co-authored with another past PalAss President Dave Harper, has recently been released. Mike has also written books for the general public, including books on dinosaurs for children, communicating our science to a wider audience. Mike will receive the medal in person at EGU in 2021.

Emily Rayfield
University of Bristol

GeolSoc medals and awards for palaeontologists

Palaeontologists were recipients of the 2020 medals and awards from the Geological Society in March. Four individuals are being honoured for their contributions to the geosciences and the geoscience profession. Prof. Rachel Wood (University of Edinburgh) has been awarded the Lyell Medal in recognition of her significant contribution to the science by means of a substantial body of research. The mid-career Bigsby Medal was awarded to Prof. Bridget Wade (University College London), as recognition of her eminent services to geology. The early-career Lyell Fund was awarded to Dr Thomas Wong Hearing (University of Ghent) and the Murchison Fund to Dr Alexander Dunhill (University of Leeds), both for their noteworthy published research. The winners usually receive their awards at our President's Day in June, which has been postponed to a later date due to the coronavirus pandemic.

Alicia Newton
The Geological Society of London

Mentoring scheme: update

The Palaeontological Association has established a mentoring scheme to assist palaeontologists throughout their academic careers. We identified priority areas and in the first instance focused on the transition from postdoctoral to permanent job. We are now expanding the scheme to include PhD students, and mid-career to senior leadership role will be considered later.

The Palaeontological Association mentoring scheme operates through direct mentoring, via e-mail, telephone or video calls, or other forms of communication. Twenty-three palaeontologists in permanent positions are currently acting as mentors and, so far, ten postdoctoral palaeontologists have taken part in the scheme. Recently, feedback was sought from all mentors and mentees about the scheme and this was largely very positive.

If you are a PhD student or postdoctoral palaeontologist and are interested in having a mentor or a palaeontologist in a permanent position who would be willing to act as mentor, please e-mail me (<**vicepresident1@palass.org**>) for more information.

Fiona Gill
Vice President

Mentoring scheme: case study

I first heard about the PalAss mentoring scheme while I was finishing my PhD, and I signed up almost as soon as I finished my viva. At the time, I was moving abroad for my first postdoc, and was in a bit of limbo when it came to academic advice – I was leaving my supervisory team at Leicester and joining a new one in Cork, so it felt hard to know where to go for advice. The scheme seemed like a really sensible idea – get paired with a senior academic who has considerable experience. Someone who you can talk to and ask for career advice. What's not to like? After enquiring about joining the scheme, I was really impressed by the list of academics who had volunteered their time to help out fledgling early-career researchers. From senior professors to newly tenured staff, of varying ages and nationalities, the list made it very difficult to choose just one person to contact!

After reaching out, Richard Butler (University of Birmingham), agreed to become my mentor through the scheme. We had met a few times before, and it was important to me to have a mentor outside of my area of research. I sent him my CV and we had a preliminary Skype conversation and talked about what we both expected from the scheme. We agreed to chat around once a month or so when convenient, often via Skype or e-mail, to catch up unless I had a particular question, where I would fire off a quick e-mail. This has been so invaluable to me – I've approached Richard about grant writing, how to deal with tricky work issues, best practice for cover letters, whether or not certain jobs were right for my career progression and so many other things. The scheme allows a relationship with someone impartial, who is not academically 'related' to you, so you can hear perspectives you might not normally hear. I value that very highly. So far, his advice has been very balanced, rational and productive – it helps that Richard is a very conscientious, kind and patient person, giving up his time to help me navigate along the academic career path.

I would highly recommend signing up to the Palaeontological Association mentoring scheme. It is often invaluable to have that connection with another academic, who has been through the perilous journey that all early-career researchers have to make. I value Richard's advice greatly and wouldn't have had that opportunity without this scheme.

Thomas Clements
University of Birmingham

ASSOCIATION MEETINGS

64th Annual Meeting of the Palaeontological Association
Online *16 – 18 December 2020*

Volunteer to organize Virtual PalAss 2020

Due to the coronavirus pandemic the 2020 Palaeontological Association Annual Meeting will be run as a virtual conference. We are seeking an individual willing to take on responsibility for the main coordination of the meeting. We anticipate that this person will reflect on the very best of recent virtual meetings to bring an innovative Virtual PalAss 2020 that fulfils the aspects of our normal Annual Meeting and also brings new ways to explore and discuss the science of palaeontology.

We are also seeking other volunteers to take on supporting roles. We envisage the following organization and support network:

1) A volunteer will take charge of the meeting (they will help to decide on the format and mode of IT necessary to deliver this). The Association will remunerate this individual. Ideally he or she will have palaeontological experience (*e.g.* someone between postdocs/jobs) and have experience of organizing a virtual conference;

2) It is anticipated that the organizer will be backed up by a team of volunteers from the Association membership who will help out with scientific administration (such as abstract selection *etc.*);

3) The Association will employ an external events management company to deal with the logistics of the virtual setup that is decided upon.

Anyone interested in this role should contact the Association Secretary Dr Crispin Little before **31st July 2020** with an expression of interest, briefly outlining their experience and suggested plans for the conference. For informal discussion please feel free to contact President (Prof. Charles Wellman), Secretary (Dr Crispin Little) or Executive Officer (Dr Jo Hellawell).

Logo
For our virtual Annual Meeting it seemed appropriate that the logo should feature a virtual fossil. The image is taken from 3D computer simulations associated with a paper in *Palaeontology* by Jorge Esteve and colleagues on modelling enrolment in Cambrian trilobites. This image from the model of an enrolled *Bailiaspis ? glabrata* is used with their permission and the logo was designed by Russell Garwood.

Code of Conduct for Palaeontological Association Meetings

The Palaeontological Association was founded in 1957 and has become one of the world's leading learned societies in this field. The Association is a registered charity that promotes the study of palaeontology and its allied sciences through publication of original research and field guides, sponsorship of meetings and field excursions, provision of web resources and information, and a programme of annual awards.

The Palaeontological Association holds regular meetings and events throughout the year. The two flagship meetings are the Annual Meeting held at a different location each December, and the annual Progressive Palaeontology meeting, run by students for students with the support of the Palaeontological Association. The Association Code of Conduct relates to the behaviour of all participants and attendees at annual events.

Behavioural expectations

It is the expectation of the Palaeontological Association that meeting attendees behave in a courteous, collegial and respectful fashion to each other, volunteers, exhibitors and meeting facility staff. Attendees should respect common sense rules for professional and personal interactions, public behaviour (including behaviour in public electronic communications), common courtesy, respect for private property and respect for intellectual property of presenters. Demeaning, abusive, discriminatory, harassing, or threatening behaviour towards other attendees or towards meeting volunteers, exhibitors or facilities staff and security will not be tolerated, either in personal or electronic interactions.

Digital images and social media

Do not photograph a poster or record a talk without the author's express permission. While the default assumption is to allow open discussion of presentations on social media, attendees are expected to respect any request by an author to not disseminate the contents of their talk or poster.

From our Correspondents

A Palaeontologist Abroad

Highlighting early career researchers who have taken posts outside their home country and the opportunities they used. This issue's palaeontologists are Yara Haridy, Christina Shears-Ozeki and Camilla Souto.

Yara Haridy is an Egyptian/Canadian in Berlin, Germany, studying as a PhD student at the Museum für Naturkunde on a Deutsche Forschungemeinshaft grant.

Photo by Pablo Castagnola.

Q1: How did you end up in Germany?
I put it out into the palaeo-sphere through conferences and networking that I was interested in the evolution of hard tissues and biomineralization. So, when my current supervisor was advertising a PhD position on bone evolution I was quickly notified. The topic interested me, and he previously worked with methods I was familiar with and others that I wanted to learn so it was a perfect next step! I usually say for a PhD there is a 'choice triangle' with the following criteria at each angle: 1) person you want to work with, 2) topic you want to work on, and 3) place you want to live. This was a rare trifecta where I was happy with all three, so it was a no brainer and I moved to Germany!

Q2: How is your position funded?
My position is fully funded by a grant that my supervisor applied for under the DFG, the main German funding agency. It is incredibly comfortable to live on, this is due to the low costs of living in Berlin and the generous amount of both salary and travel funding. I would also like to add that in the COVID-19 crisis the DFG made it known early on that there would be opportunity to extend funding to everyone, not just those who are in their last year of funding. This kind of clarity from the DFG early on helped to reduce anxiety, and shows empathy from funders which can be a rare thing.

Q3: What is your project about?
My project is about the evolution of bone! Sounds very general, I know, but I am focusing on tissue and cells through deep time. This means looking at everything from early jawless vertebrates to modern mammals and specifically looking at osteocytes (bone cells) to see what kind of changes occur through evolution and through changes in the environment, for example the water to land transition. Traditionally this has been done through palaeohistology, however because we wanted to look at each cell in more detail, we basically had to find a novel type of

imaging that can go down to the cellular level. All I can say for now is keep your eyes open for some new technology and new insights into really old bone!

Q4: What surprised you most about living in Germany?
I'll start with the good, and end with the real. Berlin is beautiful in the summer; I could walk around forever – it is full of food, art, culture and creative people, almost anything within the city is accessible by cheap public transport (a fevered dream in North America). In general, the atmosphere around work life balance is much more relaxed than in North America, and resources like grants for equipment or APCs are plentiful. The collections are amazing, and I am a sucker for old fossil labels, things you rarely find in North America.

I've so far lived in six different countries, mostly in the Middle East, but also Canada and I have been lucky to travel all my life. So, I am no stranger to cultural differences and the difficulties with moving continents, this contributed to my hubris when moving abroad. So, when I say I was shocked by the difficulties and cultural differences I really mean it. I moved to Germany at the tail end of the Syrian refugee crisis, this made everything from paperwork to general public attitudes difficult. Examples include: when applying for apartments, I was told that my last name could be flagged since it is an Arabic name, if I spoke Arabic in public like on the phone with my family I was stared at, so I stopped and switched to English for everyone's comfort. The staring is constant and something like out of a Black Mirror episode, at first it was funny, then it was exhausting. Incidents ranged from comments from people walking by to a time I was attacked on a bus – those who weren't part of it just turned away. I have never ever experienced such apathy. I was lucky enough that my supervisor and his family were incredibly supportive and helpful, but I couldn't imagine getting this far without them.

Q5: Apart from friends and family what do you miss most about Canada?
Smiling strangers, a messy pile of poutine and a decent winter!

Yara (excessively) tweets at @Yara_Haridy and blogs at <**http://www.thebarebones.org**>.

Christina Shears-Ozeki is a Briton in Japan studying the bone modification of fossil marine vertebrates, including the Mesozoic marine reptiles of Japan. She is a palaeontology PhD student in the Historical Geoscience of the Biosphere study group of Kyoto University's Department of Geology and Mineralogy.

Q1: How did you end up in Japan?
My Japanese husband and I had originally planned to move to Japan after I completed a PhD in the UK. But in 2017, a few months before I was due to graduate from my Master of Research at the University of Portsmouth, UK, we found out his elderly parents were sick. Subsequently, we brought our plans forward and moved here in May 2018, along with our five cats.

Image courtesy of Christina Shears-Ozeki.

Q2: How is your position funded?
I am a self-funded student, which means I need to keep finding ways to fund my doctorate, such as scholarships and awards. Unfortunately, since I am a mature student and many scholarships and awards in Japan have younger maximum age limits, I am ineligible for most funding. Additionally, any funding or scholarships that I am eligible to apply for are often extremely competitive. Recently I was extremely lucky to win the departmental tuition fee scholarship that will cover my fees for this year. Alongside this, in December 2019 I was granted a Stan Wood Award from the Palaeontological Association to undertake fieldwork on the south coast of the UK, which will add an important international component to my research. Furthermore, I have also been organizing a research crowd-funding page to help with the continued expense of my research, but since everyone is experiencing financial difficulties due to the pandemic, I have not set this up yet.

The costs involved for studying as an international student at Kyoto University are approximately the same as self-funding a PhD in the UK. Current tuition fees are ¥566,000 per year (roughly £4,000 a year), subsequently it is approximately £12,000 for three years' study. Normally students would need to pay rent for either a university apartment, which is more like a small studio flat and is approximately ¥45,000 per month (£400 per month), or a privately rented apartment, which is costlier (approximately equivalent to £800–900 per month). Utility costs in Japan are normally cheaper than the UK and everyday food is also cheaper. But imported food items are more costly.

Q3: What is your project about?
Unlike my Masters project – that investigated various macro- and millimetre-sized trace marks (mostly borings) on dinosaur bone from terrestrial palaeoenvironments – my doctorate project is focused on analysing micromillimetre- to millimetre-sized ichnological features (again borings) observed on fossil 'deadfalls' found in marine environments. The project heavily relies on observing features in thin sections and stubs using optical and scanning electron microscopes, as well as CT and micro-CT scanners. Up to now, bioerosional features have been observed on some Mesozoic marine reptiles from Japan. In future I plan to incorporate the examination and comparison of other global fossil and modern specimens.

Q4: What surprised you most about living in Japan?
Since my husband is Japanese, I was already familiar with many cultural differences between Britain and Japan. However, I was surprised at how expensive fruit is in Japan, which is very disappointing since I used to eat fruit daily. Another aspect I am not accustomed to here are the earthquakes.

Q5: Apart from friends and family what do you miss most about the UK?
Japan has many things from other countries or its own version, so most of the time I don't miss anything from UK. Nevertheless, occasionally I used to like drinking a stout/porter, but it is difficult to find those here and they are quite expensive when I do, but at least it keeps me healthy!

The only other things I miss are crusty loaves of bread and proper flaky croissants, they are a little too soft here.

Christina sometimes tweets as PalaeOzeki (a.k.a. 'Boring girl') at @CSOzeki and has started a KOFI page (<**https://ko-fi.com/cozeki10**>), but her crowdfunding page is not active yet.

Camilla Souto is a Brazilian in the USA, employed as a postdoctoral researcher at the Smithsonian National Museum of Natural History (NMNH) on a Peter Buck Deep Time Fellowship.

Image courtesy of Camilla Souto.

Q1: How did you end up in the United States?
My Masters project was on a rare group of echinoderms, the cassiduloid echinoids, so I reached out to the echinoderm community (via <**echinoderm-l@googlegroups.com**>) for guidance. Rich Mooi from the California Academy of Sciences (CalAcademy) was very responsive and encouraged me to deepen my research on the group. Also I needed to examine fossil cassiduloids, and the CalAcademy and the University of California Museum of Paleontology (UCMP) at Berkeley had a lot of specimens. I then used my fellowship and airlines mileage (you could do a lot with them back then!) to go to San Francisco. After I finished my Masters, Charles Marshall, also an echinoderm enthusiast, agreed to be my mentor at the UC Berkeley PhD program. That extended my stay in the Bay Area until I graduated and was awarded a Peter Buck Deep Time Fellowship at the NMNH in Washington, DC. This two-year, palaeobiology-focused fellowship includes a research and an education and outreach component, and the application window typically opens in the spring.

Q2: How is your position funded?
International students do not have many fellowship opportunities in the US, so I worked as a teaching assistant during my PhD to cover my tuition, fees and living expenses. The two semesters that I did not teach were funded by the UCMP and by my supervisor. After graduating, I worked as a lecturer at UC Berkeley for two semesters and my current position at the NMNH is funded by the Peter Buck Foundation.

My research has also been funded by grants provided by The Systematics Association, various natural history museums and the UC Berkeley.

Q3: What is your project about?
I am interested in biodiversity discovery and macroevolution of marine invertebrates, especially morphological evolution, adaptation and palaeobiogeography. My main project is focused on the cassiduloids, a group of burrowing echinoids very closely related to the sand dollars. The order Cassiduloida originated in the Mesozoic and despite its successful initial trajectory, it has been declining throughout the Neogene; there are only about 35 living species, and most of these are endemic and rare. In addition to understanding the relationships within the Cassiduloida, I want to calibrate the timing of its diversity decline and test some of the proposed hypotheses for this demise.

Q4: What surprised you most about living in the United States?
I had never been to a desert until I went to Death Valley, California during a UCMP field-trip.

Tropical forests still rank top on my list, but I was astonished by desert beauty. I was also surprised by the nice weather in the San Francisco Bay Area. It rarely snows, it rarely gets too hot and there are no mosquitos! (True, the cold winds are not always pleasant, so never forget to take a jacket with you.)

Q5: Apart from friends and family what do you miss most about Brazil?
I miss the Brazilian way of life – the genuineness, the friendliness, the empathy, the sense of humour, the laid-back workplace.

Camilla tweets at @csout0 and further information about her research can be found at <**https://www.researchgate.net/profile/Camilla_Souto**>.

Legends of Rock

Florentino Ameghino
The father of Argentinian palaeontology

Florentino Ameghino was born on 19th September 1854. He came from a family of Italian immigrants who settled in 1854 in the town of Lujan, Buenos Aires, Argentina, where the extraction and exportation of fossils were a lucrative activity. The first well-known fossil from South America, *Megatherium americanum*, was recovered by Fray Manuel Torres here and later described by George Cuvier in 1796. Fossil collectors and museum commissioners visited the Lujan area pursuing the colossal fossil bones. Darwin himself described the small city in his famous notebook: "The houses at Luxan are all of one ground-floor, except that of the Cabildo, on the east side of the plaza, which has rooms above. They are all built with sun-burnt bricks, called adobes, not white-washed. The church is a small plain building, with a little turret, and a cupola top."

Portrait of Florentino Ameghino. Copyright-expired image from the collection of the Museo Nacional de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires.

Despite being a self-taught naturalist, Ameghino became an international authority in the field of palaeontology of vertebrates, geology and archaeology. He was portrayed by his biographers as the incarnation of materialism, leftist culture and national genius. Throughout his scientific career, Ameghino was seconded by his younger brother Carlos Ameghino (1865–1936), who was a 'travelling naturalist' for the Museo de La Plata. During his trips, he gathered a remarkable collection of fossil mammals, later described by Florentino.

Thanks to the financial support obtained by members of the Genovese community in Argentina, Ameghino travelled to Paris in 1878 and presented his archaeological and palaeontological collections at the Paris Anthropological Exhibition. He studied with various French experts, including Paul Gervais and Gabriel de Mortillet, and sold part of his collection to the North American palaeontologist Edward Drinker Cope. In 1879, he married Léontine Poirier. She became an important part of Ameghino's scientific career, helping him with his writings, their bookstore and hosting her husband's visitors in their home in La Plata. In 1880, Ameghino published *La antigüedad del Hombre en el Plata* (*Man's Antiquity in the La Plata Basin*). He and Léontine stayed in France until 1881.

In 1884, Ameghino published *Filogenia,* his most important theoretical work which evidenced that Ameghino was a true Darwinist. The book was shaped by Haeckel's reconstruction of the human ancestral tree, and Gabriel de Mortillet's ideas. A year later, Ameghino was appointed professor of zoology at Universidad de Córdoba, a position that he quit for the vice-directorship of the recently founded Museo de La Plata.

Between the 1880s and 1890s, Ameghino's descriptions revolutionized scientific opinion regarding primitive mammals. He began corresponding with Hermann von Ihering, a German scientist who had settled in São Paulo, Brazil. They both studied the Tertiary geological formations in South America and elaborated the idea that all mammals had originated in Patagonia and then moved to Africa through the continental bridges connecting the ancient continents. This partnership was internationally known as Ameghino, von Ihering and Co. At the time, Ameghino had already published his monograph *Contribución al conocimiento de los mamíferos fósiles de la República Argentina*. The work was praised by Karl von Zittel in his *History of Geology and Palaeontology* of 1899, who remarked that "the most important paleontological event of the last two decades of the nineteenth century has been the disclosure made by Florentino Ameghino of a rich mammalian fauna in the Tertiary rocks of Patagonia".

In 1887, Ameghino described a large, toothless jaw from the Miocene of the Province of Santa Cruz, naming it *Phorusrhacos longissimus* and assigning it to a new family of edentulous mammals. He used this finding as critical evidence for his contention that modern mammalian lineages originated in Argentina and later spread across the globe. At that time, Ameghino and Francisco P. Moreno, Director of the Museo de La Plata, were in the middle of a bitter dispute. The feud between the two men was in many aspects similar to the well-known feud between E. D. Cope and O. C. Marsh, which took place in the United States at roughly the same time. Four years later, Moreno and Alcides Mercerat recognized for the first time that the mandible described by Ameghino was really that of a bird.

Ameghino's sketch of the Phorusrhacos longissimus *holotype. Copyright-expired image.*

Ameghino resigned from his position at the Museo de La Plata in 1888, and Moreno denied him access to the palaeontological collection. From that moment, and until he became head of the Museo Argentino de Ciencias Naturales in Buenos Aires in 1902, the Ameghino brothers continued with their palaeontological exploration, without any permanent official support, but they managed to get the funds to run their palaeontological investigations as a private enterprise. Karl von Zittel subsidized their explorations, receiving in exchange fossils for the collection of Munich University. Meanwhile Moreno, in order to gain priority over his rivals, published a series of brief reports about the new palaeontological discoveries made by his field researchers.

In 1895, the critical financial situation forced Florentino Ameghino to sell his fossil bird collection, in order to support his further work in Patagonia. The collection was purchased by the British Museum (Natural History) in London for the sum of £350 in 1896. When Florentino became director of the Museo Nacional de Buenos Aires in 1902 the selling of fossils ceased, and he started making claims for the return of the Museum's collections. He also proposed that the most remarkable specimens of Patagonian and Pampean fossil faunas be cast and stored in Buenos Aires and La Plata museums to be used in Argentinean schools. The same casts were sent to Museums all over the world and in exchange, Ameghino received casts of the oldest fossil mammals from Africa and the Northern Hemisphere to compare with the Patagonian faunas. It was a clever way to prevent the sale of the original fossils.

Florencio Ameghino died on 6th August 1911. After his death, he became a national icon for his role in creating national science and culture. The Ameghino collection is still today the reference collection of the entire Cenozoic Era biostratigraphic system for the South American continent.

Florentino Ameghino in his archaeological deposit, 1902. Copyrght-expired image courtesy of the Archivo General de la Nación Argentina (Inventario 4738).

