THE LINNEAN

Newsletter and Proceedings of
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THE LINNEAN SOCIETY OF LONDON

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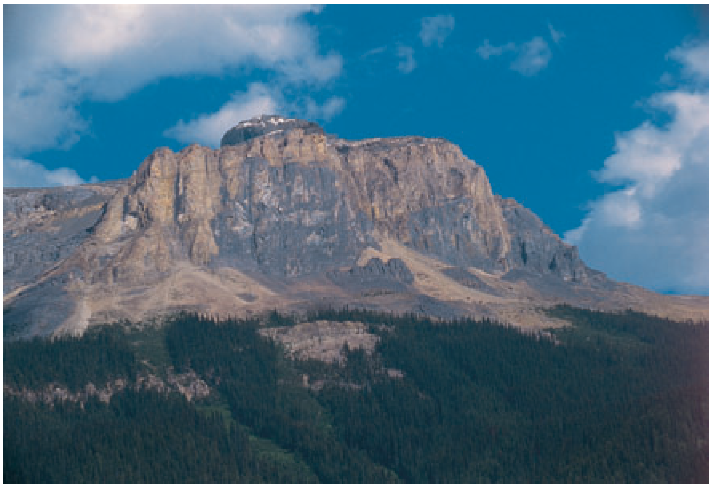
Edited by B.G. Gardiner

Editorial

This issue contains an article on the 'Crucible of Creation' otherwise known as the Burgess shales, which came to light as a consequence of the British Association for the Advancement of Science's 1884 meeting, held in Montreal (28th August – 3rd September). The meeting concluded with a field trip to the Rockies organised by the Canadian Pacific Railway (50 cents a day – free meals), which went from Montreal to Banff and the Kicking Horse Pass. The trip was led by Dr G.M. Dawson (Canadian Geological Survey) and Professor Selwyn. Accompanied by Rev. H.H. Winwood, the party walked along the base of Mount Stephen and through the Kicking Horse Pass collecting numerous trilobites[1].



The earliest recording of Mount Stephen fossils appears to have been made by Mr L.M. Lambe, one of the CPR's initial surveyors in Spring 1884. Lambe who was later to become a palaeontologist with the Geological Survey of Canada, sent four trilobites back to Dawson who immediately recognised the potential of the locality and who in 1885 described one of the trilobites as *Olenellus*, congeneric with that which Walcott had described in 1884 from Central Nevada. In 1886 the CPR commissioned a topographic Survey of the area around Kamloops, with the intention of building a tourist hotel. The survey was conducted by Otto Klotz; the hotel itself was built at Field. During the construction of the hotel some of the carpenters had climbed up the mountain behind and had found the famous trilobite bed. Meanwhile on the advice of Dr G.M. Dawson, the GSC sent Richard G. McConnell to map the geology along the western part of the CPR. In September 1886, acting on the information passed to him by Klotz, McConnell not only discovered the famous trilobite bed, but stumbled unknowingly on the Burgess Shale and brought back to Ottawa a specimen of *Anomalocaris canadensis*, which was subsequently described by Whiteaves in 1892. Klotz involvement with the famous

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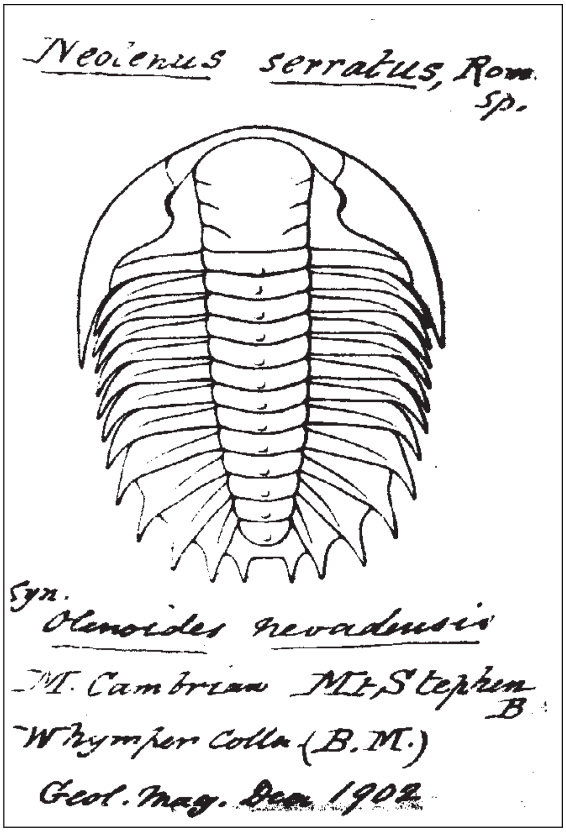
1. Some of which were incorrectly identified as *Paradoxides* and *Conocryphe* by Dr Hicks back in the UK.

trilobite bed, however, did not end there; Walcott (1888) records that Klotz presented a collection of fossils from Mount Stephen to the US Geological Survey[2], while J.F. Whiteaves sent a series of fossils collected by McConnell from the same locality. Thus, it was at this point that Walcott realised that the Mount Stephen trilobite bed contained identical specimens to those from the Middle Cambrian of Central Nevada (viz. *Zanthoides spinosus, Bathyuriscus howelli*) while *Agnostus interstrictis* and *Olenoides nevadensis* both occur on Mount Stephen and in Western Utah. However, he realised that both *Ogygia klotzi* and *Ptychoparia cordillerae* were unique to Mount Stephen, and resolved that one day he would collect in Canada.



Meanwhile, in 1891 Henry Ami (GSC) had made a much larger collection of trilobites from Field and showed that the trilobite bed represented over 300´ of strata resting about 6,580´ up on Mount Stephen.

The next collection made from Mount Stephen was by Edward Whymper in the summer of 1901 when he was asked by the CPR to publicise the Rockies and to open up trails around Mt Stephen. In the course of these duties he found time for an excursion to the celebrated Mt Stephen trilobite beds. His collection, exhibited at the Royal Society in 1902, was later described in a paper, read that December by Henry Woodward to the British Association for the Advance of Science held in Belfast. Its subsequent publication in the Geological Magazine (1902) figured both *Anomalocaris* and *Neolenus serratus* Rominger which Woodward considered synonymous with *Olenoides nevadensis*. Again, just like McConnell in 1886, Whymper had unwittingly also collected from the Burgess Shale.

2. It was Klotz who had named the various mountains around Kamloops including one for A.M. Burgess, the Deputy Minister of the Interior, and who had also presented some of his trilobites to the University of Michigan – where they were described by Rominger in 1887 (see also Klotz, *National Geographic Magazine*, 1911, **22**, 6 June).

Early in 1907 Charles Walcott left the US Geological Survey and succeeded Samuel Langley as Secretary of the Smithsonian Institute. As soon as he could, he arranged to commence summer collecting from the Mt Stephen trilobite beds. Thus, in August 1909 we find him, together with his family, camped below the ridge between Mt Field and Mt Wapta. His diaries tell us that on splitting a loose block they "found a remarkable group of phyllopod crustaceans … took a large number of fine samples to camp". This entry is accompanied by three drawings clearly recognisable as *Marrella*, *Waptia* and *Nardoia*. This loose block was indeed the Burgess Shale. Later, accompanied by his sons, Sidney and Stuart, they located the source in 1910, and between then and 1917 Walcott and his family collected over 65,000 specimens, even returning to sift over their spoil heaps in 1919 and again 1924.

MCCONNELL, R.G., 1886-1887. Report on the Geological Structure of a portion of the Rocky Mountains. *Geol. Nat. Hist. Surv. Canada* **2**: 28-30.

WALCOTT, C.D., 1888. Cambrian fossils from Mount Stephen's North West Territory of Canada. *American Journal of Science* [**3**] **36**: 161-166.

ROMINGER, C. 1887. Description of the Primordial fossils from Mt Stephen, North West Territory, Canada. *American Journal of Science* [**3**] **1888**: 12-19, pl. 1.

WOODWARD, Henry, 1902. Canadian Rockies. Part 1: On a Collection of Middle Cambrian Fossils obtained by Edward Whymper, Esq. FRGS from Mount Stephen, British Columbia. *British Association for the Advancement of Science (Belfast) 1902*; *Geological Magazine*, **1902**, NS, Decade IV, **9**: 502-544.

Postscript

In the early 1920's when anti-evolution laws were being passed by many States, Walcott fought surreptitiously against them and while the exhibits of that period in the National Museum did not actually use the word evolution, they were designed so as to convey the ideas of both variation and change. Surprisingly it took more than half a century from the time of Walcott's death (1927) before the word EVOLUTION was used in a Museum display (1979). And then the Smithsonian Institution had writs taken out against it and was openly sued. However, the United States District Court ruled that the exhibit came under the "increase and diffuse" mandate of the Institution as laid down in the original will of James Smithson. So ironically the will of the bastard son of the Duke of Northumberland, who never set foot in the USA, overcame the petty prejudices of the deep South when the *Dynamics of Evolution Hall* was declared "not a religious display" by the Appeal Judge Justice Oberdorfer. Walcott would have been pleased with the outcome since he was a great admirer of Smithson (and Carnegie) and very proud of his English forebears (being a descendent of William Walcott who emigrated to Salem in 1637).

BRIAN GARDINER

Society News

Gather ye rosebuds while yet ye may….

Pittsburgh, PA. Swedish botanist, physician, and zoologist Carolus Linnaeus (also Carl von Linné, 1707–1778) was famous for sending his students around the world to explore and collect specimens. The Hunt Institute for Botanical Documentation is pleased to enable new generations of Linnaeus' students to explore, collect and learn by making our spring 2002 exhibition, *Order from Chaos: Linnaeus Disposes*, available online at our Web site (huntbot.andrew.cmu.edu). Linnaeus devised comprehensive, consistent schemes for classifying and describing plants and animals and for assigning two-word scientific names to all species, thus laying the foundations of modern biological systematics and nomenclature. Pages of manuscripts, plant portraits, portraits of botanists and rare books from the Institute's Archives, Art Department, and Library, including the Strandell Collection of Linnaeana, highlight Linnaeus' achievements in the broader context of botany over two millennia. We invite everyone to become one of Linnaeus' students as he brings order from the chaos of early scientific thought and practice while inspiring future generations of botanists.

The first section of the exhibition covers pre-Linnaean botany. Long before Linnaeus, classical science was important in the shaping of subsequent science in the West. Transmitted through the cultures of the Mediterranean area, classical science was recovered during the Renaissance and ensuing Scientific Revolution, and undergirded the search for a new botanical system. Highlights from this portion include four pages of a 13th-century Arabic manuscript, several leaves from a 15th-century incunabulum herbal, *Gart der Gesundheit*, and a number of books from the 15th and 16th centuries.

The second section shows how Linnaeus drew on the work of his predecessors and contemporaries and developed a coherent system for describing and naming organisms that has continued into the present. Key works by Linnaeus including his *Species Plantarum* (1753) and *Genera Plantarum* (1754), which are the starting points for botanical binomial nomenclature, are featured as well as books, portraits and biographical information of his predecessors and contemporaries.

The third section explores the Linnaean inheritance. It shows how Linnaeus' students travelled the globe to explore and collect information and specimens, and how aspects of the Linnaean system have enabled amateurs and professionals worldwide to identify, name and describe plants for more than two centuries. Included are books by Linnaeus' students, along with portraits and biographical information, and selected examples of post-Linnaean works showing how aspects of his system have been used from the 18th century into the present day.

In January 1996, the Society's programme contained an evening meeting on *Dr. Francis Boott (1792–1863): the Instigator of General Anaesthesia in Britain* by Dr. Richard H. Ellis of Guy's Hospital. The lecture was prevented by Dr. Ellis's death the preceding summer. His namesake, but no relation, Professor Harold Ellis CBE FRCS, also of Guy's, has offered to make good the loss on **Thursday, 27th February 2003 (tea at 5.30 for 6pm).**

16th October 1846 is one of the most important dates in medical history; the first operation performed in public under ether anaesthesia. The anaesthetist was a dentist, William Morton, and the venue the Massachusetts General Hospital, Boston. It signalled the beginning of modern surgery, and news of this miracle spread rapidly round the world. Its first use in England, just a month later, has a Linnean Society connection via Dr. Francis Boott, a Secretary, Treasurer and Vice-President of the Society. In this lecture *Anaesthesia – The Early Story of a Great Discovery – With A Linnean Society Connection*, Professor Ellis, Emeritus Professor of Surgery, University of London, will reveal all!

On **Thursday, 6th March** Dawn Sanders FLS Head of Education at the Chelsea Physic Garden will speak on *Walled stranded arks or environments for learning?* exploring schools education during the last 120 years at the Chelsea Physic Garden. Utilising fascinating archival images and anecdotal comments from today's young learners, Dawn Sanders will tell the unique story of the Physic Garden's involvement with schools. (Tea at 5.30 for 6pm.)

….Old time is still a-flying….

2002 saw the appearance of the House of Lords Select Committee Report *What on Earth? The threat to the science underpinning conservation* (published by The Stationery Office Ltd. and at www.public-ations.parliament.uk/pa/ld/ldstech.htm; ISBN 0104420723), extracts of which are cited below (the **bold** comments are in the Report):

Accessibility, co-ordination and priorities

5.15 While we recognise that systematic biology is an academic pursuit taken up in part because of researchers' interests in identifying and discovering animals, plants, fungi and microbes, it is also of fundamental importance to efforts to conserve biodiversity.

