Newsletter No. 258
December 2019

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Copy date for the next Newsletter is Saturday 1 February

To find out more about this photo - read on!

Robyn Amos, **Honorary Secretary,** ☎ 07595 444215 secretary@bcgs.info	**Andy Harrison,** **Field Secretary,** ☎ 07973 330706 fieldsecretary@bcgs.info	**Julie Schroder,** **Newsletter Editor,** 42 Billesley Lane, Moseley, Birmingham, B13 9QS. ☎ 0121 449 2407 newsletter@bcgs.info
For enquiries about field and geoconservation meetings please contact the Field Secretary. To submit items for the Newsletter please contact the Newsletter Editor. **For all other business and enquiries please contact the Honorary Secretary.** For further information see our website: bcgs.info, Twitter: @BCGeoSoc and Facebook.		

Future Programme

Indoor meetings will be held in the Abbey Room at the Dudley Archives, Tipton Road, Dudley, DY1 4SQ, 7.30 for 8.00 o'clock start unless stated otherwise.

Visitors are welcome to attend BCGS events but there will be a charge of £1.00.

Please let Andy Harrison know in advance if you intend to go to any of the field or geoconservation meetings. If transport is a problem for you or if you intend to drive and are willing to offer lifts, please contact Andy with at least 48 hours notice.

Monday 16 December *(Indoor Meeting, 7.00 for 7.30 start):* Members' Evening and Christmas Social. The BCGS Members' evening is always a special occasion and this year members will be treated to three 20 minute talks, plus a buffet, and various objects from the Dudley Museum archive to identify. The first 20 minute talk will be from Ray Pratt on the heat network potential of the Sherwood Sandstone underlying Solihull, the second from John and Julie Schroder on the geology of the Kerlingarfjöll mountain range in Iceland, and to complete the evening Graham Worton will give insights into dinosaurs old and new during a guided tour of the Museum.

Saturday 18 January 2020 *(Geoconservation Day):* Wren's Nest. Directed by the Reserve wardens. Meet at 10.30 at the Warden's office, at the end of Fossil View (the road into the new housing estate, formerly Mons Hill College). Parking along Fossil View. The day will involve some scrub clearance and fossil hunting not far from the Warden's base. Bring gloves, stout footwear and packed lunch. Wardens will provide tools, hard hats if necessary and a hot drink. Finish around 2.30.

Wishing you all a very Happy Christmas

Monday 20 January *(Indoor Meeting):* 'Jurassic Brain Teasers'. Speaker: Stephan Lautenschlager (Lecturer in Palaeobiology, University of Birmingham). Fossils represent physical evidence for the existence of extinct organisms and have vast potential for the study of ancient life. However, the majority of fossils are preserved in the form of hard-tissues (e.g. bones and teeth), while soft-tissues, such as muscles and internal organs, have withered away. Using modern computer technology and digital visualisation techniques, it is now possible to reconstruct some of these soft-tissues in fossils. The anatomy of the brain is of particular interest, as it can reveal information about extinct animals' behaviours and how they might have sensed the environment around them.

Saturday 8 February *(Geoconservation Day):* Saltwells Local Nature Reserve. Meet at the Nature Reserve car park (Grid ref: SJ 934 868) on Saltwells Lane at 10.30. Wear old work clothes, waterproofs and stout footwear or wellies. Please bring gloves and garden tools (hand brushes, trowels, loppers, secateurs, forks and spades if you have them). Either bring packed lunch or hot food can be acquired from the Saltwells Inn adjacent to the car park. Finish at 2.30.

Monday 17 February *(Indoor Meeting):* 'The Impacts of Future Climate Change on Industrial Landscapes: recent work in The Derwent Valley Mills WHS and its relevance to the Black Country'. Speaker: Dr Andy J. Howard ('Landscape Research & Management', and Honorary Fellow, Dept. of Archaeology, University of Durham). The availability of coal, limestone and metal ores together with water for power, were critical to the development of the heavy industries that kindled the Industrial Revolution. Paradoxically, many of these advantageous characteristics also create environments where geomorphological processes are most sensitive to future climatic and environmental change. This talk by Dr Andy Howard describes a 'landscape' approach developed to manage the built and other historic assets of the Derwent Valley Mills World Heritage Site, along the river between Matlock Bath and Derby. As we move forward into the Anthropocene, the applicability of this study to other industrial landscapes such as that of the Black Country is considered.