The Florentino Ameghino Partido, situated in the north-west of Buenos Aires Province, was named after him, as well as various educational institutions across the country, libraries and museums, squares, schools, parks and other locations. The Ameghino Crater, located to the north of the Sinus Successus on the Moon, is also named in his honour – a very rare privilege for a palaeontologist.

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Behind the Scenes at the Museum

Kronosaurus Korner

Kronosaurus Korner in 2020. Image © Michelle Johnston.

Kronosaurus Korner is Australia's premiere marine fossil museum. Located in Richmond, northwest Queensland, the region is primarily cattle and sheep grazing. It's hard to believe that this drought-ravaged Outback Queensland was covered by the shallow Eromanga Sea during the Early Cretaceous period (98–110 million years ago). Fossilized remains of creatures that lived in this sea – including marine reptiles, dinosaurs, pterosaurs, birds, fishes, crustaceans, cephalopods, gastropods, bivalves, echinoderms, plants and trace fossils – have been found in this region since the late 1800s.

Kronosaurus Korner was the vision of Rob Ievers, a local grazier, after two significant fossils were found in 1989 on his family property 'Marathon Station' whilst mustering sheep. The Richmond Polycotylid was found in 1989 only 800 metres from the homestead. Three months later, another specimen was found – *Kunbarrasaurus ieversi* (formerly *Minmi*), only three kilometres from the Polycotylid. These specimens of international significance were collected by the Queensland Museum.

These finds were the catalyst for the opening of the Richmond Marine Fossil Museum in September 1995, which would not have been possible without the efforts of countless local volunteers from the Richmond region. Incorporating a Visitor Information Centre, the Richmond Marine Fossil Museum showcased the fossils found by local graziers whilst mustering cattle or tending to their land. Economic sustainability through tourism gave further benefits to this cattle-grazing region. A growing collection and the need for additional space saw the opening of Stage 1 of Kronosaurus Korner in May 1999, with further expansions in June 2001 and May 2012.

The Rob Ievers Gallery, displaying the Richmond Polycotylid. Image © Kronosaurus Korner.

Today, three galleries exhibit many specimens often just as they have been found on local properties (stations) or the Museum's local fossil-hunting sites. Fossils are collected from the Richmond region, with donations by local residents, guests and volunteers safeguarding the local geological heritage. Collaboration with the Queensland Museum has facilitated the loan of the Richmond Polycotylid, housed in its own gallery.

Visitors to Kronosaurus Korner have access to audio guide handsets, or alternatively can access the Kronosaurus Korner app on their own device (launching late June 2020). Bonus app material includes accounts from those involved with the collection and research of the specimens on display.

Accessibility of palaeontology to the public is a priority for Kronosaurus Korner, particularly during the tourist season between Easter and October. Tours of the Museum are held regularly, in addition to a variety of field excursions accessible to the public, including children. Public dig programmes include Digging@Dawn and Mini Palaeo Adventures in which members of the public are encouraged to accompany the Curator into the field. Access to the local quarry is via a permit system, encouraging fossils to be brought back to Kronosaurus Korner for identification and donation to the collection if the find is of significance. A great deal of the collection at Kronosaurus Korner has been from public donations.

Mini Palaeo Adventure. Image © Michelle Johnston.

The primary function of the collection is scientific, with many visiting academics, students and volunteers contributing to the already published material. Kronosaurus Korner's Significance Assessment in 2016 acknowledged that many of the specimens housed in the collection are of State, National and International significance. This growing collection has necessitated further expansion which is 'shovel ready'. We eagerly await this next stage which provides additional gallery, collection and preparation laboratory space.

Kronosaurus Korner is part of the Australian Dinosaur Trail incorporating the towns of Richmond, Hughenden and Winton – all of which embrace the palaeoheritage of the region.

Michelle Johnston
Curator and Interpretive Manager

For more information, check out:

The Museum's website: <**https://www.kronosauruskorner.com.au/**>.

The Australian Dinosaur Trail: <**http://www.australiasdinosaurtrail.com/**>.

Outback Queensland: <**https://www.outbackqueensland.com.au/**>.

Sleeping beauty

It's always an apprehensive moment, when one revisits some favourite novel of one's younger days, to see whether the narrative can still fascinate – or whether the years of experience accreted since would now make it seem trite, or banal. Reading Albert Camus's *The Plague* in my student years made a deep impression on me, as a picture of how different *people*, and not just some idealized humanity, reacted to an implacable and deadly threat that turned the familiar course of life upside down. Re-reading it a little while ago – by coincidence, a little before the eruption of a new coronavirus into all our lives – I was just as impressed, despite finding that I had completely misremembered the ending[1]; it is still, for me, one of the books to make sure to salvage for that desert island. But revisiting – admittedly more for fun than illumination – Conan Doyle's *The Hound of the Baskervilles*, a favourite of my youth, was a disappointment. A touch laboured, I thought, and to hide the great detective away for most of the book, leaving poor Dr Watson to carry the increasingly strained plotline and trip over the McGuffins, seemed, on mature reflection, ill-considered as a Literary Device.

When one revisits tales from rather deeper times, it is not only one's reflexes that have moved on, but the story itself too. It is as if Tolstoy had re-done *War and Peace* and kept Natasha away from the ball, or Shakespeare had recast Richard III as the good guy[2]. So it was, when, a little while ago, I revisited the hyper-saga that is Snowball Earth, to catch up on the Cryogenian. It's a narrative that is now hard-wired into any first-year teaching course on Earth history, and if mine was anything to go by, there it tends to stay, year on year, ever more petrified by the calcifying drips of regular repetition. One skates on ice of ever more uncertain thickness, of course, but the ever-more-creaky plotline will always have to suffice until a smidgeon of time is found for a proper spring-clean.

Not that the original plotline lacked melodrama – or indeed that it is so very old. 'Snowball Earth' as a term was coined in 1992 by Joe Kirschvink in a short but (still) thought-provoking paper in a large book on the Precambrian, crystallizing – and undoubtedly dramatizing – the concept of a glaciation so great that it reached the equator. Kirschvink duly acknowledged the hard labour of the geologists such as Brian Harland, Michael Hambrey and others over several previous decades, who had chased ancient ice-lain strata across the world in fair weather and foul; and, he proposed the escape clause from an ice-bound world, via a buildup of volcanic carbon dioxide on a world no longer able to easily absorb that gas. Kirschvink also noted – a classy touch – that the Earth was lucky not to get so cold at the poles that carbon dioxide would freeze onto them as layers of dry ice, as it does on Mars, because that would have closed off that escape route, to leave a permanent ice-world.

In his short paper, though, Kirschvink did not mention the rather more cerebral contribution of the Russian climatologist Mikhail Budyko, for the planetary enforcer that he brought into the story, the albedo effect, would have added muscle to his argument. Make the ice-caps grow to about half-way down the Earth from the poles, Budyko said, and they will reflect so much light and heat that ice simply carries on growing, and will inevitably advance across the whole world

[1] Which of course I will not give away as a spoiler – not least for the next time of re-reading and mis-remembering.

[2] Which, according to Josephine Tey in *The Daughter of Time*, he should have done.

and stay there. Budyko's insights were used, though, by that eloquent champion of Snowball Earth, Paul Hoffman, as he took up the standard of this idea and argued passionately that the Earth really had, once upon a time, completely iced over.

A striking hypothesis, it inevitably attracted vigorous pushback, and the positions of the various battlefronts that emerged were neatly encapsulated by a couple of the protagonists, Ian Fairchild and Martin Kennedy in 2007, so neatly and with such scrupulousness to act as impartial observers, that this summary likely provided the 'go to' summary on this conundrum for one's students by many more than me. Lining up against the hard Snowball were a series of contenders: the 'zipper-rift' Earth, where the glaciers followed high mountains around the Earth as they grew and were eroded away; the 'high-tilt' Earth where the Earth's spin axis leaned over so far that ice formed more easily around the Equator and on the poles; and what seemed to many to be the sensible and safely conservative option, the 'Slushball Earth', where glaciation was widespread, for sure, but left large areas of sea still unfrozen. This last option seemed to help explain, too, how life survived such an extreme climatic event, as it clearly did – and might even have acted as some kind of catalyst for the complex multicellular life to arise as quickly as it did after the glaciations ended, to end the something like three-billion-year-long microbial-only realm that had preceded it.

And, as in any good detective story, mysteries swirled around the central plotline. How many times did the ice come and go? As many as four major phases had been suggested. Though these were settling into two, the earlier Sturtian phase and a later Marinoan one, there was much uncertainty as to how long they were, how great was the time gap between them and whether they started or ended at the same time or at different times around the Earth. And there are strange limestones, 'cap carbonates', that lie above the glacial strata, and clearly had something to do with the ending of glacial conditions – though were there more layers of these too, tangled in and around the ice-lain deposits? All in all, this was the kind of deeply satisfying whatdunnit that is ideal to point students towards, to help develop their critical acumen, or perhaps just deepen their despair that our planet might ever be understandable.

A decade-and-a-bit on, I finally (only three years late[3]) caught up with another review that sifted through the mountain of data that had accumulated subsequently, as teams of geologists across the globe tried to lift different parts of the veil that separates us from that other kind of planet, to commune with the soul of the Cryogenian. The review was headed by Paul Hoffman, but 26 co-authors, including *inter alia* Ian Fairchild of that scrupulously even-handed earlier review, help blunt suspicions that it is simply another stage of a personal crusade – or if so, the ranks of the crusade have palpably swelled (Hoffman *et al.* 2017). Anyway, it's a fascinating mixture of hard evidence and the numerically informed speculation of climate models, transmuting the earlier cartoon version(s) of Snowball Earth into something more like one of the more lovingly detailed anime films. It made the resulting mirage seem tantalizingly close to solidity.

First things first. There is a good deal of clearing up of basic uncertainties, such as whether the ice came and went at once or at different times in different places. Here the age-dating specialists have been hard at work, not in any practical sense with the few fossils to be found in these rocks (more on those anon) but with the tools of geochronology, notably those much tried-and-tested workhorses, zircon crystals in volcanic ash layers, for uranium dating. They

[3] *i.e.* more promptly than is usually the case.

seem to have shown convincingly that ice came and went twice, and, in at least three out of the four transitions, quickly and worldwide. Following 1.5 billion years of global ice-free conditions, Sturtian ice-sheets spread quickly from 717 million years ago – and stayed for 58 million years (plus or minus about a million years) – a glaciation which is almost as long as the whole of the present Cenozoic Era – before collapsing. The remaining area of uncertainty is quite when the next, Marinoan, phase of ice began – an annoying 10 million-year slop on the timing of that transition was reported, which means that the non-glacial interlude between Sturtian and Marinoan might be anything between 10 and 20 million years, while the Marinoan itself – its termination firmly pinned at 635 million years ago – might be as brief as 4 million years, or as long as 14. The geochronologists have doubtless been scouring the world for evidence to tighten that boundary (and for all I know might have succeeded by now) but that 'grossly unequal' as the authors put it, time relationship between the two glaciations will remain striking, whatever they find or have found.

What about fleshing out the detail of Snowball times? Here the burgeoning computer models of this world came into play. Budyko's scenario, it seems, is hard to avoid: if there is land ice at sea level at the equator, then sea ice should also spread relentlessly across the oceans to reach the equator. This sea ice, as pictured – as *modelled* – is not a few metres-thick surface crust, as still covers much of the Arctic and fringes Antarctica. Rather, it progressively builds up by deposition of frost and snow on its upper surface, and by freezing of seawater on to its lower surface, to form massive 'sea glaciers' hundreds of metres thick. As they flow, these fill remaining patches of open ocean as they advance equatorward.

The hard Snowball hence is, or more precisely was, apparently alive and well. But not immortal, not least as today the trees are flowering and the birds are singing and we are here to enjoy them. In that reaffirmed frozen world with its almost-stilled hydrological cycle, volcanically derived carbon dioxide did eventually build up, to levels suggested to be around 100 times those of today, enough to overcome the reflective brilliance of the ice-world to flip the world into a 'torrid greenhouse aftermath' where global temperatures may have reached 40–60 degrees Centigrade, so hence changing the average temperature of the globe by getting on for 100 degrees. This thermal shock could have melted the ice in two thousand years, they opined, fiercely acid rain in the renewed hydrological cycle reacting with bare rock and ground-up rock debris to flood the oceans with dissolved carbonate, to precipitate to the sea floor as the ice-terminating 'cap carbonate' layers. There are, the authors firmly state, just two – terminating the glaciations only, and at no other level – and there has been nothing like them in the half-billion years since. So their status as the unique *alter ego* of Snowball ice looks, like the ice itself, to have hardened.

These are quite dramatic events for any planet. They seem tough conditions in particular for that rare thing, a *living* planet that had snoozed comfortably if unexcitingly through the previous one and a half billion years of environmental stability: the 'boring billion years[4]' of the Proterozoic shows no evidence of glaciation in that time or, as far as I know, of the hot-as-a-nice-cup-of-tea climates that have been mooted by some to have been present in even deeper, Archean, times. It was pretty well-developed life, too, if one looks beyond such showy structures as legs, backbones, teeth and brains, and recalls the 'tree of life' produced a few years ago by those who look at the

[4] The 'boring billion and a half' should be 50% more impressive, but somehow does not have the same ring to it.

real index of biological diversity, the genome (Hug *et al.* 2016): this tree was strikingly drawn as a kind of fan-shape, sprouting more than a hundred branches – almost all of which were microbial, out of which emerged one small tuft that was all of the plants, animals and fungi of the eukaryotes. Take this sophisticated, if Lilliputian, living array, and put it in a deep-freeze – twice in quick(ish) succession – and each time bring it violently out of this state via a sharply applied hot-cup-of-tea treatment at planetary scale. No wonder people have wondered how life survived at all – and then further scratched their heads as they saw that, a little while later, life did become showy and big and multicellular with the mysterious Ediacaran organisms, soon followed by the familiar creepy-crawlies of the Cambrian. So, perhaps something in this tough kind of planetary love somehow did ginger up what was left of the biosphere, and persuade it to learn new tricks.

What kind of refugia could be present for life on an ice-world? – it's a question not only for Earthly palaeontologists, but for those NASA scientists hungrily eying the terrains of Europa, Callisto and Titan in the more distant stretches of our Solar System. Hoffman and co. introduced me to a new one (new to me, at least), which is not only ingenious but is also on a nicely homely scale, just right for a warmly clad human to sit on the edge of and peer at. Even better, one can still do this today. These are cryoconites, and can be seen where drying winds blow across Antarctic ice, changing this solid into vapour and so slowly sublimating it away. Small holes – oh, about large enough to catch your boot in if walking incautiously – appear in the snow where there is a little more dust to help absorb the sunlight and so increase the sublimation rate to make a little depression, that then traps more dust to capture more warmth, and so on. In the summer, a little meltwater can collect and, fertilized by the dust minerals, cyanobacteria grow as the basis of little seasonal communities that today can include green algae, protozoans, rotifers and nematode worms – and the brightly coloured algae of course trap a little more of the sun's heat to give a little more warmth to these little shelters.

Cryoconites are mooted as one of the potential refugia for life amid the Cryogenian ice[5] – a kind of life that is necessarily attuned to highly restricted freshwater settings with rather sparse nutrients – but a possible refuge for life nonetheless. Conditions should have been dusty back then, for although the sea is envisaged as being mostly or entirely ice-covered ("Snowball Earth is essentially an oceanographic phenomenon" Is just one of many intriguing phases coined in the paper), land in those hyper-arid conditions of low snowfall should have seen large areas of bare rock that could be frost-shattered, or periodically glacially scrunched, to provide such sediment. And, if cryoconites were a haven for life they might also – with present company in mind – be a source of fossils. So where does a cryoconite pond go to on a Snowball Earth? This question, intriguingly, was explored at some depth.

With those models to hand, the dials were set to 'cryoconite accumulation on sublimating sea ice' and, plugging in estimates of the amount of dust that might have been flying around then, and multiplying those by 58 million years of the Sturtian, suggested that that ice should have been weighed down with anything from 0.3 to 3.5 kilometre thickness of cryoconite dust. This would be carried slowly and inevitably from high latitudes, to form what they term an 'equatorial cryoconite moraine' that would pile up more thickly than a sea glacier layer, no matter how sturdy, could support. So where did it go?

[5] Others have been suggested, such as the immediate outflow zones of meltwater acting as small oxygen oases in an otherwise oxygen-starved ocean (Lechte *et al.* 2019).

Overboard into the sea is the only obvious place, the corollary questions then being 'how' and 'where is it now'? One way suggested is by cataclysmic capsize events, when the weight above became too much for the ice to bear, tipping the overburden into the deep and creating a hole in the otherwise endless sea ice, soon to be healed as the surrounding ice flowed in to plug the gap. Alternatively, a less spectacular way, as suggested, would be by a kind of drip-feed, flushing the cryoconite, through meltwater-fed fissures in the equatorial sea ice, into the waters below. It would be a kind of thermostat for the ice, they suggested – the more dust, the greater the heat absorption, and so the more melt production and dust flushing; where dust is thinner and patchier, more light and heat are reflected, the flushing mechanism is throttled back, and the ice thickens.

Where is it now, as strata? Not yet apprehended, m'lud, it seems. The amount of cryoconite coming in on that conveyor belt would seem substantial – but there would also have been muddy sediment swept into the Cryogenian oceans from ice-covered continental landmasses by subglacial meltwaters; telling the two apart is not a trivial task. It is a little like the difficulty of finding fossil examples of windblown silt (loess) in ancient marine strata – there must be lots of it out there, and yet it is mostly so superficially similar to (and also it is commonly diluted by) other kinds of marine mud, that it is very difficult to spot.

So cryoconite remains, tantalizingly, as a target, to seek amongst the understandably threadbare fossil record of Cryogenian times. If modern cryoconite is anything to go by, it should have a few percent of organic carbon from the mortal remains of those minuscule ice-pond organisms. This would be precious because it would be the remains of the life of those ice-planet times, and not (as in the standard ice-eroded sediment then being formed on that crudely physical world) the glacially re-worked remains of living organisms from yet more ancient, pre-Cryogenian, times. This has its own interest of course, but one in which the narrative would be terribly scrambled and, in truth, mostly not as interesting.

Prospecting for cryocolite strata and the kind of fossils it might contain, whether body fossils or chemical fossils, might tell us a little more about the origin of the major animal groups, the roots of which must lie somewhere there or thereabouts. That is a classically palaeontological question, and so very life-centred. But it might also help us look at things from the planet's point of view. For just how much can life be diminished, or forced into hibernation, before the effect of the biosphere – or the moving spirit of Gaia, if you like – becomes negligible to the Earth System, so that the Earth *functions* like a dead planet, while maintaining scraps of living matter that do little but wait to burst into bloom again once the freeze-roast cycles are complete. One might liken such a state to Mars today, where life might (perhaps) persist beneath the permafrost, but if it does, it plays no role modulating the Mars System, which – as Gaia's inventor, James Lovelock, inferred – just shows the mundane patterns of chemical equilibrium.

Did the Earth then reach, or come anywhere near, such a functionally dead state? Escape, we must recall, seems to have come via a purely physical cause, in the build-up of volcanic carbon dioxide above the ice shell, while Gaia slept. Rescued by that side-effect of Earth's magmatic plumbing, Gaia, awakened, could get down to business again.

Gaia is still in business, though her functionality is clearly a touch compromised these days. One of the reasons cited by Hoffman *et al.* for writing the update on the Snowball Earth was

'to stimulate fresh perspectives on the Anthropocene'. Well, that might not be so far-fetched. In a recent assessment of geological analogues for near-future climates based on climate models, the 'business-as-usual' pathway of carbon emissions is projected to lead to Eocene-like climate conditions by 2130 CE. Those authors (Burke *et al.* 2018) noted, though, that things are happening much faster now than in the Cenozoic comparisons they used. Hence, the post-Snowball warming might indeed be thrown into the ring as an extra cautionary tale.

Once one brings comparisons like that into the mix, it all does seem like fiction, and far-fetched melodramatic fiction, at that. This is one narrative that will clearly need revisiting once a few more decades have gone by. If the plot still seems ridiculous by then, then that would surely count as the happiest of endings.

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Palaeontology's greatest ever graphs

Raup's shell morphospace

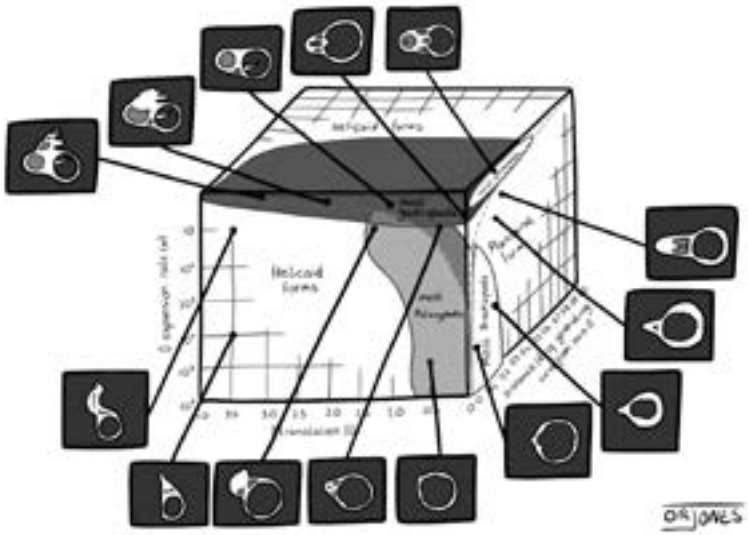
It's 2020, and for the last few months all the palaeontology any of us has been doing is virtual. Spreadsheets, strat logs, CT scans, video coffee mornings and, of course, Twitter. Digital science communication is vital, not just during exceptional times like this, but always – it's the best, fastest way to reach the largest number of people, to capture imaginations and get across the point of our research and what it tells humans about the past, present and future of the world that we live in.