5.16 **We recommend that the systematic biology community, especially via the Systematics Association and the Linnean Society, should increase efforts to demonstrate the relevance and importance of systematic biology. This should have the effect both of improving its profile to funding bodies and of making it more attractive to potential professional taxonomists and volunteers. We also hope that systematic biologists who are members of learned societies, such as the Institute of Biology and the Royal Society, will use their influence to promote the discipline.**

5.17 We were impressed by Professor Godfray's suggestions to make systematic biology a web-based discipline. This would have the advantage of simplifying the system of naming, making it more comprehensible to other scientists and to non-scientists. Also, providing and updating taxonomic data on the web would make it accessible to people all over the world overcoming the need, in some cases, to travel to collections. Furthermore, increased use of the world-wide web would also revise the image of systematic biologists.

5.18 The systematic biology community have discussed some of the proposals championed now by Professor Godfray over the last few years. There are a number of concerns about a primarily web-based science. For example, it has been argued that at present web-sites do not survive for long: few are properly maintained and many soon become out-of-date and redundant. Digitising all information would take a long time and would certainly require significant financial support (Dr Doyle Q 208). Finally, changes to the system of naming would require international agreement.

5.19 **We recommend that the United Kingdom should take the lead and propose to the Global Biodiversity Information Facility (GBIF) that the GBIF run a pilot with some priority for species groups which would form the basis of a trial for Professor Charles Godfray's suggestion of making taxonomy primarily digitised and web-based.** A **trial would demonstrate the benefits and pit-falls of this approach before implementing it more widely.**

5.20 We believe that LTK systematic biologists need to collaborate more often and more effectively, in part for the purposes of developing research and for applying for funding. It is also particularly important that they collaborate in order to attack the task of documenting and understanding the world's biodiversity. This is an overwhelming task, with only a small percentage of species being documented after 250 years of formal taxonomic research. It is necessary to be pragmatic and to decide on some priority areas. These priorities should be developed with conservationists and with awareness of international resources and taxonomic activity.

5.21 We are convinced that there is poor coordination between Government departments and between them and the systematic biology community and conservationists. Coordination is fundamental to biodiversity conservation action. The Government has signed up to various biodiversity conventions and treaties and those who are attempting to implement them need taxonomic information from the systematic biology community.

5.22 **We recommend that DEFRA takes the lead in setting up a body with the express purpose of bringing together representatives from Government departments, ecologists and conservationists and the systematic biology community, including those based at museums, universities and other institutions. DEFRA should provide funding for administrative support, in the early stages, although we envisage that the body should eventually seek to become self-financing with all participants making a small contribution to running costs. The body's main remit would be to:**

(a) **identify priority areas of biodiversity for which taxonomic research is most needed by the conservation community, and for other national purposes, such as health and agriculture.**

Additional remits would be to:

(b) **assess the taxonomic impediment to conservation action – specifically to analyse the shortage of taxonomic specialists and gaps in taxonomic data;**

(c) **campaign for resources for taxonomists researching in those priority areas.**

Attracting people to systematic biology: school education and beyond

5.23 We are concerned about the reported decline in professional and amateur taxonomists. In particular, we are concerned by the shortage of taxonomic teaching that occurs at school and university. There is little taxonomy in either the GCSE or A-Level syllabuses. The decline in numbers of taxonomists at universities ensures that fewer undergraduate students now receive good introductions to taxonomy. In order to replenish amateur and professional taxonomists in the future, education must emphasise the importance of taxonomy (p 8, pp 34–6, p 85).

5.24 Education extends beyond school and university years, and we were therefore pleased to hear from the Natural History Museum about its new Darwin Centre (to open in April 2002). This will present the public with an exciting impression of the work that is carried out by researchers at the Museum. We were similarly encouraged by the plans by the Royal Botanic Gardens, Kew to make its herbarium and library more accessible to the public (see Appendix 6)

5.25 Whilst increasing the use of modem techniques in taxonomy research could help to make it more attractive, we were struck by its close relationship to biodiversity conservation. Some aspects of taxonomists' careers are extremely attractive, particularly to young people. Being a taxonomist provides opportunities to perform field work, requiring significant foreign travel and to work in remote areas of the world, to acquire aptitude in foreign languages and to interact with different cultures. Such work can lead to discovering new species, which the taxonomist then has the privilege of naming. If these elements of work were more widely known, we believe that it would attract more young biologists (see Recommendation 5.16).

The Society asked a group chaired by Prof. Richard Bateman (botanist/ palaeontologist), Natural History Museum, with Prof. Michael Akam FRS (zoologist), Cambridge University, Prof. Paul Bridge (mycologist), Birkbeck College/Royal Botanic Gardens Kew, Prof. James Mallet (entomologist), University College London and Dr Andrew Purvis (zoologist), Imperial College London, to prepare proposals based on the Report. These are summarized below:

(1) We welcome the select committee report; we view its evidence as thorough, its discussions as well researched and thoughtful, and its timing as exemplary. We therefore give all nine formal recommendations our support.

(2) For some recommendations, notably those concerning use of the web, and for assessing the efficacy of molecular systematics, our support is qualified by a wish to explore further outline remedies suggested in the report. These issues include:

- digitisation of collections;
- web-based taxonomy;
- the role of molecular systematics.

We agree that pilot projects are needed to test the suggested responses to these controversial areas.

(3) We argue that several important issues are not adequately covered by the report and/or the recommendations. These include:

- reversing the decline of systematics research and teaching in the university sector, in part through further joint appointments with systematics institutes;
- developing an "informal apprenticeship" for systematists;
- acknowledging the important role played by amateur societies in pursuing and coordinating systematics research in the UK;
- recognising the large and increasing value of living collections.

(4) We further argue that the recommended additional resourcing of systematics activities, notably through the major collections-based organisations and the Darwin Initiative, should be made conditional on ensuring that the funding provided directly supports prioritised research, and that in competitive systems such as the Darwin Initiative and the research councils, funding proposals are assessed by panels that include systematists.

(5) We believe that the Linnean Society offers the most appropriate base to house the proposed new, diverse coordinating body for systematics. This should (a) consist of active systematists, active users of biodiversity data and representatives of government departments, (b) fulfill a genuinely independent advisory role, and (c) be given modest but long-term resourcing to ensure influence and continuity.

(6) We agree that the new coordinating body should develop a fresh national and international strategy for systematics research in the UK; this should be goal-oriented and incorporate costed, timed milestones. As part of this initiative it should revitalise the database of UK-based systematists originally compiled by the now defunct UK Systematics Forum. In order to be effective this body will require an explicit government mandate that includes the power to allocate resources.

(7) Despite the scale of the challenge, cataloguing and understanding the diversity of life should remain the ultimate goal of the systematics community. More pragmatically, prioritisation of subsidiary goals should balance:

- dissemination of existing knowledge with generation of new knowledge;
- charismatic, relatively well known organisms with poorly known organisms;
- simplification of guides and multi-media products designed for practical users relative to more complex scientific works intended for practicing systematists;
- justifying systematics research in terms of practical applications versus educational or intellectual merit.

(8) Internationally acquired taxonomic practices, including the nomenclatural codes, have served science well and should not be abandoned, but rather should be encouraged to evolve further to more effectively meet the expanding needs of the systematics community and its diverse users.

(9) With the aim of giving guidance to the revitalisation of systematics, we have encapsulated the recommendations of the report in eight outline project proposals

that cover the following topics:

- lepidoptera “taxome” programme and related projects;
- digitisation and dissemination exchanges with developing countries;
- realising the potential regional and local natural history collections;
- urban biodiversity surveys in the UK;
- monitoring changes of species distributions in the UK;
- assessing the rigour of species identification by automated DNA sequence analysis;
- determining how the remarkable diversity of tropical forests is maintained;
- understanding the process of speciation, extinction and invasion on oceanic islands.

(10) We and other biodiversity-related organisations will now reappraise our attempts to increase the profile of systematics research, at least partly through topical applications such as conservation, climate change and biotechnology. However, we strongly believe that the government must also play an active role in this process, by persuading the several departments and non-departmental public bodies that sponsor systematics research to cooperate more effectively, both with ourselves and with each other.

(11) We see several opportunities in the recent government Comprehensive Spending Review to allocate resources to targeted systematics projects, through fellowships, infrastructure/facility uplifts, and competitive grants, including the Darwin Initiative.

The full proposals are on the Society’s www site.

The President wrote to the five “wise men”, congratulating them on an an excellent job carried out on behalf of the Society; remarkably, the Clerk to the House of Lords Committee asked whether she could “circulate this to members of the Committee as I am sure that they would be interested to know that their report has been responded to in such a thorough manner”. We must all hope for better things for UK taxonomy in future.

….And that same rose that blooms today….

No end is in sight to the plethora of inquiries, studies and reports involving taxonomy. We must hope that the reaction of those who must find the very necessary money will not be that of the gentleman asked the way to Ballymena, who remarked that he wouldn’t start from here. The Royal Society has put out a request for information bearing on its study to measure biodiversity and assess biodiversity conservation. A Council member, Dr. Terry Langford, has made the following observations, which were passed on to the Royal Society together with the summary proposals on the House of Lords Report (above):

1. Background to the study.

The study is timely because of all the confusion about the value of “biodiversity” and what it really means. The various NGO and political definitions of and discussions about biodiversity are often based on an unsound knowledge of either species distribution, populations or the various theoretical studies of diversity and its controlling factors. In most cases, from experience with conservation groups, "diversity" in general use means "species-richness". Thus in their view more species means a " better or healthier environment".

The conclusion that more species means a healthier environment ignores a fundamental concept in that " species richness" is in many ecosystems more a product of disturbance, either natural or anthropogenic, rather of "nature alone". In fact many undisturbed natural systems are likely to be relatively species-poor and may be classified as "climax communities" where all the species have reached an equilibrium in the longer term. This could be regarded as the "pristine" or undisturbed state which is relatively rare globally. In such communities changes in composition will only occur when some disturbance creates an opening for immigrant species. Also, most disturbed communities are on some point in a succession gradient and may be moving toward higher or lower diversity depending upon the degree and frequency of disturbance. Thus "biodiversity" in itself means very little and is strictly a dynamic term. Consideration of Connell's theory of intermediate disturbance and its implications for biological diversity should be the basis of any study or any definitions for conservation work. Although all this will be well-known to the working group, it is unknown (or at least not admittedly so) to most users of the word "biodiversity" in the media, politics or environmentalist groups.

Further, the management of many habitats for "biodiversity" can only be defined as "gardening", that is "*the replacement of one disturbed community by another which can itself only be sustained by maintaining the disturbance*". In comparison, single-species management, for example, habitat creation for water-voles or otters may have adverse repercussions on other species, eg. food plants or fish populations, which can cause specific problems for those species. These "knock-on" effects are often not considered in single-species management projects.

Whilst it is probably too late to change ideas because of the wide usage of and media attention to "biodiversity", it is recommended that any scientific study should address the definitions and meanings of the concept and outline the causes of increases and decreases in diversity and species richness. This should then be communicated to the wider audience in understandable language and used as the basis for the body of the report. This will probably not please those who tend to use the term politically, for economic purposes or for campaigning and if the study is to use "sound science to underpin the funding" any questioning of the basic tenets may cause adverse reaction.

However, there should be a concerted effort to stress both the value of pristine or poorly disturbed habitats or ecosystems and the need to identify and protect these possibly as a priority over more disturbed but more diverse systems.

2. Increasing baseline knowledge of biodiversity

2.1. Increasing knowledge

One of the primary requirements should be to stress the historic perspectives of species-occurrence and distribution which will probably be the first task if any rate of change is to be estimated. To this end there are two generic sources of information, viz:-

(a) descriptions of the flora and fauna of regions from old texts, with such titles as "*The Flora of Staffordshire*" or "*The Fauna of Nottinghamshire*" which list species recorded at that time. Some of these, no doubt well known to the working group can date back to the 17th Century or earlier. For many regions early explorer texts will contain valuable information. Some allowances must be made for variable data quality. Paleo-ecological data can be included.

(b) long-term databases kept by scientists and interest groups in various regions and for various purposes. In the UK for example, John Prenderghast of Lymington in Hampshire has compiled a database of more than 4000 long-term biological databases of various formats. This is available on the web. Other well-known UK examples include the Rothamstead insect trap data, the Environment Agency/Freshwater Biological Association Trent historic database, the Rhine data and the Severn Estuary and Thames long-term fish data using catches on power station intake screens. Combined with data extracted from the historic texts and records this type of database may give extensive information on change and rates of change. The National Biodiversity Network Trust may be a major contributor to the initiative.

In **October 2003**, the Linnean Society is intending to host a conference on the use of such long-term databases for predicting ecological change. This could also provide a second platform for the Royal Society initiative and perhaps the meeting should be a combined event. The Convenor is Dr. T.E.L. Langford based at Southampton University. e-mail: *tel2@soton.ac.uk* or: *terry.langford @btinternet.com.*

Future knowledge will come from scientific studies but more encouragement should be given to interest groups such as The Dragonfly Society, the Butterfly Society and Wildlife Trusts. In particular the latter should be encouraged to train observers to identify plants and animals to species correctly. This should also be much more prominent in relevant university and school curricula, though it may be difficult to re-run the old "taxonomy first" arguments.

To assist in the gathering of data, some efforts should be made to improve the methods of species identification. For example, expert's dichotomous keys are only usable with great difficulty by younger people, non-biologists and wildlife conservation groups. It is time to simplify these using modern technologies of recognition, short-cut tips, computer based identification and visual images made much more readily accessible.

IT and short-cutting taxonomic initiatives already in progress or in use should be examined and given proper funding.