Saturday 7 March *(Geoconservation Day):* Barrow Hill. Directed by the reserve warden. Meet on Vicarage Lane off High Street, Pensnett (A4101), at the top end near to the nature reserve and the church (St. Marks), for a 10.30 start. The day will involve vegetation clearance in the East Quarry. Wear old clothing and stout boots or wellies. Please bring gloves and tools; i.e. brushes, trowels, loppers, saws, rakes etc. Safety glasses and hard hats will be provided where necessary. Bring a packed lunch and hot drink. We will aim to finish around 2.30.

Monday 16 March *(Indoor Meeting, 7.00 for 7.30 start):* AGM followed by two talks by young geologists, **Daniel Cashmore (University of Birmingham)** and **Matt Sutton (Oxford University)** TBC.

Monday 20 April *(Indoor Meeting):* 'Silurian Rocks of the Dingle Peninsula'. Speaker: Ken Higgs, Emeritus Professor of Geology, University College Cork. Dudley and the Dingle Peninsula in Eire have much in common, sharing a common Silurian geology. Professor Ken Higgs was not only born in Dudley but has also undertaken an extensive study of the geology of the Dingle Peninsula recently published as a field guide: 'Geology of the Dingle Peninsula', by the Geological Survey of Ireland. His illustrated talk will describe the Dingle Peninsula's dramatic 485 million year history of environmental and climate change.

Procedures for Field Meetings

Insurance

The Society provides public liability insurance for field meetings but personal accident cover is the responsibility of the participant. Details can be obtained from the Secretary, and further helpful information can be found in the Code for Geological Field Work published by the GA and available on our website. Schools and other bodies should arrange their own insurance as a matter of course.

Health and Safety

If you are unsure about the risks involved or your ability to participate safely, you should contact the Field Secretary. Please take note of any risk assessments or safety briefing, and make sure that you have any safety equipment specified. The Society does not provide hard hats for use of members or visitors. It is your responsibility to provide your own safety equipment (eg. hard hats, hi-viz jackets, safety boots and goggles/glasses) and to use these when you feel it is necessary or when a site owner makes it a condition of entry. Hammering is not permitted unless specific permission has been sought and granted. Leaders provide their services on a purely voluntary basis and may not be professionally qualified.

Other Societies and Events

BCGS members are normally welcome to attend meetings of other societies, but should always check first with the relevant representative. Summarised information for approximately **two months** is given in our Newsletter. Further information can be found on individual society websites.

Shropshire Geological Society

Wednesday 11 December: 'The Gwna Melange, Anglesey'. Guest speaker: Rosemary Dartnall.

Wednesday 12 February 2020: 'Earthquake Risk'. Guest speaker: Martin Degg, Chester University.

Lecture meetings are being be held in room 019 at the University Centre, Guildhall, Frankwell Quay, Shrewsbury, SY3 8HQ and commence at 7.00 for 7.30. A nominal charge is levied for attendance by non-Members. Further info: www.shropshiregeology.org.uk/

Geological Society, West Midlands Regional Group

Tuesday 14 January 2020: 'Periglacial geohazards in the UK, their occurrence, monitoring and mitigation'. Speaker: Dr. Paul Fish (Jacobs).

Tuesday 11 February: 'Provenance, the search for a source - using microfossils to track the origins of various items from paintings to murderers'. Speaker: Haydon Bailey (University of Birmingham).

Venue: Deritend Room, St Martin in the Bullring, Birmingham, B5 5BB. Meetings are at 6.00 for 6.30. For further details please contact the Group Secretary at: geolsoc_wmrg@live.co.uk
Click here for website.

Manchester Geological Association

Saturday 18 January 2020 at 1.30: 'Vertebrates: Cambrian to Mesozoic'. Speakers: Dr Duncan Murdock, Oxford University Museum of Natural History; Dr Elsa Panciroli, University of Oxford; Dr Martin Brazeau, Imperial College, London.

Meetings are held in the Lecture Theatre in the Williamson Building, University of Manchester, 176 Oxford Road, Manchester, M13 9QQ, unless otherwise stated. For further information about meetings: http://www.mangeolassoc.org.uk/ Visitors are always welcome.

Woolhope Naturalists' Field Club - Geology Section

Friday 24 January 2020: 'The Canaries Part 2: El Heirro and magmatic pluming problems'. Speaker: Dr. Sue Hay.