Scicomm often draws people in with breadcrumbs. Soundbites and pictures that look cool, that get people hooked and asking questions. Successful icons of palaeontology are usually 'creatures': Sue the *T. rex*, Sophie the *Stegosaurus*; *Tiktaalik* or *Tullimonstrum*. I've seen a lot of excitement about anomalocarids on Twitter lately, which is cool. Sometimes trilobites or ammonites will rate a mention (rarely specific enough to name a taxon), or Burgess animals (the

headline will definitely call them weird); whatever the flavour, the icons of palaeontology in the public mind are almost all specimens.

We have other icons as well; people and personalities who have made important discoveries or put things together in new ways, and those can hook people too (check out the @MaryAnningRocks campaign, if you haven't already!). Localities and horizons, also; Mazon Creek, the Morrison Formation, the Emu Bay Shale, the Whanganui Basin … again, everyone has their favourites, their icons. The people, places and things that are representative of what we, as palaeontologists, do.

I think there are some diagrams that could be included in the 'icon' club, too, that we could be enthusing the public with, to just as great effect as we can using a picture of a thing with great big teeth (no offence intended to creatures with great big teeth). If I was trying to summarize what I do as a palaeontologist, I'd turn to a diagram, rather than a creature; David Raup's 1966 theoretical shell morphospace, aka the Raup Cube.



This summarizes, in three dimensions, the form of coiled shells. As you go along the x-axis, your shell gets taller; as you go along the y-axis, it varies in how fast the size of the aperture expands; along the z-axis, how far the aperture travels from the theoretical 'axis' that the shell is coiling around. Vary any one of those parameters and you can make an infinitude of shells.

So many grad seminars have featured this simple little diagram. It's not a perfect model, but because of its clarity, it can be used as a general conceptual framework, or interrogated and improved upon, and I think that's why people still come back to it. It's the ideal starting point for conceptualising the relationship between growth and form. The cube's simplicity has spurred alternative ways of approaching theoretical morphology of shells, including things like moving

reference-frame models (Savazzi 1990), and adding more parameters (Schindel 1990, Noshita 2012). Its influence is ongoing: Google Scholar tells me that as of this morning, 845 papers have cited Raup (1966); that's an average of about 16 a year; 126 citations since 2016, 37 since 2019, nine this year alone and we're not even halfway through. The cube's spiritual children include ternary diagrams (Ritterbush and Bottjer 2012), tangent spaces (Gerber 2017), the truly beautiful if somewhat abstract "castle in the sky" of Tursch (1997), and so many other 'cubes' besides that Stone (1996) even produced a phylogeny of shell models themselves.

It's a simple, easy to read thing; a cube presented in an oblique projection; a combination of three bivariate plots. The addition of the theoretical shells in the margins, generated using the parameters that form the axes of the cube, orients the reader and highlights the thing that theoretical morphospaces are so good at: showing us the shapes that don't exist in nature, or that have been lost through extinction. The caption puts it beautifully: "The regions occupied by the majority of species in four taxonomic groups are outlined in the block. Species of these groups are not commonly found in the blank regions." Immediately that begs the question "why not?". You don't need to be a specialist to understand the point of the diagram, and you don't even need the caption to point you at the question; the diagram itself points you there. What's missing? What's impossible? How can we tell the difference?

In the cube, you can find what is, what was, what has never been, what might one day be: all the questions that palaeontology asks and more. And I think that's pretty iconic.

Katie Collins
Natural History Museum, London

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An Introduction to Bayesian Phylogenetics Part 2: Managing data and taxa

[Data and other useful files are available at <**https://github.com/wrightaprilm/PA_newsletter**>.]

Last session, we installed RevBayes, and an interface to use RevBayes in RStudio. In the following exercise, you can either open RevBayes and type in the commands, or you can run the commands in KnitR in the Rstudio interface. If you download this file …

https://raw.githubusercontent.com/wrightaprilm/PA_newsletter/master/01_Getting_Started.Rmd

… it is written as a KnitR document, which can be read in by RStudio as-is. If you'd like to do this this way, load the RevKnitr package.

```
library(RevKnitr)
```

In this tutorial, we will be using a dataset of cinctans, which are mid-Cambrian echinoderms. The data come from Zamora *et al.* (2013). To get started, we'll read in the data. In RevBayes, reading in data isn't done by the type of data (molecular, morphological), but by if the data are discrete or not. Because of this, we will use the function 'readDiscreteCharacterData'. If we had continuous data (such as measurements in length or weight, or landmarks), we would use the function 'readContinuousCharacterData'.

```
morph <- readDiscreteCharacterData("data/Cinctans.nex")
```

This command may look familiar to R users. Much as in R, in Rev, the object to the left-hand side of the assignment operator will take on the value of the output from the function to the right. The output of the 'readDiscreteCharacterData' function is a single dataset, read from our data file.

Once we've read in the data, we can get some basic information about it. For example, simply printing the data:

```
morph
```

Output:

```
Standard character matrix with 27 taxa and 60 characters
========================================================
Origination:                  Cinctans.nex
Number of taxa:               27
Number of included taxa:      27
Number of characters:         60
Number of included characters: 60
Datatype:                     Standard
```

What we can see here is that we have 27 taxa and 60 characters of morphological data from the Cinctans. You'll also see that it has been understood as "Standard" data. Many phylogenetic programs refer to morphological data as "Standard".

Next, we can view core statistics about the data object. Much like in R, the command

```
str(morph)
```

will give:

```
_variable     = morph
_RevType      = AbstractHomologousDiscreteCharacterData
_value        =

Standard character matrix with 27 taxa and 60 characters
========================================================
Origination:                  Cinctans.nex
Number of taxa:               27
Number of included taxa:      27
Number of characters:         60
Number of included characters: 60
Datatype:                     Standard

_dagType      = Constant node
_children     = [  ]
```

We can see that morph is of 'type' AbstractHomologousDiscreteCharacterData. This doesn't mean much for you, but if you wanted to look up what methods are available to work with this datatype, you can do that via the RevBayes documentation (<**https://revbayes.github.io/documentation/AbstractHomologousDiscreteCharacterData.html**>). The type of the method governs the functions we can use with it. We'll return to this in a moment.

You'll also notice that the data are considered a 'constant node'. RevBayes implements a graphical modelling framework in which the phylogentic model and data are considered to be an interdependent structure. You can read more about this framework here: <**https://academic.oup.com/sysbio/article/65/4/726/1753608**>, and a further tutorial on this idea is here: <**https://revbayes.github.io/tutorials/intro/graph_models.html**>. A constant node is a node that is not inferred in our estimation. Data fit that description well – they do not change through the course of the analysis.

If you had a look at the RevBayes documentation, you will have seen that there are many useful ways to look at the data. For example, we can do simple verifications that the data are what we think they should be.

```
morph.taxa()

morph.nchar()

morph.ntaxa()
```

These will return the number of taxa, characters, and the names of the characters. We can view the matrix as plain text:

```
morph.show()
```

We can also do some more sophisticated analyses of the matrix. For example, if we needed to know how much missing data we have in some focal taxon in our analysis, we can query this information out:

```
morph.percentageMissing("Sucocystis_theronensis")
```

Or we could do this for the whole matrix. Perhaps we would like to know how many taxa have over 50% missing data:

```
morph.numTaxaMissingSequence(.5)
```

You should get:

```
22
```

That is most of our taxa! Perhaps we are interested in removing taxa that have more than 90% missing data. We could do this via a loop. This loop structure may look familiar to R users.

```
for (taxon in morph.taxa()){
  if (morph.percentageMissing(taxon.getName()) > .9){
       morph.removeTaxa(taxon.getName())
  }
}
```

In this loop, we look at each taxon in our dataset. For each taxon, we calculate how much missing data it has, and then we remove the taxon if the missing data is over 90%. In this case, we use the 'getName' function of the taxon object to search each taxon by name (as opposed to any other attributes it might have, like age). Available taxon object functions can be seen in the documentation: <**https://revbayes.github.io/documentation/taxon.html**>. If you've completed this, printing morph to the screen will reflect 22 taxa.

That's all for this time. I hope you've enjoyed this look at managing data and taxa in RevBayes. Next time, we'll set up a simple model-based analysis using RevBayes.

April Wright
Southeastern Louisiana University

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Spotlight on Diversity

Highlighting different experiences in palaeontology. In this issue, palaeontologists Nussaïbah Raja-Schoob (Friedrich-Alexander-University (FAU) Erlangen–Nuremberg) and Emma Dunne (University of Birmingham) discuss minority languages in academia.

When we think of diversity, we typically think in terms of visible diversity, however many of the things that make us diverse are invisible. Linguistic diversity is one such aspect of this so-called invisible diversity. Academia, for the most part, remains monolingual. Across the world, English is commonly used as the language of instruction, and in science, English is the language we predominantly use to communicate – at conferences, in e-mails, in publications and to the media. Not all scientists are native English speakers, creating significant and largely unseen difficulties, that native speakers almost never experience, for example during peer review[1]. For others, whose native language is English, there are other regional, or minority, languages that make up a considerable part of their identity and culture, which can seldom be expressed at work and in scientific circles.

Nussaïbah is a Mauritian PhD student in Germany. Her research focuses on understanding the impact of environmental change on reefs and reef-building organisms. Languages were a big part of Nussaïbah's time in Mauritius, where she was born and raised. She grew up speaking a multitude of languages: English and French which were reserved for school, Mauritian Creole – a French based patois – which was for family and friends, and Urdu, which she learned in school as part of the 'ancestral language' initiative in Mauritius. She spent three years in Turkey at Ankara University, where the main language of instruction and science was Turkish. Now in Germany, she has had to learn German as a requirement to obtain her residence permit.

Emma is an Irish postdoc in England, studying the patterns and drivers of biodiversity through deep time. In Ireland, English is the most widely spoken language; a result of several centuries of British conquest and colonization. However, like the majority of people in Ireland, Emma grew up learning both English and Irish (Ireland's first official language). While Irish is spoken daily by only a small percentage of the population, Irish is a compulsory school subject, and Hiberno-English, the dialect of English spoken by Irish people, borrows heavily from Irish, especially in terms of sentence structure and phrasing.

As speakers of minority languages (Creole and Irish), Nussaïbah and Emma noticed several similarities but also many important differences in how their languages have shaped their academic experiences. This led to a discussion about privilege, identity, diversity and barriers to science:

Nussaïbah: The first thing that came to mind when we were asked to write this piece was how lucky I was to have grown up speaking English. English has now become my dominant language, mostly due to the fact that it is the lingua franca of academia[2]. But this has also meant that the

[1] Romero-Olivares, A. L. 2019. Reviewers, don't be rude to non native English speakers. *Science Magazine*, <**https://www.sciencemag.org/careers/2019/10/reviewers-don-t-be-rude-nonnative-english-speakers**>.

[2] Márquez, M. C. and Porras, A. M. 2020. Science communication in multiple languages Is critical to Its effectiveness. *Frontiers in Communication*, **5**. <**https://www.frontiersin.org/articles/10.3389/fcomm.2020.00031/full**>.

other languages I speak, which remain very much part of me, have had to take a back seat. More and more, I find myself forgetting a word here and there, just because I don't use these languages as much as I do English.

Emma: This was also my first thought, I am very privileged to be a native English speaker in science. Using it daily, and in a much more technical way than I would use Irish, means that over time Irish is slipping from my mind. Unlike when I was back in Ireland, I now need to actively keep up my Irish – I watch and read a lot of Irish language news media and listen to podcasts. I've even changed the language on websites like Twitter, so that I have to navigate the sites through Irish!

Nussaïbah: I also started listening to French podcasts, especially science ones, because I realized that I would never be able to speak about my research in French or Creole. This meant that I could not even explain to some of my family members who did not speak English, what my work was about. Despite English being one of our official languages, there are still not many people who are fluent in it and French-based languages are preferred. My research is really relevant to Mauritius, so I definitely would like to be able to talk about it with my fellow Mauritians.

Emma: My experience has sadly been the opposite. In Ireland, Irish still lags way behind English, meaning it's not seen as the language of science, technology or business, which excludes a small, but significant, portion of the population who predominantly speak Irish. Amongst my family and friends, Irish is more typically reserved for general conversation (and for when young children are around and you don't want them to understand what you are saying!). Usually, depending on what we want to say, we'll either say it in a mishmash of Irish and English, or use an Irish word that is more descriptive or useful in place of an English word. It's really wonderful to be able to switch back and forth like that, but something I can rarely do outside of Ireland.

Nussaïbah: There are times when I use – sometimes without even realizing – a non-English expression and end up just speaking what others would describe as "weird" English. Because of the way I look, I'm automatically placed in the "non-native speaker" pool and may even get patronizing comments on how to fix my English. I always have to be aware of whom I'm speaking to and which words/expressions to use – which then usually leads to me getting complimented on how good my English is. Creole is a very expressive language and we have many words that can't be translated because they describe the way you feel or what you want to put emphasis on rather than a specific word. In the same way, there are so many things that could be described in a better way in another language that I sometimes feel that speaking just English is too restrictive.

Emma: When I'm not in Ireland, I am hyper-conscious of any 'Irish-isms' that creep into my everyday speech, as well as my scientific writing. This isn't only to ensure that non-Irish speakers better understand me, but it also helps to reduce the number of comments I will get for not speaking or writing in 'proper English'. Though infrequent due to my privilege of visibly being a native English speaker, these comments on my accent and turns of phrase are grating and part of a wider problem in academia.

Nussaïbah: I experienced first-hand how it was to be a non-native speaker in academia in Turkey, where I was expected to be able to write my thesis and give presentations in Turkish. I had spent a year learning Turkish prior to starting university but this did not in any way make me fluent

enough to be able to do these things. People were, however, very understanding and patient with me – something that I feel is lacking in the English speaking world of academia. Whenever I would submit a paper with my Turkish affiliation, I received comments that my English was not good enough and that I should get it checked by a native speaker. Funnily enough, this has not happened since I moved to a German institution. Coincidence? Maybe.

As speakers of minority languages (and several other major world languages), we are acutely aware of the monopoly that the English language has in scientific discourse, as well as in our own scientific research. Global sampling biases amongst fossil occurrences, *e.g.* the dominance of North American and European occurrences in the *Paleobiology Database*, are well-documented but considerably less attention has been paid to how these biases, that certainly go beyond physical processes, have arisen to start with. Due to the invisibility of non-English science, there is an inherent bias in whose research gets reported[3]. As a result, scientists in the non-English-speaking world feel compelled to publish in English, often to the detriment of contributing to scientific research and communication in their own local language. This outright exclusion of other languages is intrinsically contributing to increasing inaccessibility and loss of scientific knowledge in non-English speaking communities. Scientific excellence is only reserved for those who have managed to overcome the barriers that English represents.

As we move forward in our conversations about how to make science, and specifically palaeontology, more diverse, equitable and inclusive, we must become aware of others' nuanced experiences – not just in terms of visible diversity, but also invisible diversity. It's our only way of conducting science that actually matters and makes a difference, science that goes beyond publishing or perishing.

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Emma Dunne
University of Birmingham

Acknowledgements

We would like express our sincere thanks to Rachel Warnock for encouraging us to write this article and to Sarah Greene for insightful comments.

[3] Amano, T., González-Varo, J. P. and Sutherland, W. J. 2016. Languages are still a major barrier to global science. *PLoS Biology*, **14**, e2000933.

Special Interview: Puerto Ricans in Palaeontology

In this special piece our Diversity Officer **Rachel Warnock** interviews **Stephanie Plaza-Torres**, a palaeontologist and geochemist from Puerto Rico. Stephanie graduated from the University of Puerto Rico at Mayagüez (UPRM) last year. Over the course of her degree she interned at the Smithsonian Institute, Stanford University and the University of Colorado. She has also spent time studying at the University of Salamanca in Spain. She is an NSF fellowship recipient and will begin her PhD this year at the University of Colorado, Boulder. She shares her advice and experiences below. (Note: this is an abridged version of the interview and the full version will appear on the Association website in due course: <**https://www.palass.org/**>.)

What were some of the milestones in your palaeo life?
I started doing research as an undergraduate and noticed that I liked it, and thought, I should keep doing this! But I wanted to learn a little bit more about palaeontology and that's how I ended up applying for internships. One of these internships taught me about geochemistry and how it adds context to a palaeontological question.

The gist of my decision to do my PhD at CU Boulder is that I want a place where I'm able to do geochemistry and palaeontology seamlessly. You can swim among fields a little better there than elsewhere. As an example, they have a huge eggshell collection at CU, one of the biggest in the world. I ended up thinking about eggshells as a way to study changes in climate. You'd be surprised how little has been done with eggshells, especially the geochemistry part. Isotopes could add to what things might be driving the evolution of eggshells, and at the same time be used to assess climate.

Would you describe internships as being important?
Internships are key. I think they were the most important part of my undergraduate journey. Each one added a new layer to why I was interested in palaeontology and shaped the questions I was interested in. My internship at the Smithsonian cemented my interest in palaeontology. At Stanford I learned geochemistry as a cool tool, then in Boulder I discovered you can actually mix these. The work of a summer can really change your career and connect you to a lot of people.

Are there specific challenges for undergraduates from Puerto Rico?
There's things that help and things that flow against you. Puerto Rico is different in terms of resources, compared to the US. But I wouldn't say that's detrimental to your progress because you learn other skills, like being resourceful. You learn about Caribbean geology, which is not the most mainstream. In Puerto Rico you're away from many opportunities, but we do have access to a lot because we're United States citizens.

I'm fluent bilingual. I was fortunate, I didn't have to think about purposefully learning English. Speaking Spanish opens a lot of doors, like if you want to research geology in Spain or Puerto Rico or Latin America. Latin America has a lot of interesting geology with great research potential.

I wish that the University of Puerto Rico had more resources and could hire more people. I don't know if it will get better. But if I could go back to Puerto Rico and work on something I liked I would do it because I love Puerto Rico and I love living here, and I have more of a community here.

How did the hurricane impact your journey?
I always reiterate that I didn't have the bad end of the spectrum, in terms of post-hurricane life. I lived in an area near hospitals that got electricity, water and Internet early on. Some people went more than six months without electricity. Also, the infrastructure was completely damaged. There were so many landslides you couldn't be out on the road.

There were some people, when classes went back, that didn't have electricity or water in their houses. It was really hard for them, and even worse if they didn't have a computer. The university library was closed for more than a year after the hurricane because it got flooded, so the place where most resources were for the Internet and electricity was closed. And some professors were still demanding things to get done, although the circumstances were insane!

Now I think with the corona virus everyone has been brought up to date on how it feels to be in some kind of disaster. Back then it was a similar flavour of things. You feel this underlying anxiety all the time, that doesn't really let you enjoy the downtime you currently have. When will things go back to normal? Are we going to be able to return to some kind of normal? Are there going to be remains of this tragedy? Six months after you would still see a sign or something that was destroyed by the hurricane. So you have this constant reminder that these things happened.

Can you tell us about being a Puerto Rican student in America versus Europe?
One of the biggest shocks I had going to the US was a cultural shock. It's very hard to grasp. It's a thing that you feel if you throw yourself in the ring, but to explain it, is nearly impossible.

It's hard for me to scope how an American is feeling. In terms of humour, it's totally different. Puerto Ricans are more outspoken. Candidness is definitely a thing. But if you're loud in the US, being funny and laughing, instead of making stuff a little more lively it might seem like you're being unprofessional.

The American geosciences have made great strides in terms of equalizing men and women, but in terms of diversity it's way behind, in comparison to other fields. They work on getting diverse people in but once they're in geoscience departments, there's a really big problem with inclusion. You might be there and you might be African American, you might be Puerto Rican, Latino, but you don't fit because you don't have a big community of people that are like you. It feels like you have to fit in, instead of them fitting you in. You have to mould your puzzle piece to fit their puzzle.

In Spain it feels more familiar because they are lively in the sense that we are, and there's also the commonality of speaking Spanish. I don't know if this is the standard for research in Europe, but they're way more relaxed. They seem to have a better grasp on work-life balance, and accept that you might want to chill out. In the States it feels like there's a culture of burning out. The Spanish seem more laid back but not in a bad way, more respectful that people need breaks. I think we could definitely learn from Spain in that sense.

What are your thoughts on the subconscious and cultural biases we have as researchers?
Surprisingly, Puerto Ricans can be pretty racist. There's a lot of "colourism", we call it. Black people get discriminated against a lot. And colourism is something ingrained in Puerto Rican culture. I'm trying to be more self-conscious about my [cultural] bias. Sometimes I'm saying something and I think, wow, that's so wrong! And I retract myself and try to fix it, slowly in a way that little by little I can achieve actual change. Everyone has bias. As individuals, we are strongly influenced by our in-group, and as much as you try to get out, it's hard because you were raised in a culture.

People should be a little bit chill about how hard it is for someone to suddenly change the way they operate, but also, get your shit together! Be self-aware, notice your mistakes and try to fix them. If I think that you can change, I'm thinking highly of you. It's really hard to change, but since I know people that have been able to do it, that gives me hope other people can as well.

Do you have advice for people teaching undergrads from different backgrounds?
If people are actually recruiting diverse undergraduates and trying to get them into research, I would definitely pay more attention to the space that you're going to receive those students into. Be conscious of the differences that exist amongst people.

Really opening a line of conversation that's not just, "what are we going to do for research?", but also ask, "how are you?", find out what issues they might have, and be clear about what things they might need to actually succeed in their career. Opening that channel of communication is a way an individual can make a difference for a student: understanding the challenges they faced to get to that point, and what challenges they may face once they're there.

Any advice for undergrads?
My first piece of advice is to apply for internships, and don't be afraid to try getting opportunities abroad. One of the best ways to learn about internships is being part of a society and subscribing to mailing lists, from your university or PaleoNet. And directly ask your professors. You might have to cold-email someone or randomly introduce yourself, but you don't know, you might get the friend of a lifetime or a mentor if you do that. But if you do go to internships: schedule a break!

Learning how to cope with moving somewhere else: that's a journey that's different for everyone, but I think that most people can learn it and find it rewarding.