2.2. Accessibility and need to know

Clearly, access to data via the internet is one area for expansion. Perhaps more importantly, access to the *interpretation* of the data needs great attention. Thus the RS initiative should consider a text on a "Public Understanding" basis by which both a proper understanding of the meanings of diversity and the uses of the various methods of expressing diversity are explained as a preliminary step to data collection for the future.

The "how much do we need to know" is probably covered by the introduction to this note and the previous section.

Criteria should include identification of pristine or low-disturbance sites rather than heavily managed or "high-diversity" sites. Also, the value of very high disturbance sites such as severely contaminated land, ash-tips, spoil-heaps or slag-heaps which may contain unusual species should be assessed and consideration given to preservation of some of these man-made habitats for educational purposes. Such an initiative may already be in operation in at least one region.

3. Measuring Biodiversity

The methods for measuring diversity are well described in two books (Magurran, 1988, Southwood & Henderson, 2000) and there may be little to add to these though there are fashions and preferred methods that vary with user and topic. The simplest, most robust, though possibly the most misleading index is *"number of species"* but there are limits to its use, especially where pristine sites need to be identified. All the other indices have limitations but the "Shannon-Wiener" index is most used and the concept of species-richness combined with relative abundance may be easier to explain than other indices. This index is also robust across taxa and habitats when combined with some measure of species abundance.

4. Experience of uses

This part of the Linnean Society response comes from Dr. Terry Langford. Dr. Langford has over 40 years of using biological diversity or quality indices. This experience includes regulatory use, industrial uses, independent consultancy, research and teaching at Southampton University. He is the initiator and convenor of the Linnean Society Conference on the use of long-term databases for ecological prediction planned for **23–24th October 2003**. Also, he is working on the Trent biological database which includes over 21000 records of invertebrate communities retained by Frank S. Woodiwiss and present data, collected over 50 years from 1952.

5. References

MAGURRAN AE. 1988. *Ecological diversity and its measurement*. Princeton, New Jersey: Princeton University Press.

SOUTHWOOD JRE, HENDERSON PA. 2000. *Ecological methods*. Oxford: Blackwell Science Ltd.

….Tomorrow will be dying.

Mrs. Betty Eleanor Gossett Molesworth Allen died in Spain on 11th October 2002 aged 89. She received the HH Bloomer Award in 1995; the citation (*The Linnean* **11** (2) 35) mentioned that after a childhood spent in sanatoria, she rose, without formal qualifications, to become botanist at the Auckland Museum succeeding Dr. Lucy Cranwell (who died in 2000: *Linnean Society Annual Report 2001*, 25–27). In 1963, Mrs. Allen and her husband retired to Andalucia, contributing to the Society's *Flora Europaea*, and where in 1993 she published *A Selection of the Flowers of Andalucia.* The Society was represented at her funeral in Los Barrios by Mr. Martin Jacoby FLS.

Dr. Zakaria Erzinclioglu, Albanian in origin, started from humble academic origins in the UK and made for himself a distinguished place in the annals of forensic entomology, rising to head a new Home Office laboratory in Durham which closed after a year for lack of funds. Thereafter life was a struggle for Zak, who was handicapped by a severely deformed foot which limited his mobility. He never complained about the trek to the Council Room for Council meetings; his views on all matters were honest, transparent and uncompromising. Invariably courteous to everyone, he was a staunch supporter of the Society and his early death at 50 is as unwelcome as it is untimely. An obituary appeared in *The Times* on 7th October 2002. The Society was represented at his funeral in Cambridge by Dr. Ken Joysey FLS.

Charter and Bye-Laws

Herrick's advice to young virgins hardly seems appropriate to the weightier matter of revising the Bye-Laws and tidying up the Charters of 1802 and 1904, the last of which was occasioned by events which are described below. The last Bye-Law revision took place around a dozen years ago, since when we have seen the European Charter on Human Rights, the Internet and the rapid development of 'intellectual property' with the advent of electronic publishing. It must also be noted that the Society now has members in 93 countries. It seems prudent for the Society to ponder the effects of these, and other matters, on its own regulations and the Council will be proceeding at a suitably leisurely pace to try to ensure that the Society is not brought to book at some future date. Revision of the Bye-Laws is a matter for two quorate general meetings of the Society, once Council has had its say. No changes are envisaged to the Charters of the Society, save division into headed paragraphs, the headings being derived from the current marginal notes. This latter will not require the approval of the Privy Council, whereas Bye-Law revision, if agreed, will. As part of this process the entire Charters and Bye-Laws have, with some difficulty, been converted to electronic form, a process much impeded by the continuous prose and the marginal notes. Members views are most welcome at this early stage.

100 years ago

From the Proceedings of the Linnean Society of London 15th January, 1903

[Chaired by Vice-President Mr. Frank Crisp, the President, Professor SH Vines FRS being prevented from presiding by illness]

The meeting having been made Special for the consideration of certain proposals, as announced from the Chair on the 18th December last, and communicated to the Fellows by circular letter of the 31st December, the Chairman explained that the President was

[original]	[proposed alterations]	[comment]
….and such others as shall from time to time….	….and such others *without distinction of sex* as shall from time to time….	[The Fellowship]
….Treasurer and Secretary….	…. Treasurer and *at least one* Secretary … .	[Election of Officers]
….Council shall consist of fifteen Members... …. on the Twenty-fourth day of May in every succeeding year unless the same shall happen to be on a Sunday and then on the day following assemble together at the then last or other usual place of meeting of the said Society and proceed by method of Ballot to put out and amove any five of the Members who shall have composed the Council of the preceding year; and shall and may in like manner by method of Ballot elect five other discreet persons from amongst the Fellows of the said Society to supply the places and offices of such five as may have been so put out and amoved; It being our Royal Will and pleasure that one-third of the Members of the said Council and no more shall be annually changed and removed by the Fellows of the said Society: And also that they the said Fellows or any twenty-one or more of them shall and may at the Time and Place and in a Manner aforesaid by method of Ballot elect from among the Members of the said Council when formed and elected in manner aforesaid three fit and proper persons one of such persons to be President another of such persons to be Treasurer and the other of such persons to be Secretary of the said Society….	…. Council shall consist of *twenty* Members…. on the Twenty-fourth day of May in every succeeding year unless the same shall happen to be on a Sunday *or Bank Holiday* and then on the day following *or on such other Day within the same week as the President shall fix* assemble together at the then last or other usual place of meeting of the said Society and proceed by method of Ballot *to determine which* five of the Members who shall have composed the Council of the preceding year *shall retire*; and shall and may in like manner by method of Ballot elect five other discreet persons from amongst the Fellows of the said Society to supply the places and offices of such five *retiring Members*; It being our Royal Will and pleasure that one-*fourth* of the Members of the said Council and no more shall annually *retire*: And also that they the said Fellows or any twenty-one or more of them shall and may at the Time and Place and in a Manner aforesaid by method of Ballot elect from among the Members of the said Council when formed and elected in manner aforesaid three *or more* fit and proper persons one of such persons to be President another of such persons to be Treasurer and the other *or others* of such persons to be Secretary *or Secretaries* of the said Society….	[Increase in size of the Council and an increase in the number of Officers]
…. the death of any of the Members of the Council or of the President Treasurer or Secretary for the time being within the space of three months …..… .... to elect such Persons to be Fellows … ….. …. determining the times and places of meeting	…. the death of any of the Members of the Council or of the President Treasurer or *any* Secretary for the time being within the space of three months … ….. to elect such Persons *without distinction of sex* to be Fellows…. …. determining the *Number of Fellows to be annually elected and the* times and places of meeting	[Procedure for dealing with death in office No discrimation by sex in the Fellowship Role of the Council defined]

[Items in italics represent proposed changes; those in brackets did not appear in the original proceedings] prevented from presiding by illness, and briefly recapitulated the steps which could lead to the proposals to be submitted for the consideration of the Fellows, which had been printed, and which were in the hands of those present [and here reprinted].

The Rev. T. R. R. Stebbing, F.R.S., then moved: – "That this meeting approving of the alterations in the constitution[*] of the Linnean Society of London, as shown in the printed statement circulated, hereby authorizes the Council to take the necessary steps to obtain a Supplementary Charter embodying the said alterations, and thereafter to prepare revised Bye-Laws in accordance with the provisions of the new Charter."

This was seconded by Dr. J. Reynolds Green and further discussed by Dr. J. Murie, Mr. Francis Darwin, Mr. H. J. Elwes, Mr. A. K. Coomárasswámy, Mr. W. Carruthers, Mr. A. G. Tansley, and Mr. W. M. Webb.

The first alteration, adding the words "*without distinction of sex*" to the existing paragraph on page 5 of the Charter as printed, was put from the Chair, and the result of the Ballot was declared as follows: – In favour, 54: not in favour, 17: and the motion was thereupon declared be carried.

The other alterations were explained by the Chairman, and discussed. Mr James Groves suggested that the remaining alterations should be adjourned, on the ground of insufficient notice. The discussion was continued by Mr. W. Bruce Bannermann, Prof. G. F. Bolger, Mr. V. I. Chamberlain, Mr. F. J. Hanbury, Dr. J. Murie, Prof. H. G. Seeley, Mr. E. M. Holmes, Mr. W. F. Kirby, Rev. T. R. R. Stebbing, and Mr. R. M. Middleton.

Mr James Groves's amendment not being seconded, was not put. The motion in favour of the adoption of the remaining alterations, as shown in the printed statement in the hands of the Fellows, was then put to the Ballot, the votes being: - In favour, 43: not in favour, 3. Whereupon the Chairman declared that the remaining alterations carried.

[In the 1904 Charter, these modifications were granted with some changes to the wording, and with the preface: "And whereas it has also been represented to Us that it would increase the usefulness of the Society if women could be elected Fellows thereof and that it is apprehended by the Society that women are not now eligible to be so elected."]

JOHN MARSDEN

[*The alterations in the constitution – see opposite page]

Library

The library computerization project is progressing well. New computers were installed in July, to create a library network which will be available to staff, readers and volunteers. The Library's new management system, Heritage, was also installed and networked to the new machines. We have set up an email address for inquiries (library@linnean.org), which Fellows should use in order to contact Library staff.

The small database of electronic records has been converted to Heritage, and our new Cataloguer, Lynn Crothall, has commenced cataloguing the backlog of material that was put on hold until the system was established.

A batch of cards (authors with names beginning with A and B) was sent off to India to be converted by a data conversion company. The resulting electronic records have now been included in the Heritage database, and further cards will be sent to India in batches. It is hoped that the entire catalogue will be converted by early in 2003.

Library staff will be pleased to demonstrate Heritage to Fellows and to give instructions in the use of the system.

DONATIONS: October and November 2002

The following listing is of donations received by the Library during the relatively short period from the end of September to mid November 2002. As it is relatively short it will be possible to also list some of the other accessions purchased during the past year. Those visiting the Library will have noticed the gradual clearance, both of the Library Annexe Table Case and the Accessions desk. Some previously unacknowledged accessions may be listed here, having surfaced from beneath other incoming material. Some material brought in for the Book Sale, but kept for the Library, may have lost information as to its source. If you see one of your books on display but not acknowledged, please let us know and we can put the record straight. The book sale added just under £200 to the Library purchase funds.

This list does not include a large recent donation by Prof. J.G. Hawkes, except for one item sufficiently bulky to require immediate cataloguing, as is the case with that listed for Richard Fitter. Both of these collections, together with donations and purchases from the late David McClintock's library, will be going into the new electronic catalogue in the months ahead but will probably be far too long to include in full in a future *Linnean* newsletter. The provenance details will be given in the catalogue and it may be possible to publish selected listings for information.

We are also grateful to a number of Fellows for continuing to ensure we get the publications from their Institutions or who pass on Newsletters and similar publications to supplement our holdings.

Dr C. Bowlt	Allen, C.G., *A manual of European languages for Librarians.* 803pp., London, Bowker, 1975.