Meetings are held in the Woolhope Room, in the central library, Hereford. 6.30 for 7.00 until 9.00. Non-members of the Club pay £2. Visit: https://www.woolhopeclub.org.uk/meetings or contact Sue Olver on 01432 761693, email: susanolver@hotmail.com

Warwickshire Geological Conservation Group

Wednesday 15 January 2020: 'Meteorites'. Speaker: Tom Barratt.

Venue for talks: St Francis Church Hall. There is a charge of £2.00 for non-members. For more details visit: http://www.wgcg.co.uk/ or email: WarwickshireGCG@gmail.com. Meetings start at 7.30 with tea/ coffee and biscuits available beforehand from 7.00.

East Midlands Geological Society

Saturday 14 December: 'Permafrost through Geological Time'. Speaker: Prof. Peter Worsley.
(To be followed by our Christmas Cheese and Wine Evening - £5.00. Please remember to bring a glass.)

Saturday 11 January 2020: 'Mesozoic Mammals'. Speaker: Elsa Panciroli.

Meetings will be held at 6.00 in the Geography Department of Nottingham University, which is in the Sir Clive Granger Building. Non-members are welcome and should register with the secretary. Further info: www.emgs.org.uk or email: secretary@emgs.org.uk

Teme Valley Geological Society

Monday 20 January 2020: 'Caves, Caves' Atmospheres and Caves' Climates'. Prof. Ian Fairchild.

Monday 10 February: 'ExoMars – Planetary geology'. Dr Joel Davis.

Talks are held at 7.30 in the Martley Memorial Hall, on the B4197 by the Sports Ground, Martley. For field trip details and further information contact John Nicklin on 01886 888318 or visit: http://www.geo-village.eu/ Non-members £3.

Open University Geological Society, West Midlands

Saturday 11 January 2020: Sedimentary Petrology Workshop, Leader Alan Richardson. Contact: alanrichardson.geo@gmail.com

Saturday 25 January: Branch AGM at the Lapworth Museum, University of Birmingham, and talk by Dr Andy Jones **'Phytosauria: Crocs by another name.'** Contact: Dave Green westmidlands@ougs.org

Saturday 8 February: Metamorphic Petrology Workshop, Leader Alan Richardson.
Contact: alanrichardson.geo@gmail.com

Editorial

In this Issue there's a lot to celebrate. We've had an action-packed year of field visits near and far, a varied programme of indoor meetings, and several geoconservation sessions to keep on top of the endless encroachment of vegetation over our local geosites. Where possible we may even get as far as exposing new sections of rock for scrutiny - but this all depends on the size of the workforce! The more hands on deck, the more we get done. Please make a New Year resolution to come along to at least one of these vital sessions if you haven't yet done so. This is a big part of what we do, and yes, it's hard work - but the camaraderie and feeling of satisfaction makes up entirely for the aching muscles!

Our thanks go to Keith for the indoor meetings, and Andy for organising all the field trips and geoconservation days. A special thank you is in order for Andy this year for organising the highly successful long weekend in Dorset in September. He has written at great length to remind us of the geology we saw, and inform those who were unable to attend. Part 2 of his report is in this Issue, and the final instalment will be in February. More weekend geo-escapes, please Andy!

Next to celebrate is the news about the Geopark bid *(see below, p.7)*. Just one more hoop to negotiate, and hopefully it will all be signed and sealed at the UNESCO Executive's spring meeting next year.

Then hot off the press - there's a fantastic new teaching tool for the Wren's Nest - the Voyage in Deeptime App *(see below).* It's designed to liven up geology for children, and I know from the 'Lickey Hills Deeptime Voyage' that it has so far been a great success with older Primary School children, but it's too good just to flag it up as a teaching tool! There's a wealth of information and hours of fun for young and old alike.

The final cause to celebrate is the prospect of a new project with plenty of scope for BCGS involvement. This is: 'Ice Age Geoheritage: glacial erratics in the community' *(see below).* The value of glacial erratics as a 'way in' to geology in urban areas has long been a subject close to my heart, and I'm delighted to be representing BCGS in this embryonic project. Let's hope the HLF look favourably upon the application.

Thanks are also in order for Mike Allen, who keeps us variously informed, amused and entertained with his regular feature 'Mike's Musings'. He has broken all records with the current trilogy: 'The Eyes Have it', with part 2 in this issue and the final part in February.

It remains just to remind you to renew your Membership (subscription form below) and wish you all a very Happy Christmas. ■

Julie Schroder

UNESCO Global Geopark Council backs the Black Country Geopark bid

The Black Country's bid to become a world famous UNESCO Global Geopark has received international backing, a great step forward after a long period of preparation, and now the finishing post is almost in sight!