If you would like to learn more about Puerto Ricans in palaeontology you can reach out to Stephanie or these other members of our community who have kindly shared their contact emails: Stephanie Plaza-Torres (PhD Student, CU Boulder; <**Stephanie.plazatorres@gmail.com**>), Eduardo Cruz (palaeoartist and undergraduate, UPRM; <**eduardo.cruz1@upr.edu**>), Hernán Santos (Professor, UPRM; <**hernan.santos@upr.edu**>), Kevin Vélez-Rosado (PhD student, University of Michigan; <**kvelez@umich.edu**>) and Jorge Vélez-Juarbe (Curator, Natural History Museum of Los Angeles County; <**jvelezjuar@nhm.org**>).

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

68th Symposium of Vertebrate Palaeontology and Comparative Anatomy and the 29th Symposium of Palaeontological Preparation and Conservation (SVPCA and SPPC)
Natural History Museum, London, UK *16 – 18 September 2020* ***CANCELLED***

Due to the coronavirus pandemic this conference has been cancelled. In 2021 the conference will be held in Oxford, UK.

Marine Reptiles Conference 2020
The Etches Collection, Kimmeridge, UK *29 September – 1 October 2020*
NEW DATES

This conference has been rescheduled from May 2020 due to the coronavirus pandemic and depending on social distancing measures may 'go virtual' and take place online. Confirmation of this decision will be made by 1st August. The information below is based on a physical conference, but will be amended to a virtual format if necessary.

All professionals, amateurs and enthusiasts of marine reptiles are invited to attend. The primary focus will be on the fossil record, covering not only the marine reptiles but also the other organisms that formed part of their ecosystems. A session will also take place on modern reptiles, and we welcome abstracts from researchers studying all aspects of this field.

For more information please visit the website: <**https://marinereptiles.org/index.php**>.

XV International Palynological Congress and XI International Organization of Palaeobotany Congress (XV IPC-XI IOP)
Clarion Congress Hotel Prague, Czech Republic *1 – 8 May 2021* ***NEW DATES***

The congress is postponed from September 2020 and will celebrate 200 years of modern palaeobotany. 1820 saw the first use of binomial nomenclature for fossil plants by the Czech 'Father of Palaeobotany' Caspar Maria Sternberg, who published *Flora der Vorwelt* in this year. Palynology and palaeobotany have a long tradition in the Czech Republic with several eminent pioneers. The scientific programme will cover all aspects of palaeo- and actuopalynology and palaeobotany. Several congress field-trips will be on offer around parts of Bohemia and Moravia. The International Organisation of Palaeobotany will financially support several postgraduate students, allowing them to participate in the conference and present their research results.

For more details please see the website: <**http://www.prague2020.cz/index.php**>.

35th IAS Meeting of Sedimentology
Vienna House Diplomat Prague, Czech Republic *22 – 24 June 2021*
NEW DATES

This meeting has been postponed from June 2020. The meeting will feature several sessions with a palaeobiological theme, including 'Sedimentary environments as the theatres of life and evolution' (session T05-SS05). Researchers from a broad range of fields including ichnology, palaeoecology, sedimentary geology, geochemistry and geomorphology, in both marine and non-marine settings, have been encouraged to contribute.

For more information please visit the website: <**https://www.iasprague2021.com/**>

18th Conference of the European Association of Vertebrate Palaeontologists (EAVP2021)
Benevento, Italy *Summer 2021* ***NEW DATES TBC***

The 18th conference of the EAVP has been postponed from July 2020 due to the coronavirus pandemic. The conference will be hosted by the Ente Geopaleontologico di Pietraroja and the operational office of the Soprintendenza Archeologia, Belle Arti e Paesaggio per le province di Caserta e Benevento in southern Italy, a land of history, art and culture. The Soprintendenza Archeologia has a special significance in the recent history of palaeontological research being the resting place of the exceptionally well-preserved small theropod *Scipionyx samniticum* named 'Ciro', the first dinosaur discovered in Italy. The event is also supported by the SPI (Società Paleontologica Italiana), the Sapienza University of Rome and the University of Florence. Oral and poster sessions are planned as well as flash talk sessions for poster presenters, plus roundtables, workshops, symposia and field-trips.

For more information please visit the website: <**https://sites.google.com/view/eavp2020/**>.

International Conference on Modern and Fossil Dinoflagellates (DINO 12)
Palacio Congresos De Canarias, Gran Canaria, Spain *5 – 9 July 2021*
NEW DATES

This conference has been postponed from July 2020. The scientific programme will be devoted to the latest developments in studies of living and fossil dinoflagellates. Dinoflagellates are one of the most important groups of planktonic and benthic marine microalgae and, as such, are of interest to both biologists and geologists. In keeping with the tradition of this conference series, the programme of the meeting (held only every three to five years) will consist of oral presentations and posters, supplemented by a small number of invited and keynote talks.

For more information please see <**https://dino12conference.com/**>.

36th International Geological Congress
India Expo Centre, Delhi, India *16 – 21 August 2021* *NEW DATES*

The IGC was postponed from March 2020 due to COVID-19. The IGC is a nonprofit scientific and educational organization whose meetings are held in collaboration with, and under sponsorship of, the International Union of Geological Sciences (IUGS). IUGS holds its General Assemblies in conjunction with Sessions of the IGC. The main purpose of the Congress is to encourage the advancement of fundamental and applied research in the Earth sciences worldwide.

For further information please visit the website: <**https://www.36igc.org/**>.

9th International Meeting on Taphonomy and Fossilization (TAPHOS) and 6th ICAZ Taphonomy Working Group Meeting (ICAZ-TWG)
Museo Arqueológico Regional de Madrid, Spain *September 2021*
NEW DATES TBC

The 2020 meeting has been postponed from September 2020. The 9th edition of TAPHOS and the International Council for Archaeozoology will bring together palaeontologists and archaeologists and also calls on other researchers to participate, such as forensic scholars, molecular biologists, histologists, anthropologists. A special tribute will be paid to Sixto Fernández-López, founder of the TAPHOS meetings, and to Peter Andrews for his innovative work on small mammal taphonomic methodology and palaeoenvironmental interpretations.

For more information please visit the website: <**http://taphostwg2020.es/**>.

2nd Crossing the Palaeontological-Ecological Gap (CPEG)
Museum für Naturkunde Berlin, Germany *5 – 8 September 2021*
NEW DATES

Postponed from September 2020, this three-and-a-half-day meeting is planned with oral and poster presentations and a workshop. Besides giving a platform to scientists and work that crosses the gap between modern and ancient worlds, the aim is to cover all major organism groups, ecological levels and process focuses. Keynote speakers, roundtable discussion and goals will remain the same. The Museum für Naturkunde – Leibniz Institute for Evolution and Biodiversity Science, Berlin is one of the most important research institutions worldwide in the areas of biological and geological evolution and biodiversity, with a collection of over 30 million items covering zoology, palaeontology, geology and mineralogy.

See the website for further details: <**https://cpegberlin.weebly.com/**>.

XII Congress of the Asociación Paleontológica Argentina (CAPA 2020)
Auditorios UCA Puerto Madero, Buenos Aires, Argentina *22 – 26 November 2021*
NEW DATES

This meeting is postponed from September 2020. The 12th congress of the Argentine Paleontological Association (APA) will commemorate the 65th anniversary of the Association, featuring recent advances in the field of palaeontology in Argentina. This meeting aims to promote a favourable environment to exchange knowledge and coordinate joint actions between palaeontologists, museum workers, biologists, related Earth scientists, teachers, students and institutions linked to the areas of education, protection and tourism, strengthening links between palaeontologists and the broader community. Advances in the field and outreach communication are fundamental for the conservation of Argentinean palaeontological heritage.

For more information please visit the website: <**https://www.congresoapa.org.ar/**>.

VIII International Conference on Mammoths and their Relatives (ICMR)
Indian Institute of Science, Bangalore, India *2021* ***NEW DATES TBC***

The conference is postponed from October 2020 and revised dates and deadlines will be announced later this year. However, participants are encouraged to submit abstracts without waiting for further announcements. The themes of the conference will include evolution and biogeography, genetics, ecology, extinction, conservation, archaeozoology and others, with both oral and poster sessions. Field-trips include a visit to Asian elephants in Bandipur National Park and a chance to explore the famous Neogene–Quaternary vertebrate fossil site of the Siwaliks.

Please visit the website: <**https://mammothindia2020.org/**>.

Please help us to help you! Add your own meeting using the link on the Association's web page:
<https://www.palass.org/meetingsevents/future-meetings/add-future-meeting>.

Zoë Hughes
Outreach Officer

——OBITUARIES——

Charles Hepworth Holland 1923 – 2019

Image courtesy of Professor Celia Holland.

Charles Holland died at the age of 96 on St Stephen's Day, 2019, in Dublin. He was one of the last surviving links with the foundation of the Palaeontological Association, as well as having served as its President in 1975 and 1976 and having been awarded the Lapworth Medal in 2008. Although he was not one of the fabled passengers in 'the taxi', he was intimately associated with the gestation of the Association, that was conceived as a reaction to the perceived tyranny of the Geological Society and its Dining Club. Charles, or Charlie as he was commonly called by many of his friends and students (but not by most of his staff who referred to him as 'Prof'), used to relate with relish the discussions that took place as to which senior palaeontologist should be approached for support in the creation of a society with its own journal devoted to palaeontology. The choice of R.G.S. Hudson (Hud) was made on the grounds that the latter was sufficiently senior but also an enthusiastic and incorrigible iconoclast. By coincidence, Charles was appointed to the Chair of Geology and Mineralogy at Trinity College, Dublin in 1966 in succession to Hudson. He held this appointment, and was also Head of Department, for 26 years. On his retirement, he moved office within the Department and continued to undertake research, publish and to be involved in the life of the College. However, to signify his retired status, he would leave his office at 4 pm, rather than after 5 pm, as formerly.

A full biography and appreciation of Charles Holland's work is contained in a festschrift volume (*Special Papers in Palaeontology* volume 67 edited by Patrick Wyse Jackson, Matthew Parkes and Rachel Wood) published by the Association in 2002. Rather than repeat that content here, we concentrate on the man himself and his contribution to science and humanity. Charles was an intellectual, committed to the positive values of both science and the humanities and, at heart, a socialist. He believed passionately in the value of education in the widest sense, particularly as embodied in a university, which he envisaged as a community of scholars – teachers and students – engaged in the rational exploration of ideas, civil discussion and the practice of freedom of thought and speech. As a geologist, he was similarly liberal, recognizing the value of all branches of the subject and endorsing a broad curriculum of teaching, including fieldwork, and supporting all the researchers and their research in his Department. He was fond of recounting, with a sense of disbelief, an experience in Podolia during the search for a stratotype for the base of the Devonian,

when an innocent question about tectonic structure of the area required the summoning of an expert from an institution some distance away. Throughout his tenure of the chair in Trinity College he gave the first year introductory course in geology, covering in masterful style all areas of the subject.

One of Charles's great strengths was his ability to bring people together to achieve a common goal. Departmental meetings in the Geology Department were not particularly frequent and were usually over within an hour, with the participants having a clear vision of the road ahead. This skill was particularly manifest in his role as an editor, where he brought to fruition several major publishing projects, including three successive, authoritative volumes (1981, 2001 and 2009) on the geology of Ireland, uniting the efforts of several contributors, some more laggardly than others.

Although undoubtedly a Lancastrian, proud of his upbringing in Southport, he was anything but insular and was strongly attached to his adopted country of Ireland and its institutions, particularly Trinity College, for which he had great affection, and the Royal Irish Academy, to which he was elected Member in 1971 and whose Gold Medal in Environmental Sciences and Geosciences he was awarded in 2008. He believed in an international community of scientists and as part of his work, particularly on the Silurian and on stratigraphical principles, he assembled a large group of collaborators, many of whom became personal friends. These included those working in what was then the sphere of influence of the USSR, in Russia itself, the Baltic States, the German Democratic Republic, Poland and Czechoslovakia. He recalled a meeting convened by Academician B.S. Sokolov to explain to western stratigraphers the concept of 'horizont'. He returned from Moscow none the wiser. He had a particular interest in and fondness for China and its people and was amongst the first western geologists to visit the country in the second half of the last century. He returned to Ireland with a fund of stories, including that of an appearance on a hotel balcony under the scrutiny of an enormous crowd of curious onlookers in the square below, and a set of beautiful photographic slides, the illustrations for some very popular public lectures.

These contacts led to international collaborations, now commonplace but less usual at the time, such as *Transhemisphere Telychian* (1987–1990) through which Irish, British and Chinese geologists aimed to test the limits of precision in the use of biostratigraphy between two geographically distant regions. *Silurian ecostratigraphy in Ireland and Sardinia* in the late 1980s, in collaboration with his good friend Enrico Serpagli and other colleagues from the University of Modena, cemented his admiration for Italy, its people, food, wine, climate and culture. These international collaborations developed along the same lines as his first cooperative venture, the formation, with Jim Lawson and Vic Walmsley and several other like-minded young geologists, of the Ludlow Research Group that resulted in collaborative research and life-long friendships.

Perhaps his most enduring scientific contributions will be considered to be the formalization of the principles underlying the practice of stratigraphy. The title of his presidential address to the Geological Society in 1986 *Does the Golden Spike Glitter*? still resonates and he was very much involved in the establishment and subsequent work of the International Commission on Stratigraphy, serving as Chairman of the Subcommission on the Silurian from 1976 to 1984. He considered the publication of *A global standard for the Silurian System* edited by himself and Mike Bassett and published in 1989 as one of his more important academic achievements.

But what of the man? He had informed us in 2010 that his final geological paper (on Silurian nautiloids, his favourite group of fossils) had been published. When asked had he any more projects to complete, he replied "Yes, two: the meaning of beauty; and why are we here?". He had a deep intellectual curiosity about the world and our place in it, manifest in his book *The Idea of Time*, and had wide interests in art, music, particularly jazz, and above all literature, particularly poetry. He admired what he referred to as 'style' in others, and this was apparent in the way that he himself behaved and dressed, notably in some memorable neckties. He was an inveterate traveller and confided that he would never take a holiday in the same place more than once because there was so much in the world to experience. He enjoyed good food, good wine, good conversation and good company. Above all, he was an honest man with a deep sense of loyalty to his colleagues and friends, and particularly to his family, his wife Eileen, who predeceased him, his daughter Celia, son-in-law Rory, and grandchildren Kate and Roisín, all of whose achievements he prized.

George Sevastopulo and Patrick Wyse Jackson
Trinity College Dublin

[Editor's note: read more about Prof. Holland and his role in the founding of the Association at <**https://www.palass.org/association/palass-60**>*.]*

Françoise Bigey 1941 – 2019

Image courtesy of Paul Taylor.

Françoise Paule Bigey, who died in November 2019 at her second home in Juziers northwest of Paris, specialized in the study of Devonian bryozoans, their taxonomy and palaeobiology, particularly those found in French successions. She made a considerable and valuable contribution to the understanding of these Devonian taxa which has allowed for their integration into recent syntheses of palaeobiogeography and taxonomy, and her work influenced recent taxonomic research by other colleagues.

She was the only daughter of a renowned obstetrician from Paris and a watercolour painter. In her youth she spent vacations in Juziers and at Juan-les-Pins in Antibes on the Mediterranean coast where she gained some success as a competition swimmer. From a very young age, Françoise was passionate about Earth sciences and was encouraged in her university studies by Henri Termier (1897–1989), sedimentologist and professor of geology at the Sorbonne, and Geneviève Termier (1917–2005), palaeontologist and affable research director at the CNRS. On their advice, Françoise embarked on studies of Devonian Bryozoa which she steadfastly maintained throughout her teaching and research career at Pierre and Marie Curie University in Paris. She was a skilled and engaging teacher and was responsible for the collection of fossil invertebrates which she

utilized for practical classes and instruction. During her career she preferred to maintain as much freedom as possible and to have few academic constraints. As a result, she chose not to defend her thesis even though she had plenty of research to write up, and she stayed at the lecturer grade. After her retirement from the University she became a volunteer teacher-researcher, with the title of Attaché, at the Muséum national d'Histoire naturelle in Paris and also served as Treasurer of the Société zoologique de France.

She published on the ultrastructure, and overgrowths of Devonian trepostomes, provided taxonomic reports of various assemblages from Armorica and Montagne Noire in France as well as those from further afield in Afghanistan and Morocco – and in doing so she erected several new taxa. In another important contribution she documented the biogeography of Devonian taxa. A number of these papers appeared in the conference volumes of the triennial symposium of the International Bryozoology Association (IBA) of which she was a long-term member and avid supporter having first joined in 1969. This brought her into contact not only with French and international biologists interested in bryozoans but also fellow international palaeobryozoologists such as Gilbert Larwood in the UK, Norbert Vavra in Austria and Tom Schopf in the USA who became a very close friend. Together with Jean-Loup d'Hondt, Françoise organized the IBA international congress in Paris on the occasion of the bicentenary of the French Revolution and did so with typical flair. She also led the associated geological excursions and scrupulously edited a significant portion of the ensuing conference volume.

She was widely travelled, whether it was nationally to conduct fieldwork, or internationally to participate at geological and palaeontological conferences. Her deep appreciation of culture was enhanced through visits to locations such as the Guggenheim Museum in Boston, and her sense of adventure took flight over the Niagara Falls during the Franco-Canadian zoology congress held in Montreal in 2005. On visiting Paris, Tennessee she was delighted to view its Eiffel Tower, but noted slightly caustically that it was rather small! One of her main pleasures was writing detailed reports on these trips following her return to Paris and speaking to others about her experiences; another was driving fast sports cars, and latterly maintaining the vast sloping garden and its fruit trees at her weekend villa.

Françoise was always very elegant, poised, and was passionate about art, history, theatre, and loved great music; she attended performances several times a month in Paris and was a frequent visitor to art and museum exhibitions. She was interested in and generously supportive of the research of her younger colleagues, and was great company especially over a good meal accompanied by fine wine, particularly when discussing Palaeozoic bryozoans.

Françoise Bigey was a remarkable person, well-educated and highly cultured, a passionate scientist who left a legacy of research on Devonian bryozoans, and who lived an exceptional life. Remembered with fondness, particularly by members of the IBA, she was honoured in the name of the fenestrate bryozoan *Bigeyina*.

Jean-Loup d'Hondt
Muséum national d'Histoire naturelle, Paris

Patrick Wyse Jackson
Trinity College Dublin

Jennifer Clack
1947 – 2020

Image courtesy of Tim Smithson.

Jenny Clack, FRS and Lapworth medalist, transformed our understanding of early tetrapods and revitalized study of the fish-to-tetrapod evolutionary transition. Her death in late March, after living with cancer for five years, cut short a still vital research programme, active through to the very end.

Jenny completed her first degree, a BSc in Zoology (1970), at Newcastle University in the north of England. Crucially, this established the connection with her future mentor, Alec Panchen. Alec's work on Carboniferous tetrapods triggered serious interest, but Jenny's wishes to undertake a PhD were thwarted. Redirected, she qualified in museum studies at the University of Leicester, and got her first job at Birmingham Museum and Art Gallery. However, it was during this initial stint in the world of collections, curation and public education that Jenny first made headway with Palaeozoic amphibians (*sensu lato*). She gained permission to borrow a specimen of the Carboniferous tetrapod *Pholiderpeton* from Keighley Museum in West Yorkshire. Once armed with this trophy (previously studied by vertebrate palaeontology grandees Huxley and Watson), Jenny returned to Newcastle and the Panchen lab, secured a NERC studentship and started her PhD in 1978 (completed in 1984).

Pholiderpeton the project, coupled with her appointment as Assistant Curator at the University Museum of Zoology, Cambridge (1981), set both stage and direction for the rest of her research life. *Pholiderpeton* the fossil drew Jenny deep into the meticulous comparative morphology of the Panchen school, and, in so doing, delivered a stapes, thereby establishing a lifetime's fascination with evolving (vertebrate) ears. Meanwhile, the Cambridge move provided an exceptional new working environment, replete with neglected treasures. The most notable of these were specimens collected by John Nicholson in 1970 of the Devonian tetrapod *Acanthostega*, poorly known cousin of *Ichthyostega*, the classic connecting form linking lobe-finned fishes with limbed tetrapods. Recognized, rescued and written-up, these specimens set Jenny on course for East Greenland, while at the same time providing grounds to open communications (and thaw relations) with the *ancien régime* of Devonian tetrapodology in Stockholm.

In 1987, Jenny, together with husband Rob Clack and her first PhD student, Per Ahlberg, joined the summer field programme organized by the Grønlands Geologiske Undersøgelse with Svend Bendix-Almgreen and student Birger Jørgen. Rediscovering Nicholson's field localities, they returned laden with career-defining material, mostly of *Acanthostega*, but with key *Ichthyostega* items, too. Back in Cambridge, the team assembled to carve into this Devonian tetrapod motherlode, initially

included myself and – rarely mentioned – Nick Fraser, where we struggled with recalcitrant matrix. Subsequently, fossil preparation was completed with tenacity and skill by Sarah Wallace-Johnson, plus long-term volunteer help from Rosie Rush. Resultant papers covered tetrapod gills and breathing, primitive limbs and digits, the middle ear and braincase, and propelled Jenny's research into the limelight of popular and science media attention.

But there was more. From the 1970s onwards, the Panchen lab had built a successful working relationship with Stan Wood and his remarkable discoveries of fossil sharks and ray-finned fishes, and a series of new tetrapod localities in the Lower Carboniferous of the Scottish Midland Valley. As Alec Panchen's research wound down, Jenny's stepped up and, by the mid-1990s, her lab had become the natural successor and hub for all UK-based, and arguably all European work on early tetrapods. With a fresh perspective on these early, terrestrial, or at least partly terrestrial, vertebrates, she was able to make new sense of the extraordinary array of material now available from Stan Wood's sites such as Dora and East Kirkton. A notably male-free return expedition to East Greenland in 1998 yielded yet more Devonian tetrapod material – of both specimens and taxa. Importantly, these fossils marked the start of a thorough re-evaluation of the iconic *Ichthyostega* (traditionally depicted with chin on the beach and tail in the water), leading Jenny towards new collaborations targeting the biomechanics of these extraordinary transitional forms. Specimen collecting and collections development represented an important part of Jenny's activity – likely influenced by her initial professional training in Leicester. The University Museum of Zoology, Cambridge now houses an impressively expanded collection of Palaeozoic vertebrates, many from Jenny's work with Stan Wood, but also from her own efforts, including Carboniferous sharks from Derbyshire, and a major project in the Scottish Borders (more on this below).