Brooklyn Botanic Garden	BROOKLYN, Botanic Garden, *The sunny border, sun-loving perennials for season-long color.* Edited by C. Colston Burrell, 112 pp., col. illustr., map, New York, Brooklyn Botanic Garden, 2002 (Handbook no. 172).
Dr Janet Browne	Browne, Janet, *Charles Darwin, the power of place.* 591 pp., illustr., London, Jonathan Cape, 2002.
Dr J. Cain	Chapman, Matthew, *Trials of the Monkey, an accidental memoir.* 333pp., London, Duckworth, 2000.
	Hamill, William ed., *The New York Public Library desk reference.* 836 pp., illustr., maps, New York, Webster, 1989.
Prof. J. Cairns	Cairns, John, *Collected papers, goals and conditions for a sustainable world.* 292 pp., figs., Oldendorf, Inter-research, 2002.
Czech Botanical Society	Hendrych, Radovan, *Genera Plantarum Orbis Geographicus, concise synopsis of the generic geography.* 123 pp., Prague, Societas botanica echica, 2002.
DEFFRA	Preston, C.D. (& others), *The changing flora of the UK.* 36 pp., col. illustr., maps, London, DEFFRA, 2002.
G. Douglas	Kalm, Peter, *Travels into North America*, translated by John Reinhold Forster, introduction by Ralph Sargent, illustr., col. frontisp., Barre, Mass. The Imprint Society, 1972.
	White, Gilbert, *The natural history and antiquities of Selborne* facsimile of the 1813 edition, introduction by P.G.M.Foster, 587 pp., illustr., London, Ray Society, 1993.
Fauna & Flora International	Andrews, Harry V. & Sankaran, Vasumathi eds., *Sustainable management of protected areas in the Andaman and Nicobar Islands.* 159 pp., with CD-ROM, New Delhi, FFI, 2002.
R. Fitter	Rickett, Harold William & Steere, William C., *Wild flowers of the United States. Vol. 2 The Southeastern States.* (2 Vols, 2nd printing) 688 pp., illustr. some col., maps on endpapers, New York, New York Botanical Garden, 1975.
Harold Porter Nat. Bot. Garden	CAPE TOWN, Harold Porter National Botanic Garden, *Kogelberg biosphere reserve, heart of the Cape flora.* Ed. by Jeanne Hromnik, (guidebook), 56 pp. col. illustr., map, Cape Town, Struik, 2001.
Prof. J.G. Hawkes	Hanelt, Peter, *Mansfeld's encyclopedia of agricultural and horticultural crops.* 6 vols. 3645 pp., illustr., Berlin, Springer, 2001.
Prof H.W. Lack	BERLIN, Berlin-Brandenburgische Akademie, "… *Eine Stütze des Gedächtnisses" die Akademie-bibliothek in geschichte und gegewart* 39 pp., illustr. Berlin, Berlin-Brandenburgische Akademie, 2000.
Dr H.F. Linskens	Linskens, H.F. & Jackson, J.F. eds., *Cell components* (Modern Methods of Plant Analysis, NS 1). 399 pp., illustr., Berlin, Springer, 1985.
	Linskens, H.F. & Jackson, J.F. eds., *Plant toxin analysis* (Modern

	Methods of Plant Analysis, NS 13). 389 pp., figs., Berlin, Springer, 1992.
	Sprengenberg, G., Z-Y. Wang & I. Potrykus, *Biotechnology and forage and turf grass management.* 200 pp., illustr. some col., Berlin, Springer, 1998.
Mehjabeen Abidi-Habib	Abidi-Habib, Mejabeen ed., *Green pioneers, stories from the grassroots*. 204 pp., col. illustr., maps, Karachi, UNDP Publication, 2002.
Dr E.C. Nelson	Nelson, E. Charles, *The virtues of herbs of Master John Gardener.* 112pp., illustr. some col., Dublin, Strawberry Tree Press, 2002.
E. Nystrom	Drake, Gustav ed., *Linnés avhandling Potus Thea 1765* (translated into Swedish with commentary). 22pp., Uppsala, Sveska Linnésalskapets, 2002.
Professor M.J. Petry	Linné, Carl Von, *Nemesis Divina*, edited and translated with explanatory notes, by M.J. Petry, 483 pp., Dordrecht, Kluwer Academic Publishers, 2001 (Archives Internationales d'Histoire des Idées 177).
Royal Botanic Gardens, Kew	Maunder, Michael (& others), *Plant conservation in the Tropics, perspectives and practise.* 628 pp., illustr., maps, Kew, Royal Botanic Gardens, 2002.
	Stearn, William T. (and others), *The genus Epimedium and other herbaceous Berberidaceae…*342 pp., illustr. some col., Kew, Royal Botanic Gardens, 2002.
Dr T.J. Roberts	Roberts, T.J., *The Butterflies of Pakistan.* 200 pp., col. illustr., maps, Karachi, Oxford University Press, 2001.
Dr R. Rosini	Rosini, Rosanna, *Pianeti Proibiti: descrizione traduzione intertesti.* 508 pp., Perugis, Ed. Guerra, 1997.
The Royal Society	Read, David, *The role of land carbon sinks in mitigating global climatic change.* 27 pp., figs, (Policy document) London, Royal Society, 2002.
M. Pilar San Pio	MADRID, Real Járdin Botánico, *Las rosas del Herbarium Pictum.* 6 pp., portfolio of 13 col. pl. Madrid, Rel Járdin Botánico & Ayuntamento da Madrid, 2002.
E. Slatter	Turner, Helen, *Henry Wellcome: the man, his collection and his legacy.* 96 pp., illustr., London, Wellcome Trust & Heinemann, 1980.
Dr A. Walker	Sheng, Helin, Noriyaki, Ohtaishi & Lu Houji, *The mammalia of China.* 297 pp., col. illustr., maps, Beijing, China Forestry Publishing House, 1999.
G.E. Wickens	Elton, J. Frederic, *Travels and researches among the lakes and mountains of Eastern and Central Africa.* 417 pp. illustr., map, reprinted by Frank Cass, London 1968, from the 1879 edition published in London by John Murray.

Keltie, J. Scott, ed., *The story of Emin's rescue as told in Stanley's letters.* 190 pp., map, London, Sampson Low, 1890.

Some other accessions acquired during 2002

Asher, Jim (& others), *The millennium atlas of butterflies in Britain & Ireland.* 430 pp., col. illustr., maps, Oxford, Oxford University Press, 2001.

Bureau of Flora & Fauna, *Flora of Australia Vol. 11A, Mimosaceae, Acacia part 1.* 673 pp., illustr. some col., Canberra, CSIRO, 2001.

Bureau of Flora & Fauna, *Flora of Australia Vol. 11B, Acacia part 2.* 536 pp., illustr. some col., Canberra, CSIRO, 2001.

Bureau of Flora & Fauna, *Flora of Australia Vol. 12, Mimosaceae, excluding Acacia.* 213 pp. col. illustr. maps, Canberra, CSIRO, 1998.

Bureau of Flora & Fauna, *Flora of Australia Vol. 17A, Proteaceae 2, Grevillea.* 524 pp., illustr. some col., Canberra, CSIRO, 2000.

Bureau of Flora & Fauna, *Flora of Australia Vol. 17B, Proteaceae 3, Hakea to Dryandra* pp., illustr. some col., Canberra, CSIRO, 1999.

Bureau of Flora & Fauna, *Flora of Australia Vol. 55, LICHENS, Lecanorales 2, Parmeliaceae.* 360 pp., illustr. some col. maps, Canberra, CSIRO, 1994.

Fragman, O., Levy-Yamanov, R. & Christodoulou, P., *Flowers of the Eastern Mediterranean.* 438 pp., col.illustr., mapo, Ruppell, A.P.G. Gertner, 2001.

Frodin, D.G., *Guide to standard floras of the world,* 2nd ed. 1100 pp., Cambridge, Cambridge University Press, 2001.

Güner, A. (& others), *Flora of Turkey, Vol. 11, suppl. 2.* 656 pp., maps, Edinburgh, Edinburgh Univ. Press, 2000.

Howell, S.G.N., *Humming birds of North America.* 219 p., illustr. some col., map, San Diego, Academic Press, 2002.

Jackson, Christine, *Dictionary of bird artists.* 580 pp., illustr. some col., Woodbridge, Antique Collector's Club, 1999.

Landsman, M. (& others), *Pearls, a natural history (exhibition catalogue).* 232 pp., col. illustr., New York, Harry N. Abrams, 2001.

Macdonald, David, ed., *The new encyclopaedia of mammals.* 930 pp., col. ilustr., maps, Oxford, Oxford University Press, 2001.

Mayr, Ernst & Diamond, Jared, *The birds of Northern Melanesia, speciation, ecology and biogeography.* 492 pp., 6 col. pl., illustr, maps, Oxford, Oxford University Press, 2001.

Raven, Peter, ed., *Flora of China Vol. 8 Brassicaceae through Saxifragaceae,* 506 pp., St Louis, Missouri Bot. Garden Press, 2001.

Raven, Peter H. & Wu Zhengyi, eds., *Flora of China Vol. 24 Flagellariaceae through Marantaceae*, 431 pp., Beijing, Science Press & St Louis, Missouri Botanial Garden Press, 2000.

Sharnoff, Sylvia Doran & Sharnoff, Stephen, *Lichens of North America* 794 pp., col. illustr., maps, New Haven, Yale University Press, 2001.

Smith, J. D.D., ed., *Official lists and Indexes of names and works in Zoology, Supplement 1986–2000.* 136 pp., London, ICZN, 2001.

Tongiorgi Tomasi, Lucia & Hirschauer, Gretchen A., *The flowering of Florence, botanical art of the Medici (exhibition catalogue).* 131 pp., col. illustr., Washington, National Gallery of Art, 2002.

Tuzov, V.K., *The synonymic list of butterflies of the USSR.* 73 pp., map, Moscow, Rosagriservice, 1993.

Vives, Marcos, *Catologo sistematico y sinonimo de los lepidoptera de la Peninsula Iberica y Baleares.* 378 pp., Madrid, Min. Agri. Pesc. Y Alimentacion, 1991

GINA DOUGLAS

Picture Quiz

William Macdonald (1797–1875)

A true highlander William Macdonald was born in the Western Isles on 21st March 1797. He graduated as a doctor of medicine in 1818 at Edinburgh and obtained his FRCP there in 1836 and became a Fellow of the Royal College of Physicians. One of his first jobs on qualifying was as lecturer in Natural History and Comparative Anatomy at Lane's Medical School, adjoining St George's Hospital, London. On the death of his father, however, he inherited the valuable property of Ballyshear, one of the finest estates in Kintyre, Argyllshire and immediately gave up all thoughts of practicing his profession. Instead he began using his fortune to improve the road system in that part of Scotland. The resulting free, public roads were at that time unequalled in any other part of Scotland. Eventually his fortune was dissipated and he was forced to sell up. His philanthropy though had not gone unnoticed by the Marquis of Alisa who insisted on presenting him to the professorship of Civil and Natural History and Comparative Anatomy at St Andrew's University, a chair he occupied for the next twenty-four years.

This professorship proved to be a sinecure since it formed no part of the required curriculum and only those students who desired it, took his class in natural history. To these students he is said to have behaved like a true peripatetic philosopher. On one famous occasion, learning that one his students had opted to study medicine, he remarked to his father:

Clue: Darwin had a copy of his “Critical Examination of the First Principles of Geology” with him on board the *Beagle*.

> “tell your son to learn vetinary surgery as well as human, for there is many a cuif (blockhead) who would grudge him half-a-crown to mend his wife, but would readily give him a guinea to mend his horse”.

This part time teaching position allowed him both time for his own researches and, more importantly, to visit London to attend scientific meetings. Having joined the Linnean Society back in 1826 (his chief supporter being Forbes) he was on intimate terms with Charles Lyell, who personally invited him to attend the reading of the Darwin/Wallace papers on July 1st 1858.

We have no knowledge of the influence this may have had on him, but what we do know from his publications on vertebral homologies was that he considered Owen’s views erroneous. Although he was prepared to accept archetypes he believed that it was possible to go much further than Owen and to trace the homologies in the legs of insects and Crustacea.

BRIAN GARDINER

Correspondence

10 August 2002 Albrecht-von-Haller-Institut fur Pflanzenwissenschaften, Gottingen

Dear Professor Gardiner,

I would identify the gentleman shown on p. 21 of *The Linnean* **18**(3) as the well-known British bryologist William Mitten (1819–1906). Mitten was a pharmacist who lived most of his life in Hurstpierpont, Sussex, where he dedicated himself, during his free time, to the study of exotic bryophyte collections forwarded to him from Kew for naming. He is the author of numerous publications, in which he described more than one thousand new species and numerous new genera, many of them still valid today. His main works on mosses include *Musci Austro-Americani* (in which he described the mosses of Richard Spruce – your clue) and *Musci Indiae-Orientalis*, those on liverworts *Hepaticae Indiae-Orientalis* and the chapter on the Hepaticae in Hooker's *Handbook of the New Zealand flora*. Mitten also amassed a major herbarium of approximately 54,000 specimens, probably the largest private bryophyte herbarium in his day (Thiers, 1983).

Upon his death, on 27 July 1906, Mitten's herbarium was sold within days – at the price of 400 pounds sterling – to the New York Botanical Garden in what has been considered one of the largest coups in the history of American bryology. The loss of the Mitten herbarium to North America was deplored by William Helmsley in his letter of October 1906 to Nathaniel Lord Britton, director of the New York Botanical Garden: "We are very loath that the Mitten herbarium should go abroad, especially as Mitten worked so much for Kew, but, your larger purse prevailed." (see B.M. Thiers, *Brittonia* 35: 271–272. 1983).

Yours sincerely
ROB GRADSTEIN (Prof. Dr. Stephan Robbert Gradstein)

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29 April 2002 Chichester, West Sussex PO19 5QX

Dear Brian,

I was interested to read in the Annual Report 2001 that five people were Fellows for over seventy years, and that H.N. Ridley and Anna Bidder were the longest serving Fellows with 74 years. These were substantial achievements even though each of them lived into their nineties – or beyond.

I think that an all-time record for a society membership must be Paul W. Richards who was a member of the British Bryological Society (formerly the Moss Exchange Club) for 76 years(1908–95). Although he died in his eighties, he had joined when he was only eleven years old!