The UNESCO Global Geoparks Council met in Lombok, Indonesia in August-September to assess 'revalidated' and new UNESCO Global Geopark nominations. They proposed that 15 potential geoparks should be 'proposed for endorsement' by the Executive Board of UNESCO when it meets at the Spring 2020 session. One of those 15 is the Black Country! Although the recommendation is no guarantee, the team behind the bid sees this as an extremely positive step forward in its efforts to secure this international status.

Field trip group by the Geopark notice for Doulton's Claypit - Geosite 4b

It was back in 2016, when the four Black Country authorities (Dudley, Sandwell, Walsall and Wolverhampton) with the backing of the UNESCO National Commission and the UK's seven existing geoparks, submitted an application to become part of the UNESCO Global Geopark family.

There are many world-class features in the Black Country and the geopark would link many different heritage sites and features across the area to tell the story of the landscape. In the case of the Black Country, the significant part it played in the industrial revolution is at the heart of the bid and the whole concept of the proposed Black Country UNESCO Global Geopark.

Seville meeting 2019

In 2017, after assessing the application, the UNESCO Global Geoparks Committee (UGGC) made a number of positive recommendations and gave the Black Country Geopark project a further two years to address their recommendations before resubmitting a final application. We just have to wait now for the final decision of the Executive Board of UNESCO when it meets in the Spring. In the meantime you can keep up to speed on the detail of the bid on the website where you can download lots of information including the new geosites booklet.

During the month of December the team is providing an 'Advent Calendar' of geosites information via a daily series of facebook posts, so be sure to check out the Black Country Geopark pages on facebook for the latest info. ■

Graham Worton

Mike Brooks demonstrating the Wren's Nest 'Voyage'

Wren's Nest 'Voyage in Deeptime'
a new app and website

The Herefordshire and Worcestershire Earth Heritage Trust's 'Voyages in Deeptime' project ended with 4 sites equipped with Apps for exploring local geology in an exciting new way - with the Deeptime Voyages designed as a learning game for younger children, and GeoExplore aimed more towards A-level students. The Apps are packed full of detailed information, clearly displayed with amazing graphics and even a soundtrack. I wrote a bit about the Lickey Hills Voyager App in my item on the new information panel for the Lickey Hills *(Newsletter 249, June 2018, p. 13).*

The apps were designed by Mike Brooks in such a way that the platform could be used for similar 'Voyages' anywhere in the world! In liaison with Graham Worton, Mike has now completed a Voyage for the Wren's Nest. It is available in the same format as the previous ones. Install 'Voyager Deeptime' (brooks designs) from Google Play or Apple App Store and then download the voyage or voyages of your choice - and they are all FREE!

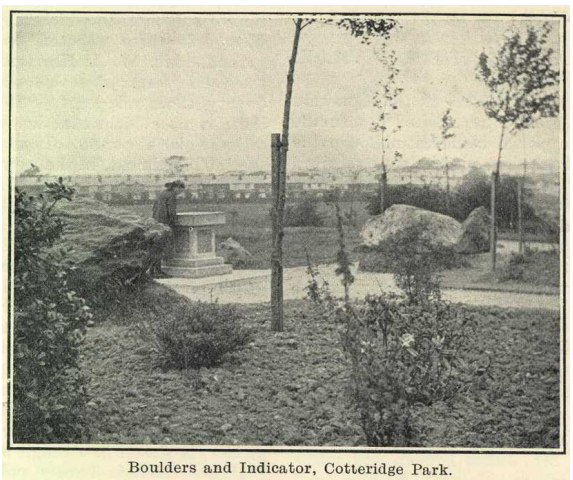
The new Wren's Nest Voyage is also in a web-based format: https://deeptime.voyage/index.php/wrens-nest-voyage/ more suitable for browsing at leisure in the comfort of your own home. (Only Wren's Nest and Bredon Hill are available in this format at the moment - the other Voyager Apps will be added in due course.) Have a look at the website and don't forget to turn on the soundtrack and listen to the soundscape of the Silurian seas!

Then there are all the other Voyager Apps. There is an amazing wealth of material here, not just for the youngsters! It's a good idea to read the 'Getting Started guide' first, then head for the Wren's nest with your smart phone and do the Voyage - score points, and beware of deep-time hazards! ■

Julie Schroder

Ice Age Geoheritage: glacial erratics in the community
BCGS in partnership for a new project

The background



Boulders and Indicator, Cotteridge Park.