Building upon this substantial and growing foundation of field- and lab-work, the early 2000s saw the publication of Jenny's grand synthesis, *Gaining Ground: The Origin and Evolution of Tetrapods*. More than a handbook, *Gaining Ground* provided space for the big picture of vertebrate terrestrialization, drawing together the complementary strands of her, and her colleagues', work. Updated and expanded, the second edition (2012) presented a further essential addition to library and lab shelves.

In terms of major research achievements, arguably project TW:eed (Tetrapod World: early evolution and diversification) capped Jenny's career. In part, this sprang from arguments in the early 1990s about the meaning of an apparent void in the vertebrate record at the base of the Carboniferous. Acknowledging previous recognition of the same phenomenon, we named it 'Romer's Gap'. At much the same time, Tim Smithson (another Panchen-protégé) was exploring the Scottish Borders for early Carboniferous vertebrate localities. Teamed-up with the aforementioned Stan Wood, the pair discovered a whole suite of tetrapod horizons running right through the gap in question. Within the framework of TW:eed, Jenny united almost two decades of groundwork from Tim and Stan with teams from the universities of Leicester and Southampton, the British Geological Survey and National Museums Scotland, creating an exemplary cross-disciplinary project (NERC-funded), the output of which is still emerging.

Jenny enjoyed motorbikes, choral singing and thriving quietly on the stimulus – provocation – of her surrounding students and colleagues. Jenny tended to avoid seeking the prominence of committee, department or professional society leadership. Rather than shape things through

organizational change, she sought to transform our discipline through research and publications. One of the very best acknowledgements of such essential stimulus-input was to her husband, Rob Clack, for 'mithering' (look it up) her into the Greenland expeditions. Jenny provided the space for projects – and people – to become established. Her successes prompted similar work internationally, spawning yet more discoveries of fish–tetrapod intermediates, and, above all, transformed our understanding of tetrapod origin and terrestrialization.

Honours awarded to Jenny, in addition to the Lapworth Medal, included Foreign Honorary Membership of the American Academy of Arts and Sciences, the Daniel Giraud Elliot Medal of the National Academy of Sciences, an honorary doctorate from the University of Chicago, and election as Fellow of the Royal Society, further distinguished as the first female vertebrate palaeontologist to be elected in the 352-year history of that institution. Jenny's students have achieved considerable success and prominence in their own right, spreading to Australia, Sweden and beyond, and these, in turn, have introduced many talented new individuals into the broad field of palaeobiological research, and/or followed her footsteps into museum education and outreach. Pandemic circumstances and imposed remoteness are delaying the impact, but I get the sense that for many of us who knew and worked with her, the size, shape and significance of the Clack-gap is only just becoming apparent.

Michael Coates
University of Chicago

Roger Alan Cooper 1939 – 2020

Roger Alan Cooper, who has died after a brave battle against cancer, was an esteemed specialist in Ordovician graptolites and Cambrian trilobites. He was a widely respected expert on the geological evolution of New Zealand, his home for almost all his life. As a global authority on the Ordovician timescale he was instrumental in developing methods of precise biostratigraphic correlation that are used worldwide.

Image © GNS Science.

Roger was born in Lower Hutt, New Zealand on 12th March 1939. He attended Victoria University at Wellington, where his undergraduate studies were influenced by Prof. Harold Wellman, a renowned enthusiast in structural and field mapping. Roger's thesis for his Master of Science in Geology degree, submitted in 1962, was on 'The Geology of the Upper Takaka-Riwaka District, North-West Nelson'. This rugged area, in the northern part of the South Island of New Zealand, became the focus of several of his later studies.

Immediately thereafter, Roger commenced short-term employment with the New Zealand Geological Survey, then part of the NZ DSIR (Department of Scientific & Industrial Research, later to become the Institute of Geological and Nuclear Sciences, and subsequently GNS Science). For 18 months in 1963–1964, Roger worked in Borneo as a field geologist on a United Nations Development programme. His first wife Dorothy (Dot) Berry completed her degree in biology after their marriage and then joined him in Borneo, assisting in geological surveying there and also developing a love of orchids in which she became an authority.

After returning to New Zealand Roger undertook PhD studies (1966–1969) at Victoria University which focused on Ordovician graptolites of the Aorangi Mine area, Wangapeka Valley and Hailes Knob in north-west Nelson Province. He delineated 11 graptolite zones in this region, which has the most complete Ordovician sections in New Zealand, and was able to precisely tie these into the well-known graptolite successions in Victoria, Australia. This landmark study was subsequently published by DSIR as a monograph in 1979 (*New Zealand Geological Survey Paleontological Bulletin* 47).

On completion of his PhD, Roger worked as a palaeontologist in the New Zealand Geological Survey, becoming Chief Paleontologist in 1989. Retiring in 2002 he was appointed Emeritus Research Scientist (Paleontology). His publications included more than 115 scientific papers and monographs, on themes as diverse as (1) graptoloids, their biostratigraphy, evolution, extinction, biogeography and palaeoecology, (2) Cambrian trilobites and agnostoids, (3) biostratigraphy and biogeographic implications of a range of groups that he was not a specialist of (such as conodonts, brachiopods and micromolluscs) but for which he supplied the essential locality and stratigraphic information for his co-authors, (4) calibration of the global Cambrian and Ordovician timescales using innovative quantitative methods (in collaboration with Pete Sadler of UC Riverside), (5) the geological evolution and tectonic development of New Zealand and more specifically the palaeo-continent of Zealandia, and (6) research into the impacts of mid-Cenozoic drowning of Zealandia

on New Zealand's unique terrestrial biota. His research spanned the globe, with locations as widely separated as Antarctica, New Zealand and Spitzbergen. In 1979 he was awarded a Nuffield Science Foundation Travelling Fellowship enabling him to spend 15 months undertaking palaeontological research in the UK at the University of Cambridge and at the Natural History Museum, London.

He led, and was the principal author of, a comprehensive revision of the entire New Zealand geological time scale, making it a precise standard against which rates of geological and evolutionary processes across the entire south-west Pacific can be compared (Cooper 2004).

Roger was elected a Fellow of the Royal Society of New Zealand (more recently renamed Royal Society Te Apārangi) in 1988 and was awarded the New Zealand Science and Technology Silver Medal by that Society in 2003. In 2017 he was the recipient of the Society's Hutton Medal, awarded "for his contributions to understanding the geological foundations and the earliest organisms of Zealandia and beyond and for his role in maintaining and developing paleobiology expertise in New Zealand". He was awarded the degree of Doctor of Science by Victoria University in 1993 based on his outstanding scholarship and scientific publications.

Roger served on the executive of the International Palaeontological Association as Vice President. He was for many years the representative for New Zealand on the Subcommission on Ordovician Stratigraphy, and played a leading role in the Working Group of that body, set up to study and select candidate sections for the establishment of the GSSP for the Cambrian-Ordovician boundary.

In the last nine months of his life Roger was afflicted with cancer. Unable to stop the progress of his illness by conventional means, he visited China for treatment that unfortunately was unsuccessful. Roger died peacefully at Te Omanga Hospice in Lower Hutt, New Zealand on 2nd March 2020, aged almost 81 years. He is mourned by his wife Robyn (whom he married in 1991), children Alan, Julie, Aaron and Katrina, and eight grandchildren.

Roger was a gentleman and a scholar who was widely respected in New Zealand, Australia and around the world. He will be sadly missed by the global palaeontological community, particularly among specialists in graptoloids and Cambrian and Ordovician biostratigraphy and biogeography. His passing is a great loss to his colleagues refining the geological timescale by developing high-precision methods in correlation.

Ian Percival
(with assistance from Roger's widow and former colleagues at GNS)
Secretary, Subcommission on Ordovician Stratigraphy

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Research Grant REPORTS

Patterns of extinction and survival in early terrestrial herbivores

Neil Brocklehurst
Department of Earth Sciences, University of Oxford

The origin of herbivory in tetrapods during the Late Carboniferous was a crucial event in the establishment of terrestrial vertebrate ecosystems. By allowing access to the vast resource represented by plants, it led to considerable changes in patterns of trophic interactions on land. Herbivores are vital in terrestrial ecosystems, not only as the primary consumers supporting higher trophic levels, but also in the movement of nutrients between ecosystems (Sues and Reisz 1998). In a striking example of evolutionary convergence during adaptive zone invasion, at least eight clades independently adopted a herbivorous diet by the end of the Palaeozoic (Sues and Reisz 1998). These convergent evolutionary origins provide a natural laboratory for examining patterns of morphological evolution, convergence and ecomorphological partitioning during radiations.

The earliest evolution of herbivores during the Palaeozoic also provides an excellent opportunity for studying patterns of extinction within herbivores. The presence of large herbivores has increased nutrient concentrations on a continental scale, and their recent decline has caused nutrient diffusion to decrease (Doughty 2017). It is therefore crucial that we understand extinction and potential recovery patterns in vertebrate herbivores in a time of environmental change and plant extinction. The Pennsylvanian and the Permian (325–250 Ma) were punctuated by multiple mass extinctions. This includes the largest biodiversity loss in Earth's history at the end of the Permian, which, critically (unlike subsequent mass extinctions), had a substantial impact on plants (Pearson *et al.* 2013), thus providing an opportunity to examine how plant and herbivore radiations and extinctions interact to affect terrestrial ecosystems.

This research project aimed to examine morphological evolution alongside examinations of species richness to understand how the evolution of terrestrial ecosystems was affected by the origin of herbivory, and how the morphological evolution of herbivores was affected by extinction events. Three aspects of morphological data were collected. Discrete morphological characters relating to the feeding apparatus (teeth and jaws) were scored for over 500 tetrapod taxa, both from the literature and direct observation of the specimens. Structured light scanners were used to create 3D surface models of the skulls, landmarked along the toothrow, allowing analysis of how toothrow shape has changed through time (this aspect of the project has been placed on hold due to lack of access to the necessary software during the current coronavirus pandemic). Finally, skull lengths were measured as a proxy for body size.

The discrete characters were used in an analysis of rates of evolution and morphological diversity (disparity of carnivorous and herbivorous tetrapods throughout the Palaeozoic). The earliest

radiation of amniotes was characterized by an early burst of dental evolution, with high rates during their earliest origin and a rapid fall to lower rates that persisted throughout the Pennsylvanian and Cisuralian (Figure 1A). By contrast, the origin of herbivory is not characterized by any such early burst of evolution. Rates of dental evolution at their first appearance during the Pennsylvanian are consistent with those of contemporary carnivore lineages (Figure 1A).

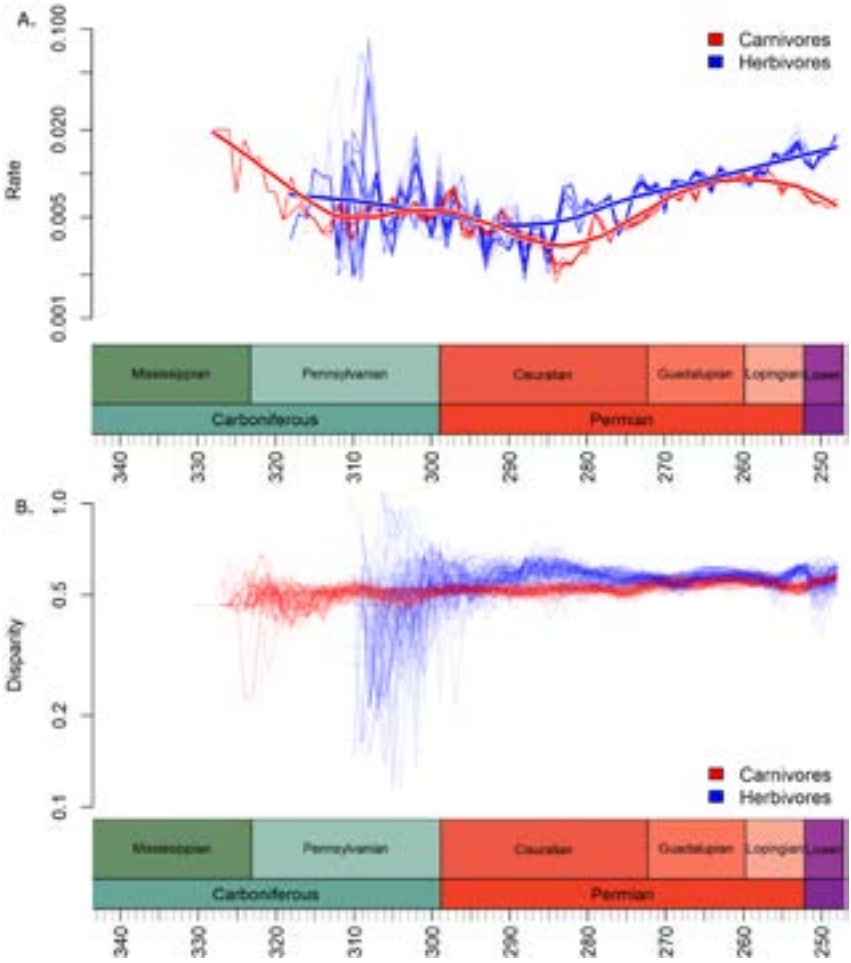

Figure 1. A) Rates of dental character evolution through time in carnivorous and herbivorous tetrapods; B) Dental disparity through time in carnivorous and herbivorous tetrapods.

Despite the lack of increase in rates in early herbivores, their dental disparity rises rapidly and had in fact surpassed that of carnivores by the end of the Carboniferous (Figure 1B). Surprisingly, the higher disparity of herbivore dentition does not appear to be related to increased rates of dental evolution. There are intervals during the Permian where the rate of dental evolution in herbivores exceeds that of carnivores, coinciding with turnovers in the prevailing herbivore lineages (Figure 1B). Towards the end of the Cisuralian, the edaphosaurids and diadectids were replaced by lineages with

entirely novel dental morphologies: captorhinids, with multiple rows of maxillary and dentary teeth forming grinding tooth plates, and caseids, with multi-cusped spatulate teeth (Pearson *et al.* 2013; Brocklehurst 2017). A second peak in rates of dental evolution in herbivores across the Cisuralian/Guadalupian boundary coincided with a mass extinction event and substantial changes in terrestrial ecosystems (Rees *et al.* 2002; Sahney and Benton 2008; Tarbor and Poulsen 2008).

The origin and subsequent radiation of herbivory in tetrapods had a substantial effect on the diversity of plants, potentially contributing to an extinction event across the Carboniferous–Permian boundary. Time series regression analysis supports a negative relationship of plant richness with herbivore richness (Figure 2A) but a positive relationship of plant richness with minimum herbivore body size (Figure 2B). This is consistent with studies of present-day ecosystems in which increased diversity of smaller, more selective herbivores places greater predation pressures on plants, while a prevalence of larger bodied, less selective herbivores reduces the dominance of a few highly tolerant plant species, thereby promoting greater local richness (Olff and Ritchie 1998). The diversification of herbivores across the Carboniferous–Permian boundary, along with the appearance of smaller, more selective herbivores like bolosaurid parareptiles (Pearson *et al.* 2013), constrained plant diversity throughout the Permian. These findings demonstrate that the establishment of widespread vertebrate herbivory has structured plant communities since the late Palaeozoic, as expected from examination of modern ecosystems, and illustrates the potential for fossil datasets in testing palaeoecological hypotheses.

The results of the analysis of rates and disparity have been presented at the International Congress of Vertebrate Morphology (ICVM 2019). The results of the comparison of herbivore and plant diversity are in press in the *Proceedings of the Royal Society B*.

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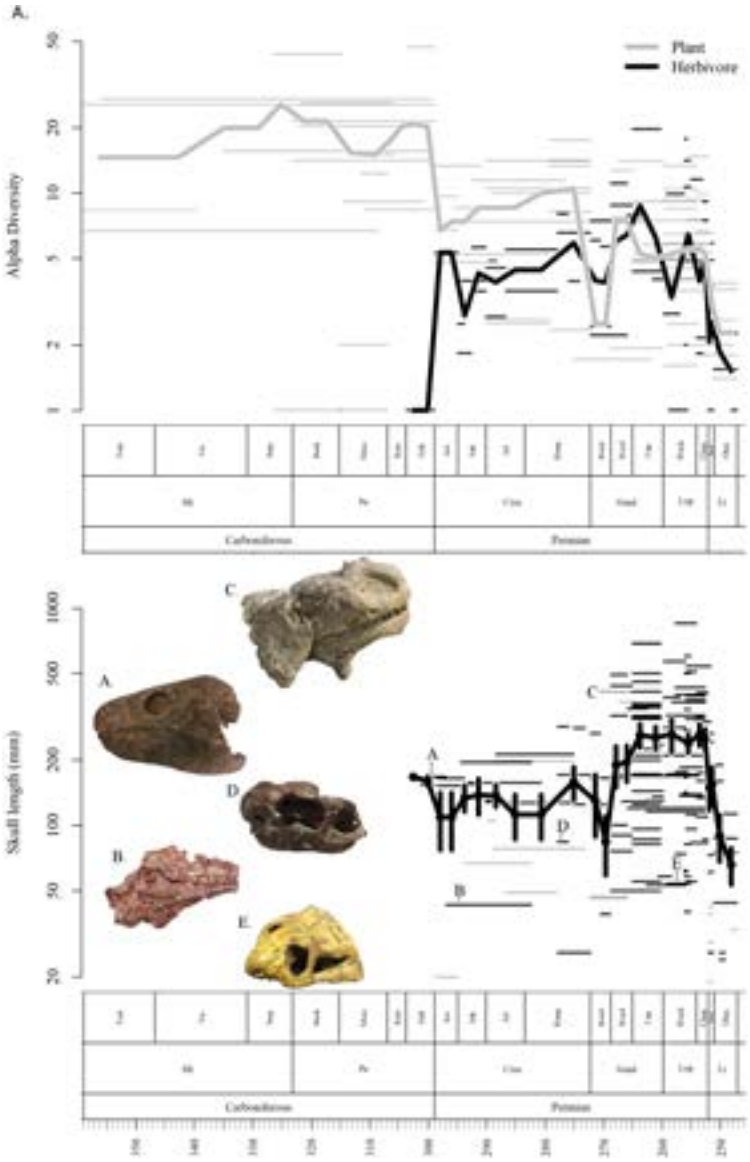

Figure 2. A) Local diversity of plants and tetrapod herbivores. Each thin line represents the diversity in a fossil-bearing formation. The thick lines represent the median diversity of all formations in each time bin; B) Size of Palaeozoic herbivorous tetrapods. The thick black line represents the median size in each time bin, and the bars represent the standard error. A = Diasparactus zenos *(FMNH UC 679), a diadectid; B* = Bolosaurus striatus *(AMNH FARB 4321), a bolosaurid; C* = Embrithosaurus schwarzi *(SAM PK 8034), a pareiasaur; D* = Casea broilii *(FMNH UC 656), a caseid; E* = Cistecephalus microrhinus *(BP/1/33), a dicynodont.*

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The origins of aerial breathing in terrestrial ecosystems: insights from virtual fossil reconstruction

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Terrestrialization represents a critical event in the history of the biosphere, resulting in the first complex palaeoecological interactions in subaerial environments and the establishment of modern land-based ecosystems (Kenrick *et al*. 2012). The fossil record plays a fundamental role in elucidating the acquisition of crucial adaptations necessary for complete terrestrialization (*e.g.* Dunlop and Garwood 2018) and, coupled with the insights provided by molecular clocks (*e.g.* Rota-Stabelli *et al*. 2015; Lozano-Fernandez *et al*. 2016), allows us to refine the timing and conditions under which different groups of living organisms migrated to this new environment.

The euarthropod fossil record has made substantial contributions to our understanding of this critical transitional period. Trace fossil evidence of activity in subaerial environments dates from as early as the Late Ordovician (see Kenrick *et al*. 2012), whereas the exceptional preservation in sites such as the Rhynie Chert offers an unparalleled view of the diversity of terrestrial organisms in full swing by the Early Devonian (Dunlop and Garwood 2018; Garwood *et al*. 2020). Indeed, recent findings from Rhynie have revealed a critical organismic link in the evolution of terrestrialization. Rhynie fossils have demonstrated that euthycarcinoids – a problematic Cambro–Triassic euarthropod group with contested affinities – are stem-group myriapods (Edgecombe *et al*. 2020). The main significance of this discovery extends beyond clarifying the affinity of euthycarcinoids, however, but rather contributes towards closing the gap between molecular estimates and the early fossil record of a major group of terrestrial animals. Palaeozoic myriapod fossils are relatively rare (*e.g.* Shear and Edgecombe 2010), at least when compared with other euarthropod groups, but have produced fundamental insights into the evolution of animal terrestrialization.

The oldest unequivocal myriapod body fossils known to date come from the so-called 'Cowie Fish Bed' in the Cowie Formation of Stonehaven, UK (Wilson and Anderson 2004; see also Trewin 1999)

(Figure 1A). Critically, the Cowie myriapods show evidence of spiracles, *i.e.* orifices on the sides of the body that allow aerial respiration in living representatives, and are preserved in braided fluvial deposits indicative of a terrestrial environment (Wilson and Anderson 2004; see also Selden 2010). This combination of body fossils, depositional environment, and stratigraphic occurrence make the Cowie Fish Bed a landmark fossiliferous site for early terrestrialization (Shear and Edgecombe 2010, Kenrick *et al*. 2012). It should be noted that whereas palynological work has suggested a Silurian (Wenlock) age for the Cowie Fish Bed (Marshall 1991), more recent radiometric U-Pb zircon dating suggests that this site may be Lower Devonian (Lockhovian) (Suarez *et al*. 2017; Brookfield *et al*. 2020) (Figure 1B).