Yours sincerely,
BRIAN HOPKINS

5 April 2002 clivefmann@tinyworld.co.uk

Dear Dr Marsden,

Re-reading Pat Morris's interesting note (From the Archives, *The Linnean* 2001, 17: 15-16) about Meinertzhagen's gift to the Society of Darwin's pipe 'prompts me to mention Meinertzhagen's presentation of a gavel to the British Ornithologists' Club. It is, I believe, oak, in the form of a solid cylinder, tapering upwards, bevelled top and bottom, and also dished at the top, with a removable handle, octagonal in transverse section for most of its length, with a carved knob at the top. The bottom is highly carved, the central motif incorporating a highly stylised cross. The rest of the body bears simple carvings. Its dimensions are approximately 7 cm radius, tapering to 5 cm, and 8 cm high; the exposed part of handle 10 cm, with a 4 cm long threaded part to screw into the main body. Sunk into the cylinder are the following:

(1) The obverse of a British Ornitholigists' Union Godman-Salvin medal (I believe gold),

(2) the reverse of the said medal inscribed

RICHARD MEINERTZHAGEN AWARDED 22nd Nov 1951

inset at 180 degrees to the obvervse,

(3) an approximately oval silver plate with a pseudogothic inscription

British Ornithologists Club from Colonel Richard Meinertzhagen 1901-1951

fixed (as are the rest of the silver plates) with silver tacks, and equidistant to the halves of the Godman-Salvin medal,

(4) a rectangular silver plate fixed below (3) inscribed

THIS WOOD IS FROM H.M.S. BEAGLE

(5) a highly ornate, diamond-shaped silver ornament which at its centre incorporates a cross, with a long cross-piece just above centre, a short horizontal cross-piece towards the upper end, and another short cross-piece towards the bottom, slanting to the right. This is equidistant to the two halves of the medal,

and finally

(6) a rectangular silver plate fixed below (5) inscribed

THIS ORNAMENT WAS BROUGHT BACK
FROM SIBERIA BY SEEBOHM WHO GAVE
IT TO MEINERTZHAGEN IN 1895.

It must have been donated to the Club post-1951, but I do not know in which year.

It is a very interesting artifact, fraudulently produced or otherwise, of which, as Chairman of the British Ornithologists' Club, I am keeper.

CLIVE MANN

The Burgess Shale hike; evolution in a day

Introduction

The Burgess Shale is “the most precious and important of all fossil localities” (Gould 1989 p.13). Located high in the Canadian Rockies of British Columbia, the original outcrop of this world famous fossil bed can be visited by the general public only through guided hikes during the summer months. Through the coincidence of specific tectonic, sedimentation and chemical processes, the rare depositional environment of the Burgess Shale preserved the soft body parts of its Middle Cambrian fauna, thus providing a fascinating glimpse of what life was like on Earth 518 million years ago. Moreover, the Burgess Shale gives an insight into an apparent evolutionary ‘explosion’ during the earliest part of the Cambrian Period.

The Burgess Shale hike is the ideal catalyst for the geological and biological enthusiast to revise and update in one day an understanding of the evolution of life as presented during the last 20 years by scholars in the field. This article relates a one-day travelogue to the original Burgess Shale quarry outcrop, with comments on the hike, current geological setting, unique Cambrian sedimentation, fossils found, and most importantly a passage through one hundred years of palaeontological research and the subsequent (often antagonistic) views presented for the evolution of life on Earth, and how these views challenged and built on the evolutionary ideas of Charles Darwin.

The Burgess Shale is the name given to a small section of ‘basinal’ facies of the Middle Cambrian Stephen Formation located between Mt Field and Mt Wapta in Yoho National Park, British Columbia (Fig. 1). The nearby small town of Field lies only a few kilometres from the better-known national parks of Banff and Jasper in adjacent Alberta Province. Field was established in 1884 when the Canadian Pacific Railway chose the Kicking Horse Valley as its pass through the up-to-then impenetrable Rocky Mountains. The nearby Upper and Lower Spiral Tunnels attest to the remarkable engineering feats in building the railroad. It permitted people from all walks of life, including tourists and scientists, to enjoy the beauty of the mountains, and a number of trails gave access to the high alpine meadows. In 1886 this included a geologist with the Geological Survey of Canada named McConnell who climbed neighbouring Mt Stephen where he discovered a trilobite rich Middle Cambrian section high above Field.

Charles Walcott was an authority on the Cambrian System and in 1907, the same year he became head of the Smithsonian Institution in Washington, he began a series of field seasons in Yoho National Park. By expanding his radius of search from the Mt Stephen trilobite bed across the Kicking Horse Valley, Walcott discovered in 1909 the well-preserved fossils of the Burgess Shale including examples with preserved soft-body tissue. He coined the name Burgess Shale after the nearby Burgess Pass and neighbouring Mt Burgess (Fig. 1). The Walcott Quarry, as it is now termed, was designated the Burgess Shale World Heritage Site by UNESCO in 1984, at a time when Yoho National

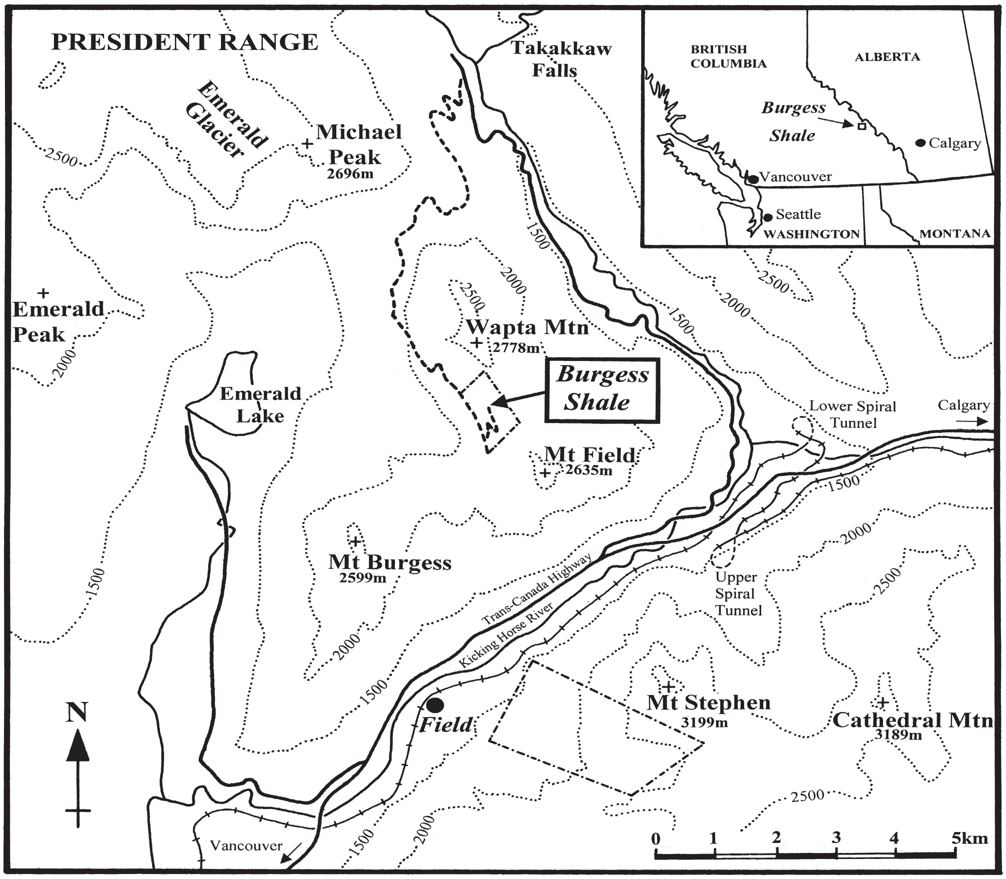

Figure 1. Location map identifying the principal mountain peaks, the Kicking Horse River valley with highway and railroad (note spiral tunnels), the Burgess Shale and Mt Stephen restricted areas, and the Burgess Shale hike trail.

Park and six other nearby national and provincial parks were also declared the Rocky Mountain World Heritage Parks – so The Walcott Quarry is a protected site within a protected area.

The hike

The Yoho-Burgess Shale Foundation is a non-profit charitable organisation, which manages guided hikes for the general public several times per week between end-June and late-September. The Walcott Quarry hike is popular so a reservation through the Foundation website *www.burgess-shale.bc.ca* is strongly recommended. The Mt Stephen quarry hike can also be booked. The present authors took their Walcott Quarry hike in late-September 2000, and together with thirteen other hikers met our licensed guide at 0800 at a location close to the Trans-Canada Highway in Field. Our guide was a PhD palaeontology post-graduate who was also knowledgeable about the local flora. It is assumed that all hikers are reasonably fit, although some measure of altitude acclimatisation in the days before the hike is almost more important. The hike is 22km, takes approximately 10 hours, with an elevation gain of 750m (*c.*2,500ft) climbing up to The Walcott Quarry at 2,300m (*c.*7,500ft).

After a short drive, the hike starts at the foot of the spectacular Takakkaw Falls, which plunges 254m from the Daly Glacier on the Waputik Icefield into the Yoho River below, and is clearly audible for several kilometres around. The hike is formed of three parts; a steep start, a less steep but long middle section, and a steep final climb to the quarry. Our guide maintained a steady pace up the initial steep "zig-zag" ascent through coniferous forest redolent with resin in the early morning air. A break after 45 minutes climb gave each hiker a chance to say something about themselves and their interest in this special fossil quarry. Our group contained a number of geologists and biologists, though hiking was an ubiquitous pleasure for all.

Three main phases of research

A second short rest period at a trail campground generated discussion on the discovery and subsequent history of research on the Burgess Shale.

Palaeontological research is split into three main phases;

1. the Charles Walcott era 1907–1924,
2. the Harry Whittington era with his Cambridge graduate students in the mid-1960s and 70s, and
3. the Royal Ontario Museum era led by Desmond Collins from 1975 to present.

Naturally, other workers contributed over the years, notably Percy Raymond from Harvard in the late-1920s and early-1930s, Franco Rasetti in the late-1940s up to 1951, and Alberto Simonetta in the 1960s, but during the hike and throughout this short article only the main participants are discussed.

Charles Doolittle Walcott's early career was with the US Geological Survey, and despite no formal geological training he rose to become its third Director, before moving over to become Secretary (head) of the Smithsonian Institution in Washington. He became an authority on Cambrian fossils, which in 1907 naturally led him to Field and the Mt Stephen trilobite beds. Various tales are attached to Walcott's discovery of the Burgess Shale, notably that related in his obituary where late in the 1909 field season whilst following the trail between Mt Wapta and Mt Field with his first wife Helena and two sons, he dismounted to clear away snow and boulders when his wife's horse stumbled, when his attention was drawn to a small silky fossil in the shaly talus; this was the "lace crab" later named *Marrella.* Other less romantic tales report it was Walcott's own horse that stumbled, while Gould (1989) claims a far more pragmatic sequence of events for the discovery by studying Walcott's diary. Walcott returned the following year and traced the talus upwards to a 2.3m thick highly fossiliferous seam containing many soft-bodied fossils, for which he coined the name Phyllopod Bed (after an old name for a crustacean group). He spent many field seasons until 1924 excavating vast numbers of Burgess

Shale fossils. Some estimates say 65,000 specimens were carried down the mountain on horseback and by rail back to Washington. Unfortunately, his duties as Secretary of the Smithsonian Institution, President of the National Academy of Sciences, and a founder of both the National Parks Service and Carnegie Institution, prevented him undertaking as extensive an investigation of the vast specimen collection as some more recent workers have expected. Nevertheless, Walcott described over 100 species (of the 170 currently recognised) in five volumes of the Smithsonian Institution Miscellaneous Collections, though as was accepted practise during such a conservative period in the development of palaeontology, as well as in the cultural life of the times, all species were made to fit into accepted recognised phyla.

Walcott's Smithsonian collection and his classifications received no further significant work until 1966/7 when Harvard professor Harry Whittington joined a Geological Survey of Canada (GSC) team to re-excavate the Walcott and (higher) Raymond quarries. In 1966 Harry Whittington also moved across the Atlantic to become professor at Cambridge, and expanded his project from there. Working on both the new GSC collection and Walcott's vast collection he recruited graduate students Derek Briggs and Simon Conway Morris in 1972 to work on arthropods and worms, respectively. David Bruton and Chris Hughes also joined the team. The team's breakthrough investigations set new standards in detailed Burgess Shale analyses. Whittington concentrated initially on what were thought to be arthropods, all of which had jointed legs and segmented bodies. All previously described arthropods were classified within four main groups, differentiated primarily on the number and type of appendages; insects and millipedes, crustaceans, spiders and scorpions, and the extinct trilobites. The revolutionary fine detailed preparation work by Whittington and his team using a modified dentist's drill examined fossil skeletons and dissected out soft body tissue below the outer surface layers. Their detailed work was published at the time in monograph format in various journals, and later as semi-popular books (Whittington 1985, Briggs *et al.* 1994 and Conway Morris 1998). The Whittington team's work was also made more accessible to the public in a stimulating book *Wonderful Life* by Stephen Jay Gould (1989), which put much emphasis on the Burgess Shale's peculiar 'weird wonders'.

The Royal Ontario Museum (ROM) under the leadership of Desmond Collins began working over the Walcott and Raymond quarry talus from 1975, and returned with larger groups (including Conway Morris and Briggs) in the early-1980s in search of other Burgess Shale localities. Collins and his ROM teams discovered more than a dozen new localities along a 20km edge of the Cathedral Escarpment (see later), some at higher or lower stratigraphic levels to Walcott's Phyllopod Bed, and each with its own distinctive fossil assemblage. Over the last 20 years new Burgess Shale fossil material has been discovered and described. Most recently the Royal Ontario Museum was granted license to excavate a large extension below Walcott's working horizon. Up to a further 40,000 specimens have been extracted by Collins over the years, with many new species as yet undescribed. Collins currently supervises a large group of Burgess Shale graduate students at the University of Toronto.

The Collins work has been supplemented during the last two decades by extensive research programmes on Lower Cambrian Burgess Shale-type discoveries in other parts of the world, most notably Chengjiang and neighbouring areas of east central Yunnan in China, and the Sirius Passet fauna from Peary Land in northern Greenland. Other similar, but less researched, discoveries are from Utah and other mid-western states in the US, NE Poland and the Emu Bay Shale on Kangaroo Island in South Australia (Briggs *et al*., 1994, Conway Morris 1998). The Chengjiang localities have recently been summarised by Zhang *et al.* (2001), with many new species discovered from over 20,000 specimens collected.

Alpine meadow flora

Before leaving the trail campground our guide briefly described the wildflowers in the Yoho alpine meadows. Unfortunately, by September most flowers had already died, hastened this year by a particularly early and heavy snowfall the previous week.

Species noted during this late-September hike include Western Anemone (*Anemone occidentalis*) seen in large swathes higher up the trail above the tree-line, Fringed Grass-of-Parnassus (*Parnassia fimbriata*), False Solomon's Seal (*Smilacina racemosa*), Common Harebell (*Campanula rotundifolia*), Four-parted Gentian (*Gentiana propinqua*), Tall Purple Fleabane (*Erigeron peregrinus*), Elephant Head (*Pedicularis groenlandica*), Indian Paintbrush (*Castilleja* spp., including the rare white/yellow colour variety), Sitka Valerian (*Valeriana sitchensis*) and Common Yarrow (*Achillea millefolium*). From 1914 onwards, Walcott's second wife Mary Vaux Walcott accompanied him in the field and painted many of the wonderful and varied wild flowers, some rare, others common. A book containing 400 plates of her work was later published by the Smithsonian.

Plate tectonics and regional structural geology

The trail continued as a long steady climb for a further 2km through the wooded saddle of Yoho Pass until it emerged from the trees between a massive limestone bluff and the scree drop-off to the west with stunning views across the valley to Michael Peak, Emerald Glacier and the President Range. A welcome third rest period was used to expand on the geological structure of the region, both from the plate tectonic perspective and the local structure of the mountains in the immediate area.

During the latter part of the Proterozoic (from about 1.3–1.0 Ga) most of the world's landmasses were fused as the supercontinent Rodinia (Dalziel 1995). Between 750–550 Ma a period of continental breakup was closely followed by many landmasses coalescing once more as the southern supercontinent Pannotia, which comprised the main continental components of Gondwana plus the ancestral North American continent called Laurentia. By the onset of the Cambrian (545 Ma) Laurentia had already broken away from Gondwana and drifted towards the equator, eventually taking up a position straddling the equator, though positioned at right angles to its present orientation (well illustrated by Dalziel 1995 p.41, and Coppold & Powell 2000 p.12–13). This northerly drift into the huge

Panthalassic Ocean created the smaller Iapetus Ocean between Laurentia and Gondwana. Laurentia remained in tropical latitudes for the next 300 million years. During the Middle Cambrian the region of Yoho National Park and the Burgess Shale was located just north of the equator and a considerable way offshore on the edge of a shallow marine shelf. Other Laurentian outcrops of Burgess Shale-type faunas such as Sirius Passet in Greenland also occupied a near-equatorial position during the Cambrian (Conway Morris 1998 Fig. 50), as did the Chengjiang locality in China (Briggs *et al.*, 1994 Fig. 2.8).

The mountains of western North America experienced a long and complex tectonic history. Since the end of the Palaeozoic (*c*.245 Ma) the basaltic ocean floor of the Pacific slowly moved eastwards and subducted beneath the buoyant overriding continental landmass of North America. The continental crust was compressed, sheared and fractured and progressively deformed to build up the mountain ranges, whilst the subducted ocean floor remelted and in places erupted through the continental margin as volcanoes, or formed island arcs that subsequently accreted to the continental margin. During the Middle Jurassic (*c*.175 Ma) the first volcanic island arc complex collided with and accreted to the western edge of North America and currently occupies the Main Ranges of central British Columbia. A second volcanic island system collided with the continental margin during the Late Cretaceous (*c*.85 Ma) and accreted as a volcanic trend along the present British Columbian coastline. The consequent deformation affected the tectonics of the area as far inland as the current Alberta foothills near Calgary. The compressional phase ceased by the Eocene (*c*.45 Ma) and extensional normal faults relieved some of the stresses of mountain building.

From their viewpoint looking across the valley to Michael Peak and Emerald Glacier, the hiking group could make out examples of both low angle thrust planes and steep angle normal faults. This eastern zone of the Rockies is a classic area for the study and interpretation of thin-skinned compressive tectonics.

Cambrian stratigraphy, sedimentation and preservation

A further kilometer or two hiking up a gently rising gradient provided another rest opportunity and chance to complete the geological story with detail of the stratigraphy of the area, and more particularly to discuss the unique sedimentation and preservation history of the Burgess Shale.

From the beginning of the Cambrian at 545 Ma the northern Panthalassic margin of tropical Laurentia (now western North America) experienced a rise in sea level and seas transgressed onto the low relief barren landmass. A huge thickness of beach sand was deposited in the Yoho National Park area and repeatedly winnowed and reworked to produce the highly quartzitic Gog Group sandstone, in places up to 2km thick (Fig. 2). The earth revolved faster during the Cambrian (21 hour days and 420 days per year) and the moon was closer to earth than today, so tidal reworking was more significant. The sun was assumed to be weaker than today but higher atmospheric CO_2 concentrations apparently compensated and so maintained life sustaining temperatures.

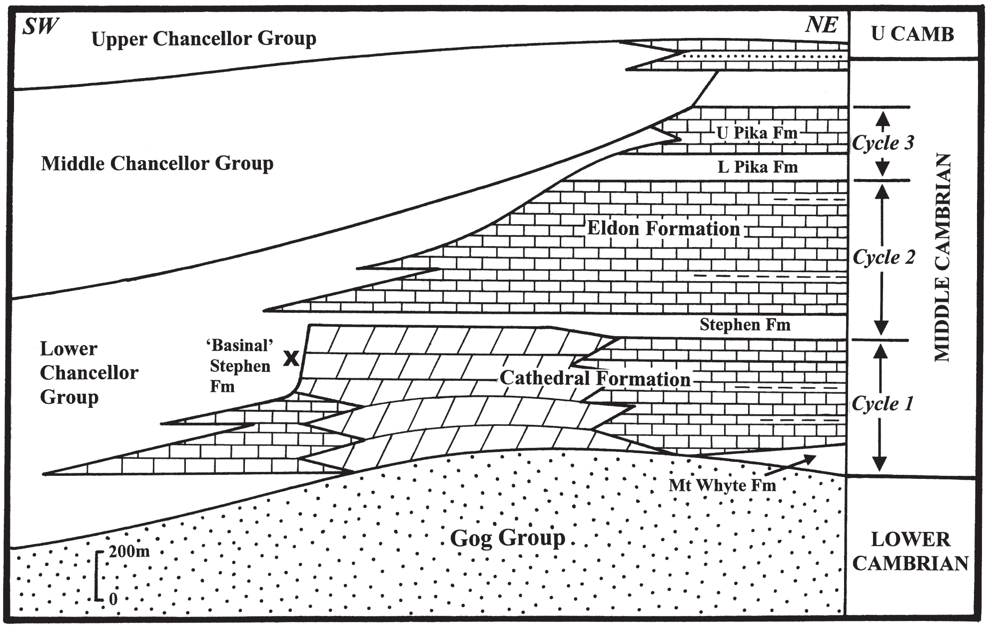

Figure 2. Schematic lithostratigraphy through Yoho National Park, identifying the three main carbonate-mudstone cycles, as well as the position of The Walcott Quarry (X) close to the escarpment. (Derived from Aitken 1997, and Coppold & Powell 2000 p. 15).

The Middle Cambrian from 518 Ma experienced repeated cycles of sea level rise and fall, with transgressions extending over the low lying land as far as today's central Canada. In the Yoho National Park area these cycles in sedimentation deposited alternating shaly mudstone and siltstone in the lower part with cleaner shallow water limestone above (Aitkin 1997). Three cycles are recognised (Fig. 2): the Mt Whyte-Cathedral cycle, the Stephen-Eldon cycle, and the lower Pika-upper Pika cycle. In each case the lower formations are essentially subtidal to intertidal mudstone and siltstone, while the upper formations are algal dominated shallow marine carbonate. Seaward (northward during the Middle Cambrian) mudstone and deep-water carbonate of the Chancellor Group was deposited throughout the Middle Cambrian and was the time equivalent to the shallow water shelf facies further south. The Burgess Shale is the informal term coined by Walcott for the fossil-bearing unit within a basinal facies of the otherwise shallow water Stephen Formation. But what makes this small zone of fossiliferous shale quite so special?

The break between deep and shallow water environments developed time and time again along essentially the same trend. The shelf edge of the three cyclical shallow water limestone formations (Cathedral, Eldon and upper Pika) developed as strongly positive morphological features. This was especially so along the front of the algal limestone of the Cathedral Formation (Briggs *et al.*, 1994 Fig. 2.2) which developed an almost vertical submarine cliff 100–200m high termed the Cathedral Escarpment. Aitkin

& McIlreath (1984) interpret this cliff as the front of a massive reef built by lime precipitating algae with a carbonate platform behind and deeper water basinal mudstone beyond (see Briggs *et al.*, 1994 Fig. 2.3). Other evidence suggests a large-scale detachment and collapse with a huge section of the platform margin sliding basinward for several kilometers. Similar structural features are recognised for the Eldon and upper Pika Formations. Eventually, the Cathedral Escarpment cliff was covered by Stephen Formation mudstone, such that the Stephen Formation is much thinner on top of the escarpment than below it.

All Burgess Shale outcrops in Yoho National Park are tucked tightly against the Cathedral Escarpment, as this escarpment was crucial to fossil formation and preservation (Fig. 3). It extends for about 20km, and at each of a dozen outcrops well-preserved fossils are confined to the mudstone within 150m of the escarpment. Further away the exceptional preservation is lost and the mildly metamorphosed Stephen Formation shale exhibits a closely spaced cleavage that prevents spitting parallel to the original bedding. This cleavage does not develop in the ‘strainshadow’ of the Cathedral Escarpment.

Throughout deposition of the Stephen Formation fine mudstone built up slowly on the sea floor, with a wedge of this mudstone up against the escarpment and thinning into the basin (Fig. 3). The thin bedded fining upward mudstone is not disrupted by burrowing and mixing of the sediment, so clearly bottom waters were hostile to invertebrates living in or on the sediment. Periodically, however, mud from the shelf above the escarpment

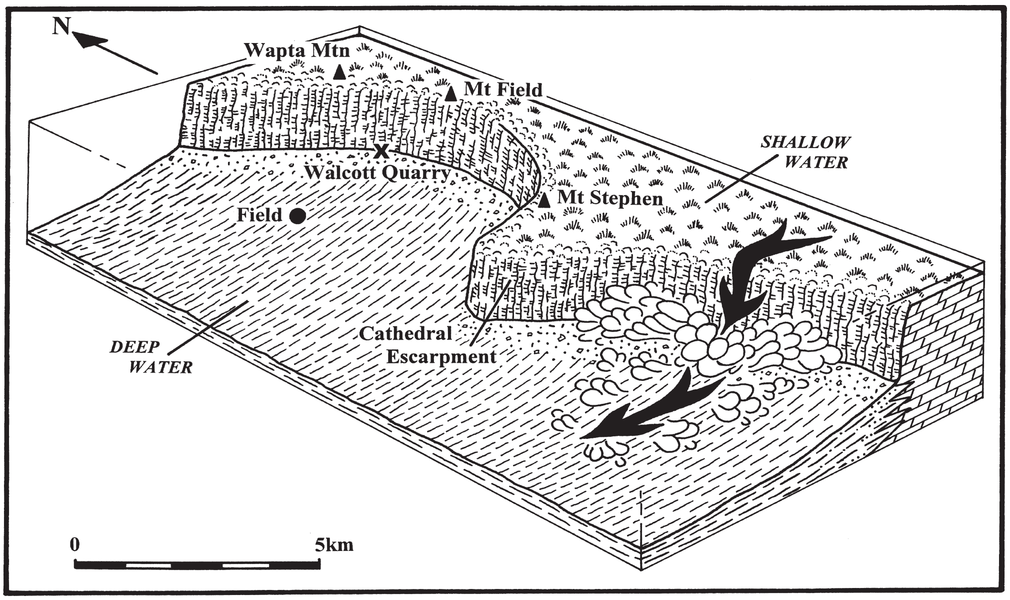

Figure 3. Reconstruction of the depositional environment of the Burgess Shale where sediment periodically cascaded down the Cathedral Escarpment. Present day landmarks shown. The Walcott Quarry (X) is located tight against the base of the Middle Cambrian cliff. (Derived from Coppold & Powell 2000 p. 27).

Figure 4. The Walcott Quarry looking northwest. The relatively flat original quarry floor occupies the foreground with the recent deeper ROM excavation seen at the far end of the quarry, and the talus drop-off to the left down to the treeline. The lower crags of Mt. Wapta occupy the middle distance, while Emerald Glacier and the President Range form the background.

where Middle Cambrian shallow marine animal life was prolific, slumped over the edge or was carried over or along the escarpment by turbidity currents triggered by storms or earth movements or by instability in the sediment pile (Whittington 1985, Briggs *et al*. 1994 Fig. 2.6). During such traumatic moments animals were swept along in the turbulent cloud to be suffocated and deposited with random orientation within the turbid mud. The mudflows quickly buried the carcasses in an oxygen-starved environment and too deep to be reached by scavengers. Moreover, aluminosilicates in the clay mineral of the original mud particles that found their way into the finest body cavities formed a fine film over soft body tissue thus preventing complete anaerobic decomposition, and fossilising some soft body parts in addition to the normal mineralised skeletons and shells. Their position in the 'strain shadow' of the Cathedral Escarpment sheltered the fossils from subsequent tectonic deformation. The preservation mechanism of soft parts in Burgess Shale-type fossils is still under active research.