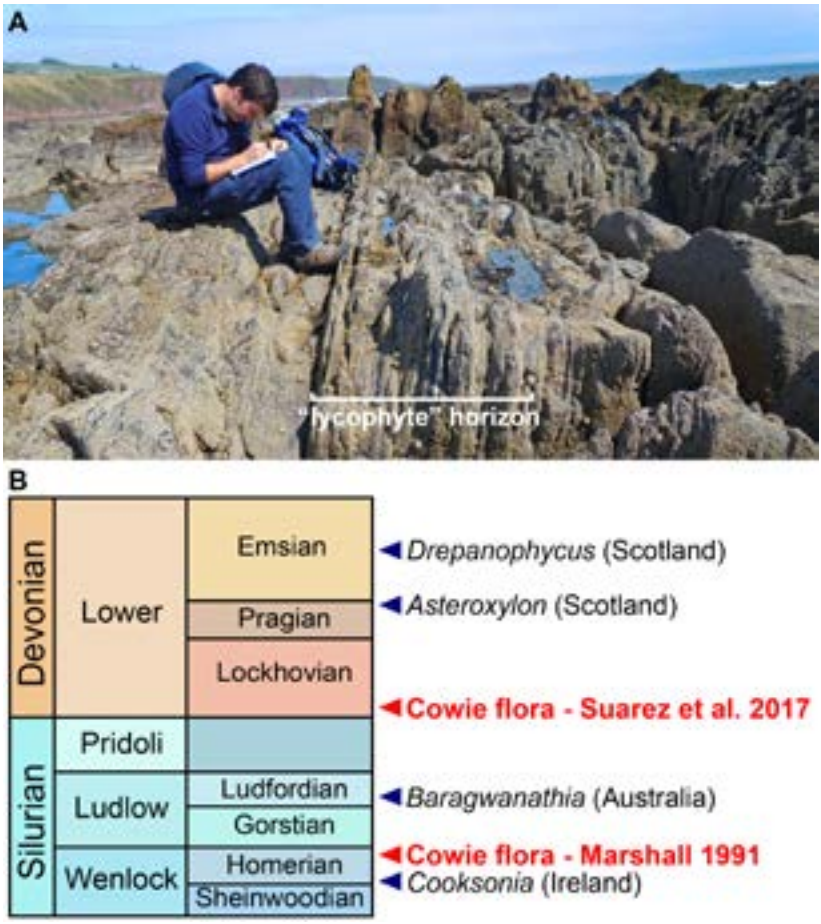

Figure 1. Stratigraphic distribution of early vascular plants in the Palaeozoic. A. The Cowie Formation reflects a fluvial depositional environment, including the moderately fossiliferous 'Cowie Fish Bed'. Within the latter, it is possible to identify a siltstone horizon containing stem-lycophyte-like macrofossils, previously unknown at this site. B. Although fossil spores suggest a Homerian age for the Cowie Fish Bed (Marshall 1991), recent radiometric dating suggests that it may be as young as lowermost Lockhovian (Suarez et al. *2017).*

Although the differences in the precise chronostratigraphic age of the Cowie Fish Bed carry important implications for reconstructing the timing of the earliest fully terrestrial euarthropods, the presence of morphological adaptations for aerial breathing remain of paramount importance. The original aim of this study was to employ cutting-edge computed tomography to investigate the fine-scale anatomy of the spiracles in selected Silurian myriapods, including the iconic *Pneumodsemus newmani* from the Cowie Fish Bed, to better understand the early evolution of land animals. Although the studied fossil material posed unexpected technical challenges and limitations that hindered the initial goals of this project, the fieldwork component produced unexpected results that may still contribute towards a better understanding of early terrestrial life.

Results

The holotype of *Pneumodesmus newmani* and a selection of fossil myriapods deposited at the Natural History Museum, London and the National Museum of Scotland in Edinburgh were analysed at the Henry Moseley X-ray Imaging Facility at the University of Manchester with a Nikon XTH 225 X-ray scanner. Although the small size of the fossil samples facilitated imaging at high resolution, the preservation of the material offered unexpected limitations. For example, *Pneumodesmus newmani* is preserved in relatively coarse green sandstone, which did not capture fine anatomical details other than the presence of slit-like spiracles on the pleurites (*i.e.* lateral body sclerites). This lack of resolution, compounded with the substantial degree of flattening observed in all the fossils, resulted in sub-par quality of the tomographic models and severely hindered comparisons with the morphology of extant representatives. Subsequent imaging efforts included the use of secondary electron microscopy and laser profilometry in order to obtain new morphological data, but again the preservation in coarse sandstone prevented the identification of fine details.

Although efforts to obtain new anatomical data from flattened Silurian and Devonian fossil myriapods did not yield substantial high-quality data, the fieldwork associated with this study presented some unexpected results. Two seasons of collecting in the Cowie Fish bed produced a large collection of material, mostly fragmentary, including isolated eurypterid sclerites, acanthodian bones, *Prototaxites* and filamentous algae. However, systematic sampling also revealed an approximately 1.5 m thick laminated grey siltstone sequence (Figure 1A) that produced dozens of a distinctive, and problematic, organism (Figure 2). The macrofossils are preserved as well-defined, and highly flattened elongate sub-conical structures with straight margins with a maximum length of *c.* 10 cm and a maximum width of *c.* 1 cm. Although it is clear that the fossils gently taper to a point, neither a clearly well-defined base nor tip were found. Throughout the fossils it is possible to observe dozens of triangular scale-like imbricated features that point towards the narrow end (Figure 2A), and which appear to be arranged in a helical pattern (Figures 2B-D). The fossils show a moderate degree of convexity and different colour relative to the rock matrix, suggesting a degree of robustness in life, but backscatter electron microscopy did not detect traces of organic carbon.

Discussion

The new macrofossils from the Cowie Fish Bed represent a new taxonomic record for this important site, but its affinities remain somewhat enigmatic. At first glance, the scale-like pattern of these structures invites comparisons with acanthodian remains, which are after all the namesake for the Cowie Fish Bed (Trewin 1999), but the preservation is entirely distinct from that of fish bone in the section, which show a distinctively dark colouration, and a fibrous-like surface texture. The scaly

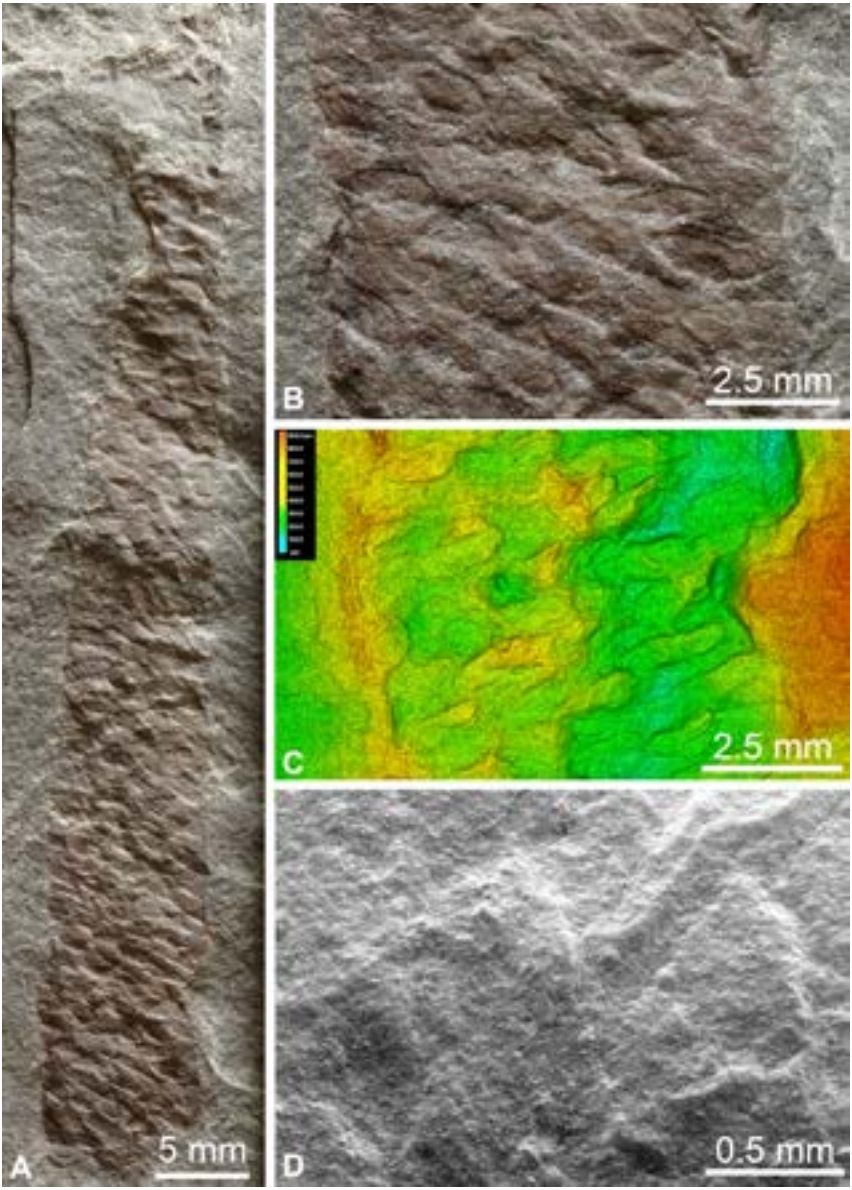

Figure 2. Lycophyte-like enigmatic macrofossil from the Cowie Formation in Stonehaven. A. Overall view of well-preserved specimen. B. Close-up of scale-like pattern on fossil. C. Laser profile of fossil showing presence of helically arranged scales. D. Secondary electron micrograph of two adjacent scales.

pattern is also somewhat reminiscent of the cuticle of eurypterids (*e.g.* Lamsdell *et al*. 2015), and their overall shape would resemble the spiniform tailspine of these euarthropods. However, the asymmetric and helical arrangement of the scales is at odds with this interpretation (Figure 2B, C). Yet another alternative is that the new Cowie fossils may represent the remains of lycopsid vascular plants; the straight outline of the fossils closely resembles a stem, and the helically-arranged scales are similar to the enations observed in lycophyte-like taxa known from Silurian and Devonian deposits around the world, including the Rhynie Chert (Kidston *et al*. 1920; see also Garwood *et al*. 2020). If correct, this interpretation would make the "Cowie lycopsid" one of the earliest occurrences of complex and large vascular plants, second only to the Silurian (Ludlow) *Baragwanathia* from Australia (Garrat 1978) (Figure 1B) based on the Lockhovian radiometric date of the Cowie Fish Bed (Suarez *et al*. 2017). However, a vascular plant affinity for the new Cowie fossil also has its caveats, as there is no evidence of branching from at least two dozen specimens, and the scale-like structures do not extend beyond the lateral margins as commonly observed in compressed lycopsid fossils (see Kenrick *et al*. 2012). It appears plausible that the problematic affinities of the (affectionately nicknamed) "Cowie fish-plant" may result from its peculiar style of preservation, which has been diagenetically affected not only by local tectonism (evidenced by the 90° inclination of the strata (Figure 1A) but also by the offshore location of the outcrop and percolation of seawater. Future collecting efforts from the Cowie Fish Bed may reveal additional, better-preserved specimens with diagnostic features that clarify the affinities and evolutionary significance of these promising fossils.

Acknowledgements

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Studying the soft tissues of exceptionally preserved Carboniferous crinoids with high-resolution X-ray microtomography

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Introduction

Crinoids were abundant and ecologically significant constituents of marine ecosystems throughout the Palaeozoic, with over 8,000 named species belonging to six major clades, only one of which is extant (Lane 1990; Ausich *et al*. 1994; Wright *et al*. 2017). Because most crinoid lineages are extinct, studying their fossils is key to elucidating the disparity, phylogeny and evolutionary history of the class. However, the internal anatomy of Palaeozoic forms has largely been overlooked in work on crinoid ecology and evolution.

Soft-tissue preservation has been recognized among Palaeozoic crinoids since the mid-nineteenth century (*e.g.* Hall 1865; Meek and Worthen 1868; Billings 1869). Fossil crinoids from Lower Carboniferous rocks (Burlington, Harrodsburg and Salem limestones) in the Midwestern USA are preserved three-dimensionally with internal structures that have been interpreted as the remains

of the digestive, nervous and water vascular systems (Haugh 1973, 1975a, b). Previous work on this material (Meek and Worthen 1868; Wachsmuth 1877; Wachsmuth and Springer 1897; Haugh 1973, 1975a, b) relied on broken specimens, some of which were intentionally damaged to expose internal morphology. These specimens were studied with the aid of drawings and photographs, hindering the reconstruction of anatomical details in three dimensions.

This project aimed to describe the internal anatomy of these exceptionally preserved fossil specimens in three dimensions using high-resolution, non-destructive X-ray microtomography (XMT).

Methods

A total of 75 fossil specimens representing 16 genera and 27 species were selected for study with XMT. The vast majority were monobathrid camerates (20 species in three families), but a small number of diplobathrid camerates (four species), cladids (two species) and flexibles (one species) were also investigated. Among the monobathrid camerates, over one-third of the specimens belonged to a single species, *Macrocrinus verneuilianus*.

We primarily selected broken specimens preserving evidence of internal structures, including many of the fossils examined in earlier work (Meek and Worthen 1868; Wachsmuth and Springer 1897; Haugh 1973, 1975a, b). Given the regularity of internal structures in broken specimens of *M. verneuilianus*, we also selected five unbroken specimens. Although internal structures were not observed in any cladids and flexibles, we selected a few well-preserved specimens for investigation. Samples were borrowed from the Museum of Comparative Zoology at Harvard University (MCZ) and the Smithsonian National Museum of Natural History (NMNH).

Scans were performed using Nikon Metrology XT H 225 systems in the Life Sciences Building at the University of Bristol and the CTEES facility at the University of Michigan. The resulting tomographic datasets were inspected and cropped in ImageJ. Select scans were digitally reconstructed as three-dimensional models using Materialise Mimics or SPIERS software.

Results

Of the 75 specimens imaged with XMT, 53 showed internal anatomy, including mineralized tissues associated with the ambulacra, perivisceral coelomic ring and gut (Haugh 1975a). The so-called 'convoluted organ', which consists of a large, spirally-coiled, spindle-shaped structure, was the most obvious feature in the scans (Figure 1). This was preserved through secondary silicification or calcification. Some internal structures described by Haugh (1973, 1975a, b), including elements of the nervous system, have yet to be identified. This may be because they were preserved in a similar material to the rest of the fossil and thus did not show substantial X-ray attenuation contrast, hampering processing with image segmentation software.

Preservation of internal structures was restricted to camerates, especially monobathrids. This included all five unbroken specimens of *M. verneuilianus*, providing an opportunity to study the interior of intact camerate calyxes for the first time. There was no soft-tissue preservation found within the studied cladids or flexibles. Especially noteworthy is the absence of the convoluted organ. Whether this is a real difference or an artefact of taphonomy remains unclear; it might reflect the enhanced calcification of organ walls thought to have occurred in living camerates, which provided a framework for secondary calcification or silicification, facilitating the preservation of major internal organ systems (Haugh 1975a).

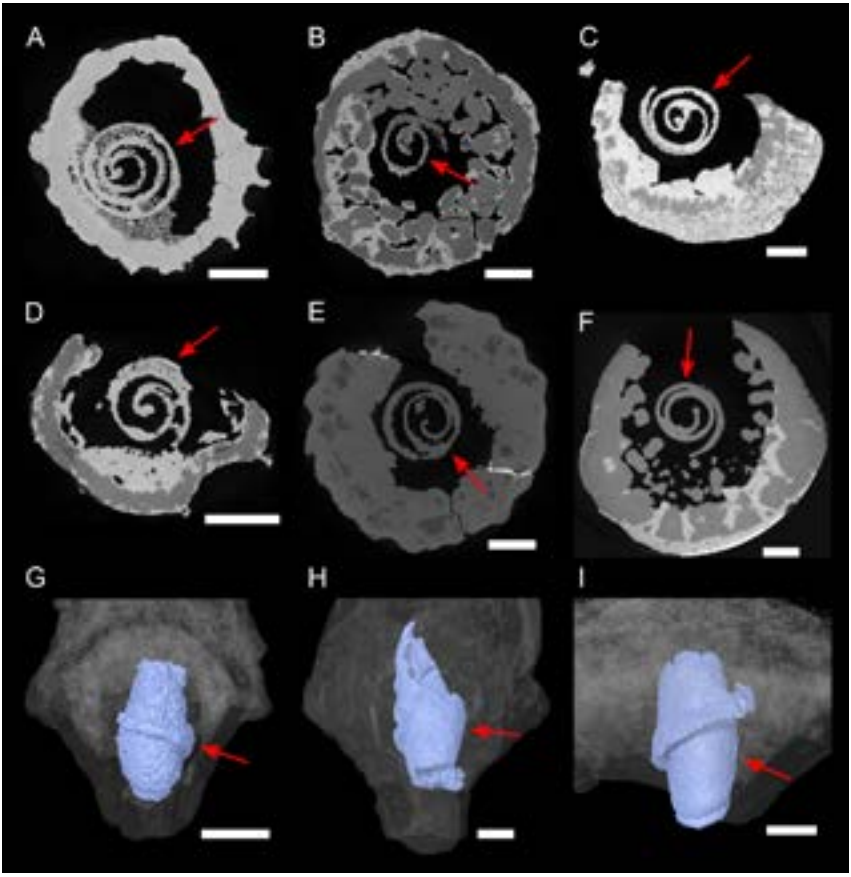

Figure 1. Camerate crinoids from the Lower Carboniferous of Midwestern USA. A) Slice from XMT scan of Cactocrinus proboscidalis *(MCZ 102199). B) Slice from XMT scan of an undetermined crinoid (MCZ 112492). C) Slice from XMT scan of* Strotocrinus perumbrosus *(MCZ 111866). D) Slice from XMT scan of* Macrocrinus verneuilianus *(MCZ 149D). E) Slice from XMT scan of* Uperocrinus pyriformis *(NMNH S8484a). F) Slice from XMT scan of* Eutrochocrinus christyi *(NMNH S885). G) 3D model of* Macrocrinus verneuilianus *(MCZ 149D) with calyx partly transparent. H) 3D model of* Uperocrinus pyriformis *(NMNH S8484a) with calyx partly transparent. I) 3D model of* Eutrochocrinus christyi *(NMNH S885) with calyx partly transparent. Arrows indicate internal convoluted organ. Scale bars are 5 mm.*

Future work

Our results demonstrate that internal anatomy can be non-destructively imaged and reconstructed in three dimensions in exceptionally-preserved Carboniferous camerate crinoids. Future work will focus on creating virtual models of all 53 specimens that preserve soft tissues. These data will be used to test hypotheses about the function of the convoluted organ, which has been debated for over 150 years (Meek and Worthen 1868; Billings 1869). We will compare our results to XMT scans of living species, thereby establishing if a homologous organ exists in extant crinoids. In addition, we will describe previously undocumented details of internal anatomy (*e.g.* preservation of hind

gut through the anal tube in *Teleiocrinus*) and explore intraspecific and interspecific variation in the convoluted organ across camerates.

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Small Grant REPORTS

Ecology of Silurian deep-water coral communities

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Corals are known to act as powerful ecosystem engineers and have the ability to form reef communities with extraordinary biodiversity through time. Putative corals have been known since the early Cambrian (Sorauf and Savarese 1995). However, it was during the late Ordovician when two major orders, Tabulata and Rugosa, came to ecological prominence until their demise in the Permo–Triassic Mass Extinction.

In this study, I used Spatial Point Process Analyses (SPPA) to address an important question in reef ecology through investigation of the mechanisms by which sessile reef-building organisms interact with one another (Wood 1999; Karlson *et al*. 2007). SPPA enable investigation of the ecological mechanisms and physical influences by which coral communities are structured by approximating organism positions to points which can be supplemented by further information such as species, size and orientation (Illian *et al*. 2008). Species spatial distributions can be summarized using spatial metrics such as Pair Correlation Functions (PCFs), which describe the density of points across the distribution as a function of radius. PCFs can then be compared to Monte-Carlo simulations of the distribution under different models, such as Thomas cluster models, which describe dispersal (reproductive) clusters or heterogeneous Poisson models which describe habitat influence. Through these model-fitting analyses, which are equally applicable to fossil and extant *in situ* sessile communities, complex patterns can be elucidated that visual inspection alone cannot detect (Mitchell *et al*. 2019).

The Kilbride Peninsula in Ireland comprises marine sediments that form part of the Midland Valley platform of Ireland and Scotland (Clarkson and Harper 2016). The Kilbride Formation is especially fossiliferous and contains brachiopods, trilobites, crinoids, skoilithos burrows and corals (Gardiner and Reynolds 1912). One particularly well-preserved bedding plane in this formation shows a diverse fauna dominated by tabulate corals preserved *in situ* by a volcaniclastic surge (Figure 1A–D). Weathering through the exposed surface reveals coral colonies that have rapidly decalcified to leave moulds of the corals (Harper *et al*. 1995). This Pompeii-esque mass mortality allowed me to use SPPA to investigate the community ecology of this deep water assemblage, moments before their demise. The coral community contained >20 genera in 199 specimens in the sampled area. The bedding planes were scanned using LiDAR and photogrammetry (see Mitchell *et al*. 2019).