After ingesting this vast amount of geological information, and a further short hike, the group reached the long awaited lunch stop. And what a stop! Beyond and across the valley is the President Range with its stunning Michael Peak at 2,696m (8,843ft) and adjacent hanging cirque that encloses Emerald Glacier (Coppold & Powell 2000 p. 57). A stream issues from the tip of the glacier, cascades over a series of vertical bluffs and finally flows into Emerald Lake, just visible at the bottom of the valley 500m below. Lateral moraines extend on either side of the glacier, with terminal moraines wedged on the hanging wall, giving some indication of the glacier's size at the end of the Pleistocene glaciation before its long retreat.

The Walcott Quarry

With lunch digested, it was less than a kilometer of relatively level trail until the hiking group approached a talus slope, the very same spot where ninety years earlier Mrs Walcott's horse is reputed to have stumbled. The slabs of Stephen Formation shale were inspected and only a few moments needed for the geological eye to pick out fossil shapes on the glinting green to dark-grey bedding planes. Examples of soft bodied animals observed by the group ranged from the dark matt-grey priapulid worm *Ottoia prolifica* Walcott 1911 (Fig. 5b), the almost white finely filamentous cyanobacteria *Marpolia*, the silky outline of the arthropod *Marrella splendens* (Walcott's lace-crab) (Fig. 5c), to the more robust calcified exoskeletons of the common trilobite *Olenoides serratus* (Fig. 5d), and slabs with dozens of the small cap-shaped helcionelloidan mollusc *Scenella*.

However, it was time to quickly move on to the main objective. A few hundred meters further south our guide turned off the main trail into the restricted access area of the World Heritage Site. At this point the climb is steep, zig-zagging its way upwards, until after about half and hour the group arrived at its destination, The Walcott Quarry.

At first sight the quarry seemed quite small (Fig. 4), but closer inspection revealed that much rock had been extracted leaving a significant cleft in the sloping mountainside (see distant view in Briggs *et al.* 1994 Fig. 2.1). Walcott maintained a level floor to the quarry throughout his period of investigation, as he was emphatic that no fossils existed above or below his Phyllopod Bed. However, a few years ago Desmond Collins and his ROM team secured authority from Parks Canada to explore deeper beds, so the northern quarry floor now steps down into new excavations. Collins' team discovered many more new Middle Cambrian species.

During the one-hour available to the group at The Walcott Quarry, more fossils of hard- and soft-bodied animals were found. All the fossils seen at the talus slope were found again at the quarry. In addition, the following examples were observed; the complexly branched common sponge *Vauxia gracilenta* (Fig. 5a), a trilobite different from *Olenoides* which is possibly *Elrathina cordillerae* (Fig. 5e), a part tail section of the arthropod *Sidneyia inexpectans* (Fig. 5f), the frond-like green algae *Margaretia*, several somewhat poor impressions of the crustacean *Canadaspis*, and the conical shape of the hyolith *Haplophrentis carinatus*. The reader should note that the photographs in Fig. 5a-f are selected to illustrate a representative sample of fossils as encountered during the one hour stop at The Walcott Quarry, and are not intended to show the detail of laboratory prepared fossils of museum and text book quality. For exquisite photographs depicting a full-range of Burgess Shale fossils the reader is referred to Conway Morris (1982), Whittington (1985) and particularly Briggs *et al.* (1994).

Our guide completed the all too short stay at the quarry with a synopsis of the more spectacular Middle Cambrian fossils extracted over the past ninety years, using a suite of line drawings on cards (Fig. 6a-q).

At this point dark clouds began to build from the west with the beautiful mountain peaks rapidly fading into a murky haze, and it was time to make the long three and a half hour slog back down the mountain.

The fossils

Not all Burgess Shale fossils are weird, but a notable proportion are! Whittington (1985) indicates that about 60% of discovered Burgess Shale fossils were fully soft bodied or had minimal hard parts, and some 40% of genera described are arthropods. Prominent amongst the arthropods was the largest predator in the Cambrian seas *Anomalocaris* (Fig.6l) approaching half a meter in length and parts of which were previously described as a shrimp and medusoid jellyfish (!), then later assigned to a hitherto unknown phylum, and recently to the extinct arthropod class Dinocarida (Collins, 1996). The rare and strange *Opabinia* (Fig.6o) with its five eyes and long flexible nozzle-like proboscis was also unassigned for many years, but is now also considered a dinocarid arthropod. Walcott's "lace-crab" *Marrella* (Fig.6d) was a primitive arthropod, and not a trilobite as Walcott proposed. The notorious Onychophora lobopod *Hallucigenia* (Fig.6f) was named for its "bizarre and dream-like appearance" by Conway Morris, who originally thought it walked on seven pairs of spiney stilts until he realised his interpretation was "upside down" and the ferocious palisade of spines was for protection. The slug-like *Wiwaxia* (Fig.6p) with its dorsal coating of scale-like sclerites and defensive spines was recently interpreted by Conway Morris as lying on the halkieriid-polychaete annelid phylogenetic line, though for now it is unassigned to any phylum. *Pikaia* (Fig.6n) was a primitive chordate and thus an early representative of the vertebrates. Other weird wonders include the arthropods *Waptia, Sanctacaris, Sidneyia*, *Burgessia*, and *Yohoia* (Fig.6h, i, j, k, m), and another lobopod *Aysheaia* (Fig.6c).

The Cambrian 'explosion' and evolution

The traditional view of evolution has long been the inverted cone tree with life progressively diversifying upwards and outwards (Fig.7a). Charles Darwin's great conundrum, however, was the sudden appearance in the fossil record just above the base of the Cambrian of well-developed fossils with mineralised skeletons and shells. With insufficient 'time' between the top of the Precambrian (then thought to be

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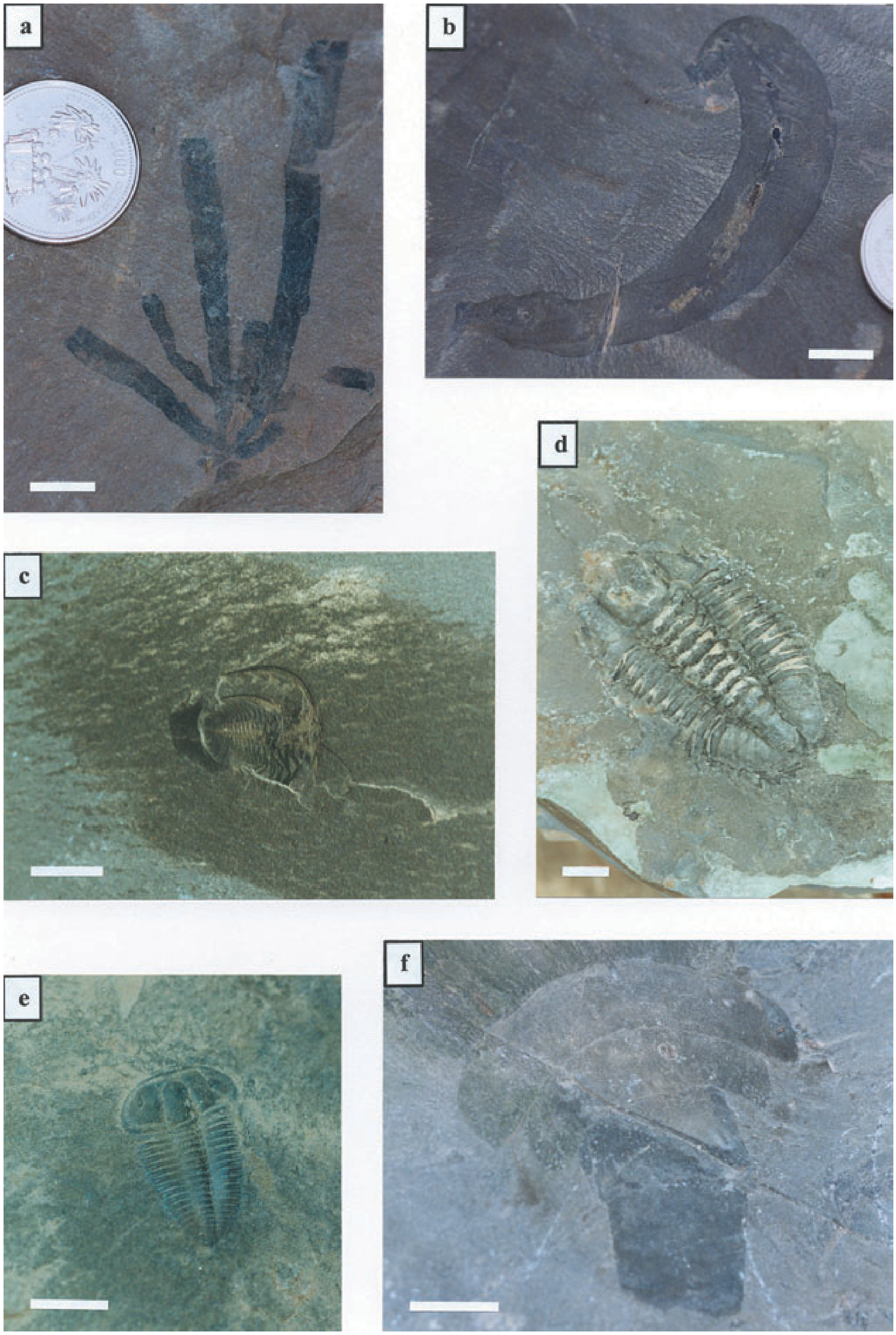
Figure 5 (opposite page). Photographic montage of Burgess Shale fossils seen at the Walcott Quarry; a) branched sponge *Vauxia gracilenta* with just the faintest polygonal network visible; b) common priapulid worm *Ottoia prolifera* with the gut clearly visible; c) diminutive primitive arthropod *Marrella splendens* with indistinct appendages lower right and the characteristic dark stain at its rear caused by seeping body fluids during decay; d) most common trilobite *Olenoides serratus*; e) trilobite *Elrathina cordillerae* exhibiting a marked tapering thorax; and f) three abdominal and two thoracic segments of the large arthropod *Sidneyia inexpectans*. Bar scale is 1cm.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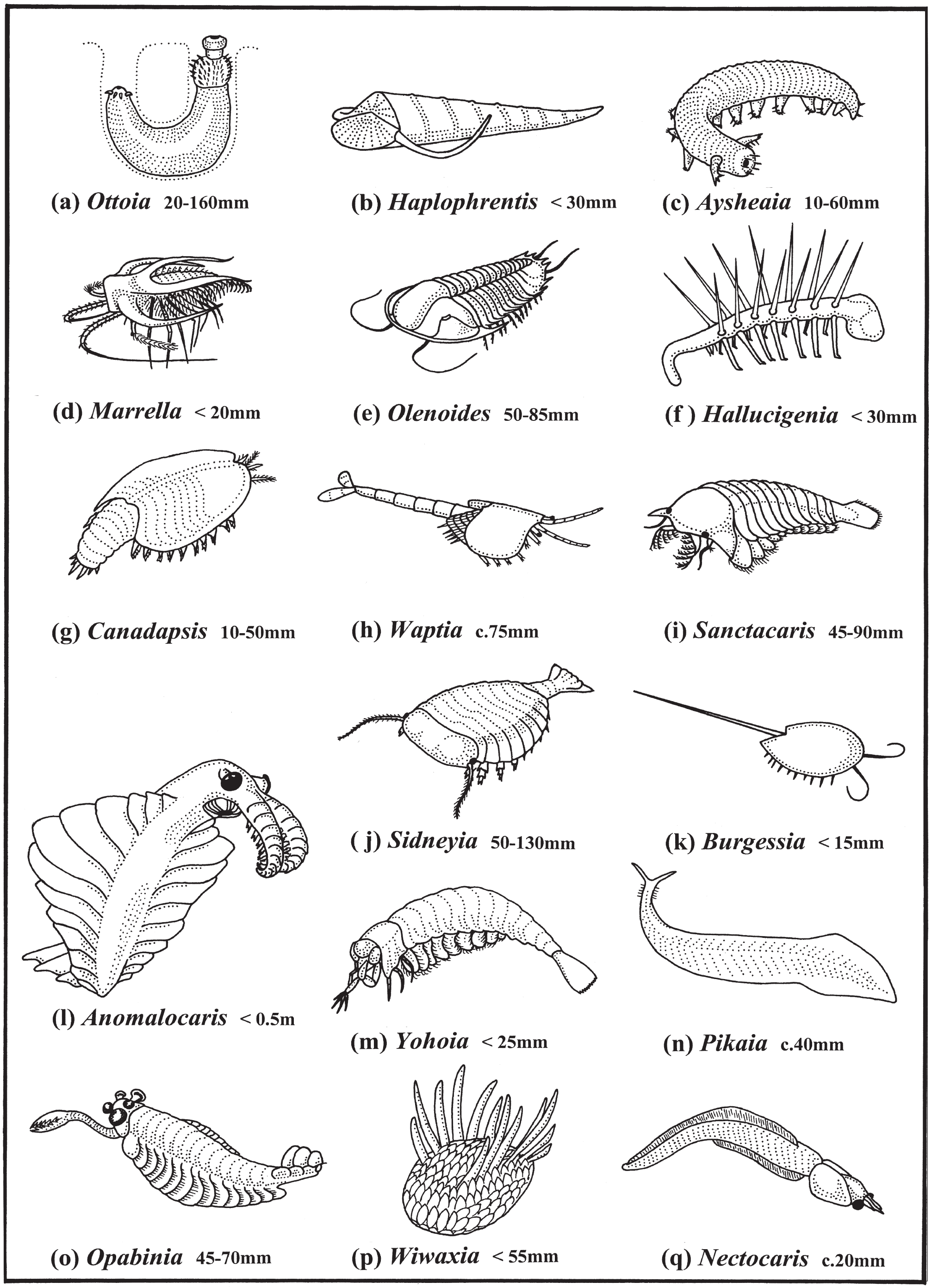

Figure 6. Sketches of selected Middle Cambrian “weird wonders” from the Burgess Shale; typical sizes indicated. (Sketches a-e, g-k, m-q derived from Briggs *et al*. 1994, sketch f derived from Conway Morris 1998, and sketch l derived from Collins 1996).

unfossiliferous) and the first Lower Cambrian fossils for such relatively advanced body plans to evolve he was forced to conclude in *On the Origin of Species* that "The case at present must remain inexplicable" (Darwin 1859, p. 308), though he never doubted the existence of life long before the Cambrian.

During the conservative early decades of the twentieth century it was unthinkable for Charles Walcott as a 'man of his time' to consider any other option than fitting his new Burgess Shale discoveries into existing phyla and classes. It was taken for granted that evolution progressed through increased diversity and complexity. Within the Phylum Arthropoda he placed *Waptia, Yohoia, Burgessia, Opabinia* and even the shrimp-like appendages of *Anomalocaris* as branchiopod crustaceans, while he considered *Marrella* and *Olenoides* to be trilobite crustaceans. Other fossils such as *Aysheaia, Hallucigenia, Pikaia* and *Wiwaxia* were regarded by Walcott as polychaete annelids.

The research of Whittington/Briggs/Conway Morris and others in the team at Cambridge through the mid-1960s and 1970s provided the much-needed crucial redescriptions of dozens of genera discovered over half a century earlier (eg: *Marrella, Yohoia, Opabinia, Aysheaia* to name just a few, and not forgetting their resolution of the shrimp/jellyfish/sea cucumber puzzle of *Anomalocaris*). In addition at this time, newly discovered fossils were described (eg: *Nectocaris*), while others were fully redescribed to the point where the generic name was changed (eg: *Hallucigenia*). Descriptions of new animals were also published by Collins' ROM research team in the 1980s (eg: *Sanctocaris*). As a consequence of all this work the Cambridge team were drawn, somewhat reluctantly, to conclude that many Burgess Shale fossils did not readily fit into either of the four accepted arthropod classes or indeed into any major group or phylum. For example, *Marrella* has only two pairs of appendages on its head, and *Yohoia* one pair of great frontal articulated appendages each with four terminal spines. The weird *Opabinia* certainly did not fit with its five stalked eyes and frontal appendage with grasping pincer. Traditionally, the phylum Arthopoda was considered monophyletic, but research by others at about this time proposed a polyphyletic origin for arthropods with each of the four major classes evolving separately from a pre-arthropod ancestor. Whittington (1985 p. 128) concludes "remarkable in the Burgess Shale …… is the large number of miscellaneous animals that do not fit into any phylum or class of animal known today". He continues (p. 131) "It is to be expected that such long-extinct forms will not fit into a classification of animals that is based mainly on the survivors of evolutionary diversification", and follows "I look sceptically upon diagrams that show branching diversity of animal life through time, and come down at the base to a single kind of animal". Clearly, Whittington was questioning the whole concept of the inverted cone of evolution since he contemplated a polyphyletic origin for arthropods.

It was at about this time that Stephen Jay Gould was researching his now famous book *Wonderful Life* (1989), which is based in large part on the Cambridge work after much personal dialogue with Whittington and co-workers. Gould (1989) leads on from Whittington's (uncomfortable) position and emphasises the 'differences' in Burgess

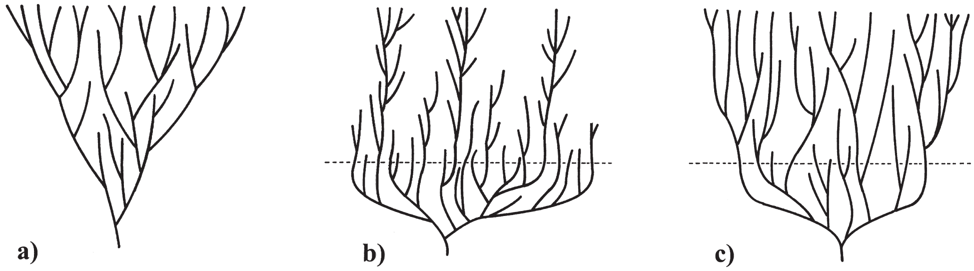

Figure 7. Evolutionary trees; a) traditional inverted cone of increasing diversity, b) maximum Cambrian disparity and subsequent contingent decimation, and c) rapid Cambrian disparity with subsequent steady increase, albeit at varying rates. The broken line indicates the approximate time of the Burgess Shale. (Sketches a and b derived from Gould 1989 p. 46 and p. 216, respectively, and sketch c based on Conway Morris 1998 p. 207).

Shale weird wonders and introduces the revolutionary concept of a vast array of new phyla and unique new classes of arthropod within the Cambrian. He is critical of Walcott over half a century before for 'shoehorning' new Burgess Shale fossils into existing phyla and classes. Gould's initiative proposeds a massive Cambrian plethora of disparity with 'biological experimentation' in body plan design, and subsequent post-Cambrian diversification with decimation. He credits much of this novel proposal to dialogue with Conway Morris. Gould's version of an evolutionary tree (Fig. 7b) illustrates this Cambrian 'explosion' in body plans followed by the removal of 'failed' designs, and at times of whole groups, by extinction which leaves large morphological gaps among the survivors. He is clear to distinquish between 'diversity' as the number of species within a group, and 'disparity' as differences in anatomical body plan. Gould envisages that the evolutionary explosion of new body plans peaked in the Cambrian, all within a short time window of a few million years, and for the last 500 million years life on Earth has seen progressive diversification (more species) but decimation of disparity from the Cambrian crop of original body plans. Moreover, he proposes that the decimation is a 'contingent' process (chance extinctions), so if the "tape of life" is rerun the evolutionary outcome for today's life on Earth will be different, including whether man would have evolved in its present form. Needless to say, this 'timebomb' in evolutionary theory fuelled intense contemporary debate with strong partisan views for and against.

From a position that inherently coincided with some of Gould's thinking, the Cambridge team had second thoughts and began their long dissociation with, and disproof of, such radical views. Briggs and Conway Morris (as distinguished professors in their own right) and other specialist workers, doubted Gould's conclusions, and by using cladistic analysis, molecular biology and the expanding database of other Burgess Shale-type faunas elsewhere around the world (particularly China and Greenland), determined a new approach to Cambrian and Precambrian evolution. Furthermore, ongoing palaeontological research by others began to fit more and more Burgess Shale weird wonders into accepted phyla, or redescribed and defined new, albeit extinct, arthropod classes (eg: Dinocarida for *Opabinia* and *Anomalocaris*), as well as recognising the potential evolutionary 'stepping-stone' role of forms such as *Hallucigenia* and *Wiwaxia*.

Conway Morris's challenge, however, maintained a confrontational style with heated ill-tempered debate with Gould in the scientific press, and culminated in his book *Crucible of Creation* (1998). Sections of this book are strongly critical of Gould as well as his ideas. Nevertheless, he acknowledges the Cambrian 'explosion' as one of the most significant events in the history of life but rebukes the idea of unrestrained experimentation of anatomical design and evolution as an unpredictable contingent process. Conway Morris' work on other Burgess Shale-type faunas, his understanding of the Ediacaran fauna (a late-Precambrian 'odd' fossil assemblage) and the ever-increasing role of molecular biology in evolution, as well as trophic resources, atmospheric oxygen levels, and ecological conditions at the start of the Cambrian (especially predation), all convinced him that the principle motor for Cambrian diversification was environmental and ecological, and so no different from elsewhere in the fossil record. Conway Morris (1999) notes that molecular biological research indicates the appearance of metazoans at least 700 Ma, perhaps even 1,000 Ma. He infers such animals must have been very small, perhaps 1mm or less, and could have occupied interstitial spaces between sand grains (meiofauna). His evolutionary tree (Fig. 7c) sees disparity increase rapidly in the Cambrian, and thereafter has generally increased, albeit at varying rates.

Cladistic analyses by Briggs *et al.* (1993) and Wills *et al*. (1994) emphasises the 'similarities' shared by Burgess Shale arthropods rather than their peculiarities as noted by Gould (1989). Their results suggest that disparity amongst Cambrian arthropods was not markedly greater than among arthropods today, and all arthropods descended from a common ancestor. Follow-up cladistic re-appraisals of the phylogenetic relationships of early arthropods, as well as for the Metazoa as a whole, also lead Fortey *et al*. (1996, 1997) to conclude the need for an extensive earlier Precambrian history for most animal phyla even though there is no direct evidence in the rocks. Fortey *et al*. (1996) place this earlier history of metazoans in the Vendian Period (late-Precambrian from *c*.700 Ma). Their cladistic research strongly supports monophyly even if the single ancestor unique to all arthropod groups was not itself a true arthropod. They demonstrate that the trilobite line had already differentiated into several groups well before it appears in the Cambrian fossil record. These early lineages of arthropods may have been as very small meiofaunal organisms in the interstitial or planktonic habitat. They interpret "the Cambrian explosion as a reflection of the nature of the fossil record, the evolution of biomineralized shells, and the proliferation of organismic design, rather than phylum or even class-level phylogenesis" (Fortey *et al*. 1997 p.433).

In tandem with the cladistic work, predictions of molecular sequence divergence times of critical genes in the major groups of living animals (Wray *et al.* 1996) demonstrate an extensive Precambrian history during which metazoan phyla began to diverge. They deduce a series of average divergence time estimates; 1.2 Ga for the divergence of chordates from the three protostome phyla arthropods, annelids and molluscs, 1.0 Ga for the echinoderm-chordate divergence, and 600 Ma for the divergence of jawed and jawless vertebrates. These results clearly cast doubt on the notion that animal phyla diverged explosively during the early Cambrian. The long time periods between molecular divergence dates and the first appearences in the fossil record remains a concern for some palaeobiologists, who believe molecular dates are over-estimated due to the rates of evolution used.

In conclusion, therefore, the Cambrian explosion is now seen as a combination of the scaling-up in animal body size and the simultaneous commencement of bio-mineralization of animal skeletons and shells, rather than a massive burst in metazoan disparity. Early divergence of metazoan lines began over one billion years ago among tiny animals in a planktonic regime or perhaps in the meiofauna. A critical threshhold in atmospheric oxygen at the start of the Cambrian is presumed to have triggered the increased metabolic rates that permitted the formation of hard skeletons and shells, both as necessary support for increased body size and for protection from predation. This may have been a genuinely rapid change.

Looking further back into the Precambrian before the evolution of metazoans, an extensive record of microbial life has been discovered through research over the last few decades. Many dozens of Proterozoic microfossil localities occur throughout the world, the most notable of which are the filamentous cyanobacteria in stromatolitic cherts of the 850 Ma Bitter Springs Formation in central Australia, similar cyanobacterial stromatolites of the 2.1 Ga Gunflint Chert from Ontario, Canada, as well as the oldest eukaryotic unicelled microalgae (acritarchs) from 1.8 Ga rocks east of Beijing, China. More isolated records exist of even older microfossils from the Archean, in particular the famous 3.4 Ga Apex Chert from the Pilbara of Western Australia where several species of prokaryotic filamentous cyanobacterium-like microbes are recorded; these results have recently been challenged. Some authors forecast the origin of life between 3.6–4.1 Ga.

Is paleobiological research nearing the point where Darwin's conundrum will finally be put to rest?

BARRY MAPSTONE & GILLIAN MAPSTONE

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The Linnean Society
Programme

2003		
23rd Jan.*	6 pm	AROID TAXONOMY Dr Simon Mayo
27th Feb.	6pm	ANAESTHESIA – THE EARLY STORY OF A GREAT DISCOVERY – WITH A LINNEAN SOCIETY CONNECTION Professor Harold Ellis, Guy's Hospital
6th March	6pm	WALLED STRANDED ARKS OR ENVIRONMENTS FOR LEARNING? Dawn Sanders FLS, Chelsea Physic Garden
3rd April	6 pm	CAN EVERYONE UNDERSTAND? EXHIBIT DEVELOPMENT AT THE EDEN PROJECT AND THE PUBLIC UNDERSTANDING OF SCIENCE. Sue Minter FLS
27th-30th April		International Polyploid Conference (with RBG Kew) † Andrew Leitch FLS at RBG Kew
24th May	2 pm	**Anniversary Meeting**
18th-22nd Aug.		Systematics Association 4th Biennial Meeting † Prof. Chris Humphries FLS & Gordon Curry
25th Sept.	6 pm	HUXLEY & THE RATTLESNAKE Jordan Goodman
2nd Oct.		ROBERT HOOKE (1635–1703) COMMEMORATION † Paul Kent with and at Christ Church, Oxford

Unless stated otherwise, all meetings are held in the Society's Rooms.
For further details please contact the Society office or consult the website – address inside the front cover.

* Election of Fellows † Organisers

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