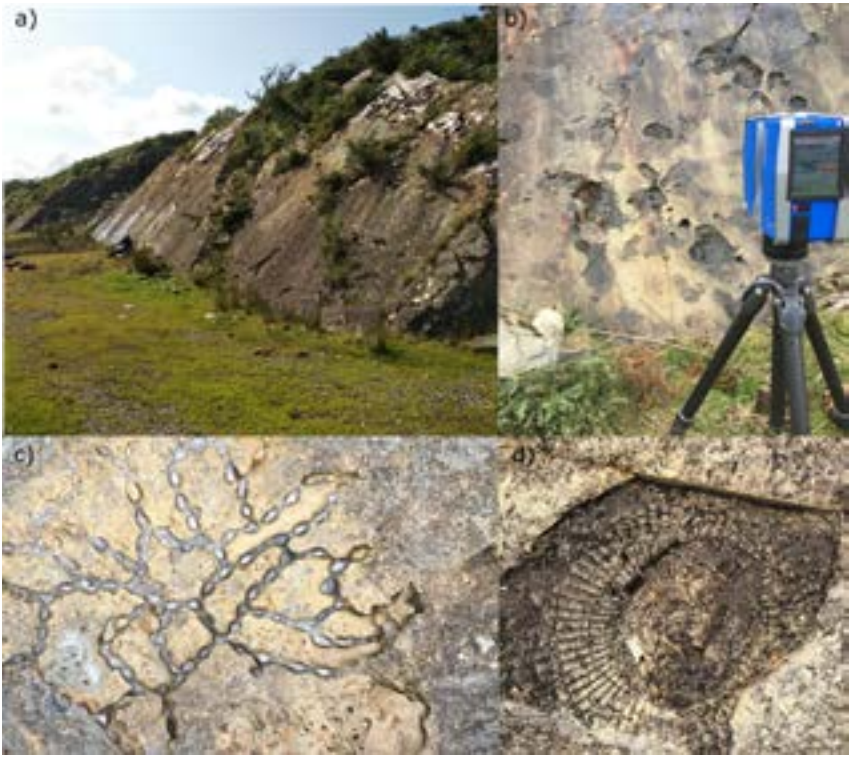

Figure 1. A) Field image of the bedding surface investigated. B) LiDAR scanner, with the coralliferous surface in the background. C) Heliolites *sp. (tabulate) coral from the Kilbride Formation. Image width 6.8 cm. D)* Schlotheimophyllum patellatum *(rugose) epitheca external mould from the investigated surface. Image width 7.6 cm.*

Multiple models were investigated for each distribution. All of the univariate distributions best fit Double Thomas Cluster processes (Figure 2A, C, D). The bivariate distribution describing the rugose and tabulate corals best fit Linked Double Thomas Cluster (LDTC) processes (Figure 2B), centred on the tabulate corals. LDTC indicates facilitation (whereby one taxon increases the survival of another), with the clusters centred on the facilitating taxa (Dickie *et al*. 2005). Facilitation is thereby the key driver of the inter-specific spatial structure in this assemblage and could be an important factor that drives the aggregation of corals that eventually form closed-packed, long lasting (reef) communities.

The implications of positive interactions and ecological engineering on longer evolutionary timescales is now being recognized (*e.g.* Valiente-Banuet *et al*. 2006). In the context of communities of corals, if the presence of these organisms can facilitate other sessile taxa, as is demonstrated in this study, this effect in itself has the ability to increase the diversity of sessile organisms through time by allowing the facilitated taxa to survive in a greater range of environments through time. By expanding the niches of taxa, more diverse communities can be sustained and so the presence of facilitating taxa can increase diversity of organisms through time. Corals, as structural physical

ecosystem engineers, play an ecosystem engineering role in the Ordovician radiation (Erwin and Tweedt 2012). These analyses provide a mechanism by which the rugose and tabulate corals, which originated during this radiation, interacted in a physical, ecosystem-engineering context.

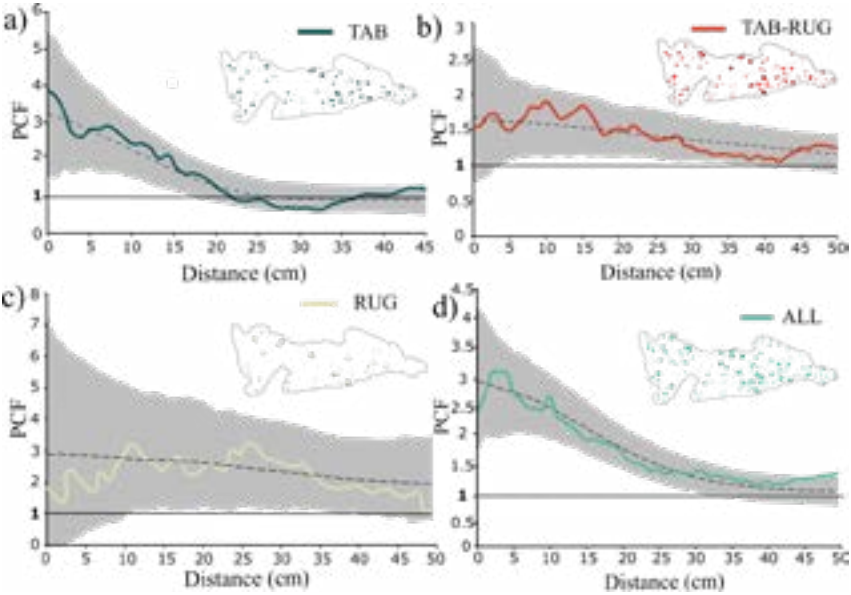

Figure 2. Best fit models of univariate and bivariate PCF analyses. A) Univariate PCF of the tabulate corals overlain on the best fit 999 Monte-Carlo simulations of a Thomas double-cluster model for the tabulate distribution. B) Bivariate PCF of the tabulate-rugose distribution on a linked-double Thomas cluster envelope. C) Univariate PCF of the rugose corals and best fit (double-Thomas cluster) envelope. D) Univariate PCF of all the corals on the surface, also best fit with a double-Thomas cluster model.

Acknowledgements

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Morphological changes in benthic foraminiferal tests in oxygen-stressed environments

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Introduction

Patterns of organism size change in the fossil record are often used to help interpret the potential environmental triggers and physicochemical causes of species turnover because size is correlated to metabolic rate (Peters 1983). The morphology of benthic foraminifera has been used to reconstruct ancient oxygen levels (*e.g.* Kaiho 1994; Payne *et al*. 2012). Morphological patterns in foraminifera are often inferred to be species replacement, with more elongated, flattened species replacing more spherical forms with decreasing dissolved oxygen concentrations (Bernhard 1986). Select modern rotaliid species possess alternative metabolic strategies that permit them to inhabit low oxygen environments, like oxygen minimum zones (OMZs). Thus, their sizes do not conform with predictions based on first principles of cell physiology (Keating-Bitonti and Payne 2017). Nevertheless, within-species variations in test morphology of foraminifera possessing alternative metabolic strategies might exist along oxygen gradients that extend into OMZs. Although the species are presumed facultative anaerobes, these foraminifera might alter their test morphology in ways that do not alter size, but still offset the effects of reduced oxygen bioavailability. To build on the findings of Keating-Bitonti and Payne (2017), I tested the hypothesis that pore density increases on tests with decreasing oxygen concentrations to enhance oxygen gas exchange. I also tested the hypothesis that test walls thin with decreasing oxygen concentrations to reduce metabolic energy for calcification.

Methods

In this study, I examined within-species patterns of test wall thickness, test porosity, and chamber and test volumes of modern benthic foraminiferal species collected from core-top sediments in the Santa Monica Basin (SMB) OMZ located off southern California, USA. Using 0.3-mm resolution micro-computed tomography (micro-CT) scans, I created high-resolution images of the tests of *Bolivina argentea*, *Bolivina spissa* and *Uvigerina peregrina* specimens (Figure 1). These three species are presumed facultative anaerobes: *B. argentea* is known to denitrify (Bernhard *et al*. 2012; Piña-Ochoa *et al*. 2010), and *B. spissa* (Glud *et al*. 2009) and *U. peregrina* (Piña-Ochoa *et al*. 2010) accumulate intra-cellular nitrate in the absence of oxygen. I selected megalospheric forms from

rendered micro-CT images to quantify proloculus and chamber volumes, test wall thickness, and test porosity.

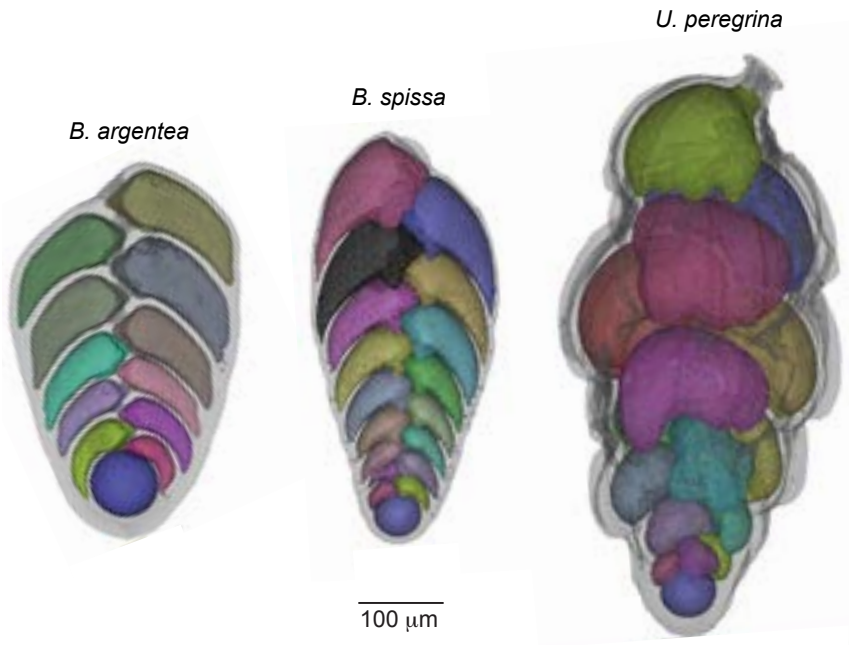

Figure 1. Micro-CT images of B. argentea, B. spissa, *and* U. peregrina *specimens (left to right).*

Results and summary

In response to varying dissolved oxygen levels, *B. argentea*, *B. spissa*, and *U. peregrina* reveal different patterns of chamber addition and growth (Keating-Bitonti and Payne 2017). *U. peregrina* has a significant trend of increased proloculus size volume (*p*-value = 0.01; $R^{2 = 0.3}$) and increased total test volume (*p*-value = 0.002; R2 = 0.4) with decreasing dissolved oxygen concentrations. This inverse relationship might reflect the cell volume required for *U. peregrina* to harbour large nitrate-storing vacuoles (*e.g.* Piña-Ochoa *et al*. 2010) with decreasing oxygen bioavailability.

B. argentea and *B. spissa* show no variation in proloculus volume or total test volume across the oxygen gradient. Although *B. argentea* can offset the effects of oxygen limitation on cell size via denitrification (*e.g.* Bernhard *et al*. 2012), this species has a significant trend of thinning test walls with decreasing oxygen concentrations (*p*-value = 0.05; R2 = 0.1). Decreasing test thickness likely reflects the increased metabolic cost of calcification in OMZs, which are environments of low seawater carbonate saturation (Paulmier *et al*. 2011). *B. spissa* shows an increased range in test porosity with decreasing oxygen concentrations, suggesting a potential means to increase oxygen gas exchange in oxygen-stressed waters (Bernhard *et al*. 2010; Bernhard *et al*. 2012; Burke *et al*. 2018). This new research suggests *B. argentea* and *B. spissa* offset the effects of reduced oxygen bioavailability by altering different aspects of test morphology, aside from test volume. Thus, the sizes of benthic foraminifera in the fossil record cannot be used in any simple way to reconstruct

ancient dissolved oxygen concentrations without fully understanding the metabolic strategies of the indicator species.

Acknowledgements

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Patagonian Ornithopod dinosaurs and the conquest of Western Gondwana

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Introduction

Ornithopods were the most successful group of Mesozoic herbivorous dinosaurs in terms of worldwide diversity and duration. The clade is formed of basal forms (*Thescelosaurus*, *Parksosaurus*, *Gasparinisaura*, *Notohypsilophodon*), iguanodontids and hadrosaurids (Fastovsky and Weishampel 2009). From their first appearance in the Jurassic until their extinction at the end of the Cretaceous, the ornithopods included around 100 species globally (Fastovsky and Weishampel 2009). Throughout the Cretaceous the ornithopods showed a wide distribution, characterized by a lower diversity in the Southern Hemisphere with respect to the Northern Hemisphere (Weishampel *et al*. 2004). In Argentina they represent the most abundant group of ornithischian dinosaurs with most finds being Patagonian (Cruzado-Caballero *et al*. 2018, 2019; Jimenez-Gomis *et al*. 2018). In the Argentine inventory of these dinosaurs it is possible to differentiate two different groups: a first group formed by small-sized ornithopods such as *Gasparinisaura* and *Anabisetia*, and a second group composed of medium-sized ornithopods such as those of the clade Elasmaria.

Figure 1. The fieldwork team at the Municipal Museum Argentino Urquiza.

The first discovery of a bone from an ornithopod in Argentina dates from the late nineteenth century, a fragment of a femur of the *incertae sedis* '*Loncosaurus argentinus*' Ameghino 1899 (from the Santonian–Campanian age Mata Amarilla Formation). This fragment was first described as

belonging to a theropod, and later Molnar (1980) reassigned it to the clade Ornithopoda. Since this reassignment in the later decades of the twentieth century, Ornithopoda have undergone a significant increase in Argentina with the description of several new species, such as *Talenkauen*, *Mahuidacursor*, *Sektensaurus*, *etc*., and multiple fragmentary remains (Cruzado-Caballero *et al*. 2018, Jimenez-Gomis *et al*. 2018).

Although the remains of these dinosaurs have been known for some decades, their phylogenetic relationships remain problematic and require new studies and analyses in order to help clarify them. An example of this is the clade Elasmaria which, according to the phylogenetic analysis consulted, can include Argentine, Antarctic and Australian taxa (Rozadilla *et al*. 2019) or can only be formed of Argentine taxa *Macrogryphosaurus*, *Nothohypsilophodon* and *Talenkauen* (Boyd 2015). This problem is largely due to the scarcity of cranial material and the incompleteness of the specimens limiting the presence of overlapping material.

Recently, remains of a new basal taxon, *Mahuidacursor lipanglef*, and several indeterminate remains of ornithopod from the Late Coniacian–early Santonian sites of Puesto Hernández, Cerro Overo and La Escalonada and the Santonian of Rincón de los Sauces (Neuquén, Argentina) have been published (Cruzado-Caballero *et al*. 2018, 2019; Jimenez-Gomis *et al*. 2018). These finds show a rich record of ornithopods in the area that exhibit affinities with the Elasmaria clade, demonstrating the need for further fieldwork.

Field campaign

Between 8th and 15th November 2019, a field campaign was carried out in the area of Cerro Overo (Rincon de los Sauces, Neuquén province) with a multidisciplinary Argentinean team of researchers (Figure 1), comprising vertebrate palaeontologists, palaeobotanists, taphonomists and geologists: five researchers and three PhD students from the National Council of Scientific and Technical Research (CONICET), the Museum Olsacher Zapala and the Municipal Museum Argentino Urquiza in Rincón de los Sauces. Resulting from this fieldwork were two partial skeletons representing a sauropod and a theropod dinosaur (Figure 2); isolated remains of ornithopods and crocodiles and several remains of fossil tree trunks were found. The skeletons of the sauropod and the theropod dinosaurs were partially excavated and extracted. In the case of isolated remains and tree trunks, all were collected. The materials were deposited in the Municipal Museum Argentino Urquiza as dictated by Argentine law. The fossil preparation work is being carried out in this Museum to enable further study.

Figure 2. Digging a new theropod dinosaur.

Preliminary data collected in the field, prior to a more detailed study to be carried out following completion of the preparation of fossils, tell us that we are probably looking at two new species of dinosaur (one sauropod and one theropod) and remains of new ornithopods with affinities to the clade Elasmaria.

Acknowledgements

I would like to thank the team of palaeontologists and geologists who helped me with their time and effort during the field campaign: Leonardo S. Filippi (Municipal Museum Argentino Urquiza), Ariel H. Méndez (Centro Nacional Patagónico-CONICET), Ariadna Paulina-Carabajal and María Laura Pipo (Instituto de Investigaciones en Biodiversidad y Medioambiente-CONICET), Elena Previtera (Instituto Nacional de Nivología, Glaciología y Ciencias Naturales-CONICET), Alberto C. Garrido (Museum Olsacher Zapala) and Francisco Barrios (CONICET). Without their help it would not have been possible. Thank you also to the Palaeontological Association who funded this project with a Stan Wood Award (PA-SW201802).

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Investigating cranial morphology in two geographically distinct groups of Oligocene cetaceans

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Background

The order Cetacea (whales, dolphins and porpoises) is composed of two extant suborders, Odontoceti (toothed whales) and Mysticeti (baleen whales), which are estimated to have diverged at ~39 Ma (Marx and Fordyce 2015). Of ~90 extant cetaceans, >70 are odontocetes. Oligocene odontocetes rapidly evolved refined, high-frequency echolocation, shifted cranial bones further posteriorly, and developed cranial asymmetry (Churchill *et al*. 2018), while mysticetes evolved larger masses and filter and suction feeding, with proto-baleen appearing around 34 Ma (Marx *et al*. 2016). However, to date there has been little quantitative study of shape evolution spanning the full breadth of cetacean diversity. Here, I analyse cranial shape in living and extinct cetaceans to quantify cranial morphology in specimens spanning the evolutionary history and diversity of cetaceans (n=162), and to quantify ecological influences on cranial morphology in cetaceans and ecological rates of shape variation in a subsample of our dataset (n=62).

Methods

Skulls were selected based on their completeness, and the sampling was designed to represent cranial morphology across Cetacea both temporally and geographically. I analysed skull shape using high-dimensional geometric morphometrics. Skulls were scanned using a Creaform GO!Scan 20 or Creaform GO!Scan 50, depending on the size of the skull. Scans were cleaned and decimated in Geomagic Wrap software (3D Systems). The dataset comprises 162 cetacean crania, of which 78 (48 %) are extinct, ranging in age from 48.6 Ma to 2.59 Ma. I placed 123 landmarks on digitized skulls and analysed data in R (R Core Team, 2017) within a phylogenetic framework. I then ran further analyses on a subset of data (n=62) to quantify ecological influences on cranial morphology in cetaceans and ecological rates of shape variation. I analysed data in the 'geomorph' package (Adams *et al*. 2019) in R. Landmarks were subjected to generalized Procrustes analysis, followed by a Principal Components Analysis. Centroid size was used to measure allometric effects, and ecological correlates of cranial shape were assessed with non-parametric MANOVAs. Ecological data on extant habitat and diet were obtained from the literature (Jefferson *et al*. 2011; McCurry *et al*. 2017).

Results and summary

The largest component of cranial variation (PC1 = 41.2 % (subset = 35.2 %)) discriminates odontocete and mysticete cranial telescoping, reflecting a posterior shift in the nares. Rostrum length is a major component of variation (PC2 = 23.7 % (subset = 25.6 %)) with dolicocephalic (*e.g. Pontoporia blainvillei*) and brachycephalic (*e.g. Kogia sima*) crania representing the extremes (Figures 1 and 2). Allometry is also an aspect of cranial shape variation ($r2 = 0.18$, $p < 0.001$). On a subset of our data (n=62), habitat does not significantly correlate with skull shape ($r2 = 0.31$, $p = 0.14$), but diet does ($r2 = 0.57$, $p = 0.001$) (Figure 2). Assuming a similar ecomorphological

relationship in extinct taxa, we can hypothesize potential ecologies for our sampled fossil cetaceans based on cranial morphology. For example, Miocene and Pliocene mysticetes such as *Piscobalaena nana* (4 in Figure 2) likely fed on euphausiids as they occupy a similar morphospace to extant mysticetes (Figure 2).

The highest disparity in odontocetes is in the premaxilla (3.21), nasal (2.45), and frontal (2.36), with the highest evolutionary rate ($\sigma 2_{mult}$) in the frontal (3.17). In mysticetes the highest disparity and evolutionary rate is in the premaxilla (4.39 and 1.39, respectively). Disparity and rate of evolution are lowest in the basisphenoid and basioccipital. Disparity rises rapidly in the middle to late Oligocene and peaks in the middle to late Miocene.

Next steps

Future work will focus on running these and other analyses on all skulls in my dataset (*n*=~200). I will also work with sliding-semi landmark curves in addition to landmarks to more accurately capture complex cranial morphology (see Bardua *et al*. 2019).

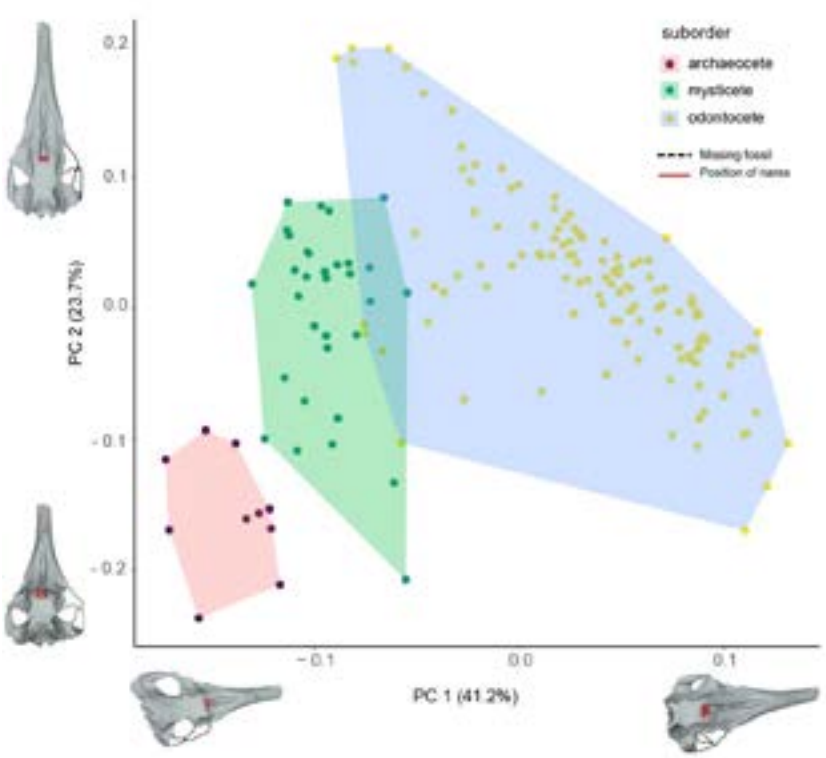

Figure 1. Morphospace occupation of cetacean crania with principal components (PC) 1 and 2 using 123 landmarks over the surface of the skull. PC1 (41.2 %) shows variation in the positioning of the nares – the shift posteriorly on the skull from archaeocetes to extant cetaceans. PC2 (23.7 %) shows variation in the length of the rostrum. Axes extremes indicated on a warped skull of a patriocetid. Full

cetacean dataset (n=*162). Dotted line = missing data, red line = nasals.*

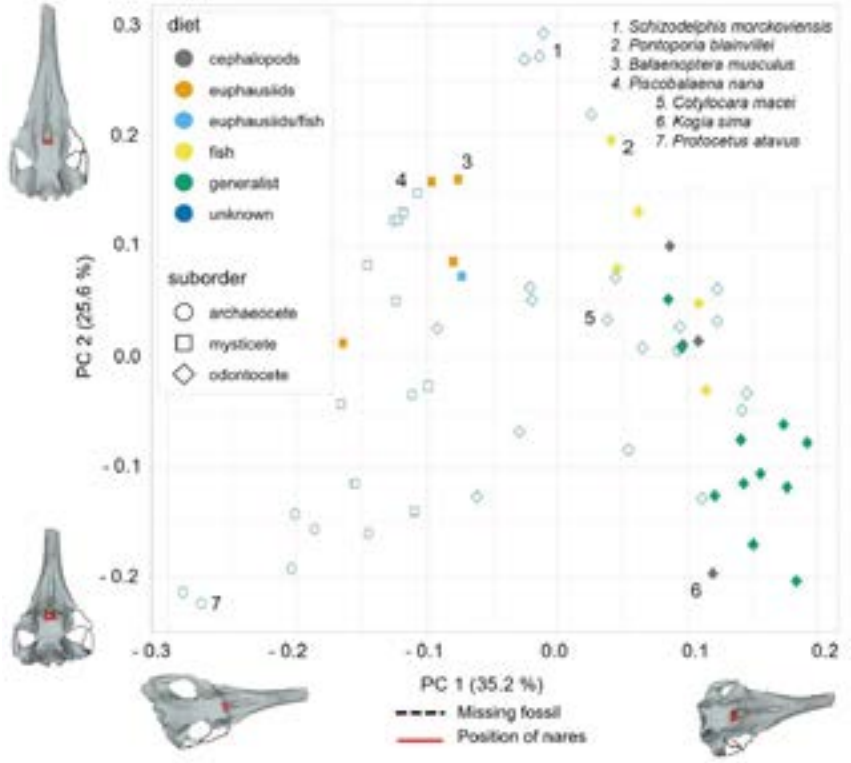

Figure 2. Morphospace occupation of cetacean crania for principal components (PC) 1 and 2 on a subset of the data (n=*62). Colours indicate diet type. Shapes indicate suborder. Open shapes indicate fossils. Numbers indicate species of particular interest. Axes extremes indicated with warped skull of a patriocetid.*

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The evolutionary history of mekosuchine crocodylians from the Cenozoic of Australia

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Introduction

Today, living crocodylians (crocodiles, alligators, caimans and gharials) number around 25 species. They belong to the crown group Crocodylia, whose fossil record of some 140 species extends back to the Campanian, 80 million years ago (Brochu 2003). Crocodylia can be divided into three principal groups, Alligatoroidea (including alligators and caimans), Gavialoidea (comprising *Tomistoma schlegelii* and *Gavialis gangeticus*), and Crocodyloidea (including *Crocodylus, Osteolaemus* and *Mecistops*). Among extant crocodylians, Crocodyloidea is the most speciose of these three groups, accounting for ~50 % of crocodylian species richness. This includes three species of the African dwarf crocodile genus *Osteolaemus*, two species of slender snouted crocodile *Mecistops*, as well as 12 species of *Crocodylus* (such as the saltwater crocodile *Crocodylus porosus*). *Crocodylus* is a particularly speciose genus. After originating in the Miocene (~20 Ma) (Oaks 2011), it quickly diversified, and due to the tolerance of saltwater was able to achieve a circumtropical distribution by the Pliocene (~5 Ma) via multiple oceanic dispersals.

Extinct members of Crocodyloidea have long been known from as far back as the Maastrichtian in North America and the Paleogene of Europe and Asia. However, one of the most recent and exciting discoveries of the twentieth century was of an endemic Australian radiation of crocodyloids in the Cenozoic, Mekosuchinae (Willis *et al*. 1990). Mekosuchine crocodyloids are interesting in several regards, not least because they included a multitude of disparate morphotypes (Figure 1), including 'pug-nosed' dwarf crocodiles (*e.g. Mekosuchus* and *Trilophosuchus*), tall snouted ambush predators (*e.g. Baru*) and terrestrial forms with serrated teeth (*Quinkana*).

Furthermore, the origin of Mekosuchinae has remained very enigmatic. This is because the evolutionary relationships of this group to other crocodyloids are poorly resolved, and because

Australia remained geographically isolated from all other major landmasses from the late Early Eocene (~50 Ma) (after it severed from Antarctica) until the present day (Wilf *et al.* 2013). The aim of this research project was to determine the evolutionary relationships of Mekosuchinae based on first-hand observations of the mekosuchine collections housed in the Queensland Museum in South Brisbane, Australia.

Methods

Mekosuchine specimens from the Queensland Museum (Figure 1) were included in a new character taxon matrix, devised to re-evaluate the phylogenetic relationships of Crocodylia. This dataset comprised 139 taxa across the three principal crocodylian groups, and 330 morphological characters. The new character list was developed from existing studies (*e.g.* Brochu 1999), containing 20 continuous characters and 40 novel discrete characters. Parsimony analyses were performed in TNT, using extended implied weighting (k = 13).

Figure 1. Mekosuchine crocodyloids from the Queensland Museum, Australia. A) Baru wickeni *(QM F16822); B)* Kambara implexidens *(QM F29662); C)* Australosuchus clarkae *(QM F16788); D)* Trilophosuchus rackhami *(QM F16856). All scale bars = cm.*

Results and discussion

One of the key findings of this analysis is that latest Cretaceous–early Paleogene crocodyloid species from South East Asia are closely related to Mekosuchinae, with one species from China (*Asiatosuchus nanlingensis*) recovered within Mekosuchinae. That several Asian taxa as closely related to Mekosuchinae, indicates an Asian origin of the clade. If the ancestors of mekosuchines originated in Asia in the latest-Cretaceous–early Paleogene, how did they reach Australasia? A terrestrial dispersal route from Asia to Australasia would require dispersal through North and South America, as well as Antarctica. This seems unlikely given that there is no unequivocal evidence for crocodyloids reaching South America in the latest Cretaceous–early Paleogene. The remaining alternative is that mekosuchines originated from an oceanic dispersal from Asia via eastern Tethys. Today, the Indo-Australian (=Malay/Malesia) Archipelago comprises a chain of more than 20,000 islands, partially

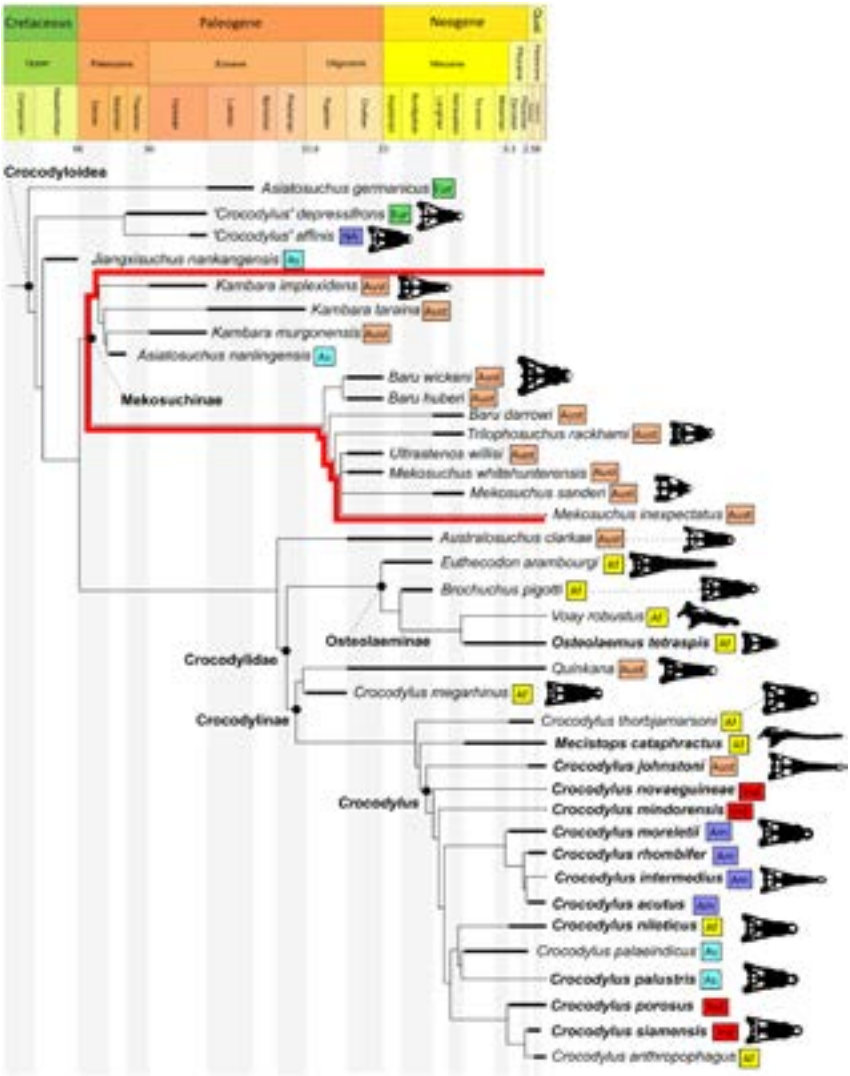

Figure 2. The new evolutionary relationships of Crocodyloidea recovered here, Mekosuchinae highlighted in red. Geographical abbreviations: **Af**, *Africa;* **As**, *East Asia and Indo-Pakistan;* **Aust**, *Australasia;* **Eur**, *Europe;* **NA**, *North America;* **Ind**, *Indonesia.*

bridging the gap between southeast Asia and Australia. However, this archipelago did not exist in the early Cenozoic, with the eastern Tethys forming a large oceanic barrier between Asia and Australasia. Although most mekosuchines are recovered from freshwater environments, there are several lines of evidence to suggest they may have been tolerant of saltwater, and therefore capable of crossing such an oceanic barrier. Firstly, living crocodiles all have physiological adaptations for tolerating saltwater (Taplin and Grigg 1989), and it may be reasonable to infer that their ancestors also had such adaptations. Secondly, several mekosuchines reached isolated Pacific islands in

the Quaternary, such as Vanuatu and Fiji (Mead *et al.* 2002). Even accounting for lower sea levels at this time, such a distribution would have required the crossing of oceanic barriers. Finally, fragmentary remains of Paleogene crocodyloids that are most likely related to the Asian relatives of Mekosuchinae (*i.e. Asiatosuchus*) are known from marine deposits. Together, these facts support an Asian origin of Mekosuchinae via an oceanic dispersal. However, the fossil record of Asian crocodyloids is poorly known. Future taxonomic and systematic study of the few known Paleogene Asian crocodylian taxa will be required to test these new hypotheses.

Acknowledgments

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The evolutionary history of North American nodosaurid ankylosaurian dinosaurs

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Thyreophora, the armoured dinosaurs, are a group of bird-hipped ornithischian dinosaurs, and were a significant component of terrestrial Mesozoic ecosystems. They are characterized by their elaborate use of osteoderms, or body armour, on the head and body, and comprise the

lineages Ankylosauria and Stegosauria, of which the most famous and recognizable members are *Ankylosaurus* (Arbour and Mallon 2017) and *Stegosaurus* (Maidment *et al*. 2015), respectively. They are a diverse group, with up to 100 species known (Maidment *et al*. 2008; Arbour and Currie 2016), and survived from the earliest Jurassic to the latest Cretaceous, living on every continent (see Figure 1). However, despite their familiarity with the general public, and an excellent fossil record, they are relatively understudied, especially in terms of their phylogenetic and evolutionary patterns, with most studies focusing either on taxonomy of the sub-clades, or on the form and function of

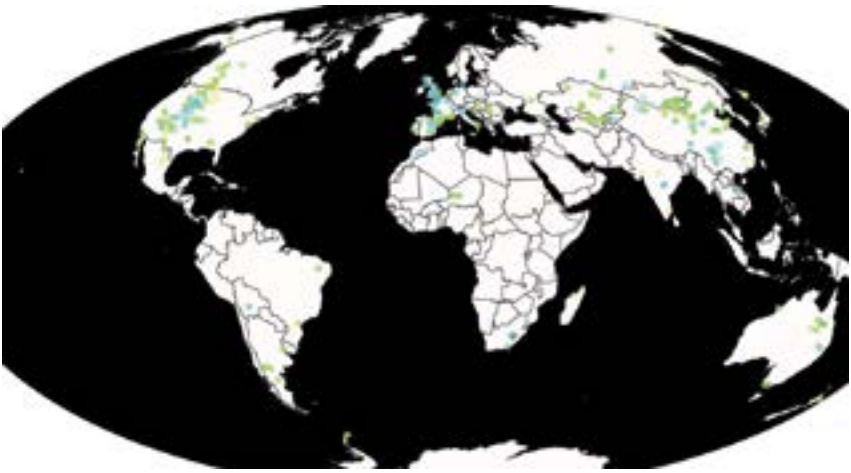

Figure 1. Geographic distribution of thyreophoran taxa from the Paleobiology Database. Jurassic taxa are in blue and Cretaceous taxa in green. Note the high density of plots in North America, as well as in Europe and China.

their bizarre ornamentation. The most comprehensive phylogenetic study to date (Zheng *et al*. 2018) included 177 morphological characters and 59 taxa, but this focused on the Ankylosauridae, meaning the relationships of many taxa such as non-ankylosaurid ankylosaurs as well as stegosaurs were not adequately tested. There has been no previous attempt to build a species-level phylogenetic tree of the thyreophoran dinosaurs, meaning the relationships of many early diverging taxa are labile, and the degree of convergence between the two major clades has been difficult to assess. This in turn has hindered any attempts to study their macroevolutionary patterns, meaning key research topics such as the diversification of ankylosaurs in the Early Cretaceous, which was coincident with the extinction of the stegosaurs, remain unexplored.

Support from the Palaeontological Association's Whittington Award (PA-WA201801) allowed me to visit the USA and Canada in May and June 2019. The institutions visited included the Smithsonian National Museum of Natural History, Washington D.C., the American Museum of Natural History, New York, the Peabody Museum of Natural History at Yale University, the Field Museum of Natural History in Chicago, the Royal Ontario Museum in Toronto and the Canadian Museum of Nature in Ottawa where I was able to study world-class examples of thyreophoran dinosaurs (Figure 2). North America has one of the highest diversities of thyreophoran dinosaurs of anywhere in the world; the Upper Jurassic Morrison Formation has at least five species, including the iconic *Stegosaurus*, and there are numerous Cretaceous ankylosaurs found from across the continent. Accurate inclusion of these taxa is therefore vital to fully understand thyreophoran phylogeny.

This trip allowed me to make first-hand observations of 19 taxa for inclusion into a species-level dataset – the largest ever constructed for the thyreophoran dinosaurs. Phylogenetic analysis of this dataset included equal- and implied-weights parsimony and Bayesian inference, and was combined with exploration of the dataset using constraint trees, partitioned analyses and stratigraphic congruence tests. The results reveal a novel hypothesis of thyreophoran relationships. The traditional ankylosaurian dichotomy is not supported, with the long-standing 'traditional' clade Nodosauridae rendered paraphyletic: instead, four distinct ankylosaur clades are identified and are well supported by numerous synapomorphies. This new phylogenetic hypothesis will be the framework for future studies into thyreophoran dinosaur macroevolution, including biogeographical analyses and diversity and disparity studies.

Figure 2. The ankylosaur Animantarx *from the Utah State University Eastern Prehistoric Museum (left) and the iconic* Stegosaurus *mount in the Denver Museum of Nature and Science (right).*

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Books available to review

The following books are available to review. Please contact the Book Review Editor, Tom Challands (e-mail <**bookreview@palass.org**>), if you are interested in reviewing any of these.

- *History of Life*, 5th Edition, by Richard Cowen.
- *Fossils of the Milwaukee Formation: A Diverse Middle Devonian Biota from Wisconsin, USA*, by Kenneth C. Gass, Joanne Kluessendorf, Donald G. Mikulic and Carlton E. Brett.
- *Across the Bridge*, by Henry Gee.
- *Beyond Extinction: The Eternal Ocean. Climate Change & the Continuity of Life*, by Wolfgang Grulke.
- *Charles Darwin's Barnacle and David Bowie's Spider: How Scientific Names Celebrate Adventurers, Heroes, and Even a Few Scoundrels*, by Stephen B. Heard.
- *Trilobites of the British Isles*, by Robert Kennedy and Sinclair Stammers.
- *Fossilien im Alpstein: Kreide und Eozän der Nordostschweiz*, by Peter Kürsteiner and Christian Klug.
- *William Smith's Fossils Reunited*, by Peter Wigley (editor) with Jill Darrell, Diana Clements and Hugh Torrens.

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We extend our thanks to Dr Thomas Clements who has been handling the book reviews during Tom's recent absence. Reviewers currently liaising with Thomas should continue to do so.

Careers Q & A

Professional palaeontologists in the wider world

After finishing a two-year postdoc at University College London, Mark Bell has worked as a Senior Assistant Statistician in Justice Analytical Services in the Scottish Government since 2016.

Image courtesy of Mark Bell.

Q1: When you were a child what did you want to be when you grew up?
If you asked the six-year-old me he might say starship captain (the 36 year old me might also say that!). It's fair to say I was never focused on a specific job as a child and ended up where I am by making decisions based on what I found interesting at the time.

Q2: How did you first get interested in palaeontology?
Similar to other palaeontologists of my era I went, at the age of eight, to see a small movie called *Jurassic Park*. Professionally though, I developed an interest in geology at high school where I had a great teacher who encouraged me to take on the Higher qualification (the only person in my school that year). This continued into university where my palaeontology interest grew through having great lecturers who were passionate about the subject.

Q3: What is your favourite fossil and why?
I don't think I've ever had a specific favourite fossil (feel free to stop here if this offends you). I guess what I've always loved about fossils is how much they can tell us about how and where they lived. Also those transitional fossils that fundamentally changed our understanding of the history of life. (*Walliserops* though. What is going on there?!)

Q4: What made you pursue your current job?
When I came to the decision that a future in academia was not going to suit me I went looking for data scientist type roles where I could best apply the skills I'd worked hard to develop in academia – specifically around coding and data interpretation – but would also give me some new challenges. It was important that any job provide good security. opportunities for progression and also that allowed me to choose where I live.

Q5: What are the main responsibilities of your job?
I work in a team that is focused on producing statistics relating to police activity. Our main role is to produce the annual National Statistics on Recorded Crime in Scotland (a hefty 100-page bulletin) along with other bulletins detailing more specific areas of crime such as homicide and domestic abuse. As well as producing these annual publications, the rest of my time involves either providing briefing materials for ministers that relate to these statistics or answering questions from other Members of the Scottish Parliament, journalists or the general public.

Q6: What gives you the most satisfaction in your job?
Being able to apply my skills to a wide range of problems which have some real-world impact. For example I've led and assisted on research projects which have helped to inform policy on the nature of victimisation in violent and sexual crimes.

There is also something to be said for hearing words you've written being spoken either by a minister or, on rare occasions, by the First Minister herself.

Q7: What are the worst things about your job?
Definitely the tight deadlines. I often get requests for information or to assist in the drafting of briefing documents with short deadlines (sometimes already overdue by the time it gets to us). The added pressure comes when working on something that could potentially be said publicly by the Cabinet Secretary for Justice. In those cases it is important to be both concise and accurate which is definitely a challenge.

Q8: What has been the best career advice you have received?
Basically – that life's too short to spend it doing a job that you either don't feel suited to or are not enjoying. Also, it's not a failure to recognize that you might be better off elsewhere.

Q9: What skills does it take to be successful in your job?
While there are a lot of technical skills required (statistics, problem solving, project management), potentially of more importance are the soft skills such as being able to take in a lot of information (often in a limited amount of time) and being able to concisely explain technical information to non-specialists. You also have to be adaptable to change. I am currently writing this at my make-shift office at home as part of the coronavirus lockdown. My day job has changed a lot as we shift to producing regular daily information for ministers and the public on the impact of the current situation on the justice system for example.

Q10: Do you have any tips for students who would like to take a similar career path?
To consider your degree (whether that is your undergraduate, masters, PhD *etc.*) as an opportunity not just to widen our collective understanding of evolution, for example, but to think of it as a training exercise where you are developing applied skills that could be useful in another career. I would advise that after each piece of work it is important to critically review the project, what worked and what didn't, what would you do differently?

Q11: Are there any major obstacles to being successful in a career like yours?
Getting used to the competency techniques used for recruitment and promotion is very different to the kinds of interviews used in academia and is something I've spent a lot of time working at myself. As you can imagine the Scottish Government is a complex beast with a lot of moving parts which takes a lot of getting used too.

Q12: What's the best thing about your job?
As someone who has had issues with mental health in the past the stability my job affords along with a much better work-life balance. I've been in a much better place than I can remember for years. Along with improved mental health I now have more time to spend on my other passions of hiking and photography.

Q13: What are your future ambitions?
In the short term I am hoping to lead my own analytical team in the production of interesting analysis. In the longer term, it would be great to have a wider impact on social policy through evidence-led work.

Mark tends to hide on social media, but has appeared on the Careers Panel for the 2020 *Progressive Palaeontology* meeting, has previously written a column on using R for the PalAss *Newsletter* (archived here: <**https://www.palass.org/publications/newsletter/r-palaeontologists**>), and can be followed on LinkedIn at <**https://www.linkedin.com/in/dr-mark-bell/**>.

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TAXONOMY/NOMENCLATURE UPDATE

This publication is now registered on ZooBank and is thus deemed to be valid for taxonomic/nomenclatural purposes. However we request contributors (especially those contributing grant reports) not to include names of new taxa in their reports.

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