Work began during the summer to devise a new project focussed on the glacial erratic boulders scattered around South Birmingham and North Worcestershire. This follows from a successfully completed project initiated by the Friends of Cotteridge Park, firstly to save the park from 'decommission' by Birmingham City Council in the late 1990s, and then to restore and protect the park. Amongst the park's treasures is an array of glacial erratic boulders once proudly displayed with an interpretation board on a plinth. Evidence for this is recorded in the Bournville Works Magazine dated August 1913, *(photo)*. By the completion of the project, the remaining boulders had been cleaned with new signage, and links added to the Cotteridge Park website: https://cotteridgepark.org.uk/history/ ►

The geological input resulted from funding granted by the National Lottery Heritage Fund (NHLF), and this part of the project was led by Ian Fairchild, Chair of the Herefordshire and Worcestershire Earth Heritage Trust (H&WEHT). This opened the door for more, and bigger aspirations...

Former BCGS member Roland Kedge had long held an interest in glacial erratics, and had found and noted numerous boulders in and around south Birmingham. I became interested after a BCGS field trip in March 2010, to see the surviving glacial erratics in Wolverhampton. This led to a flurry of articles and comments in our Newsletter on the subject from 2010 to 2012 *(see p.11 below for details)*. But earlier than this, in 2006, Alan Cutler had asked BCGS members (via the Newsletter) to report on any erratics known to them. This was for the 'Scorching Deserts and Icy Wastes' series of leaflets.

The Gilbertstone and its information panel at Blakeskey Hall Museum, Yardley, Birmingham

My interest led me to do some research into the history of the Gilbertstone glacial erratic, now at Blakesley Hall Museum in Yardley, Birmingham, and to play a small part in a new information board installed there a few years ago *(see photo)*.

Meanwhile, Roland Kedge was working hard to raise the profile of the Great Stone in Northfield ending in the successful installation of a small information plaque in 2016 *(see photo, and p.11 below for details of Roland's report)*.

Roland had also produced a small booklet detailing a 'South Birmingham Glacial Boulder Trail' which he had devised, and shown to Ian Fairchild. This became the catalyst for Ian to envisage a much bigger project encompassing the glacial erratics in South Birmingham and North Worcestershire, and involving a partnership of organisations, to be led by the H&WEHT. The Ice Age Geoheritage project was born!

Roland Kedge at the Great Stone panel 'launch', Northfield

Ian had an encouraging response after submitting an enquiry form to the NLHF, and invited representatives from the Lapworth Museum, Birmingham Open Spaces Forum (BOSF) and BCGS to join him on a steering committee. I was honoured to be invited to represent BCGS. With the backing of the BCGS committee, I have now attended 3 planning meetings since October, making this my first Newsletter opportunity to outline the objectives of the project to you, and how you can be involved.

Aims of the Ice Age Geoheritage Project

In the late nineteenth century people in the Midlands were excited by the recognition that the area had once been covered by ice, and that the erratic boulders strewn around the landscape were a tangible record of this and of the great distances involved in the transportation of these boulders. In the case of Birmingham and North Worcestershire, the main source of the large boulders was the Arenig Mountains in north Wales, which are made of a very hard Ordovician volcanic ash. ►

It is known from early maps that there were hundreds of these boulders in the late nineteenth century, now reduced to a few remaining specimens still protected in parks and museums, and a few more as yet lying in or close to their original locations *(see Lower Frankley Hill photo).* The rest have succumbed to urban expansion and destruction - made easy with the power of modern machinery.

Lower Frankley Hill, two huge erratics

The project will aim to bring this heritage to the notice of the public, by providing in situ information, plus leaflets and a dedicated website. It will also link the boulders in a series of proposed walking and/or cycling trails. The first, based on Roland's route, is a linear trail from Northfield to the University of Birmingham, with an extension to Cannon Hill Park. Four shorter circular walks are planned: Bournville and Cotteridge, Kings Norton, Woodgate Valley, and an urban/rural route around Frankley. A more challenging circular cycle route will begin in Longbridge then visit Frankley Hill, Romsley Hill *(see photo below)* and Calcot Hill, then southwards to Bromsgrove and back to Longbridge visiting a selection of erratics en route.

Romsley Hill erratics

The project intends to link geological history and the much shorter human history timescale, with written and oral accounts building a picture of the use and meaning of these iconic boulders in the community from historic times to the present. This will encompass peoples' knowledge, memories and attitudes towards the boulders in the local communities.

It is this aspect of the project which will involve BCGS volunteers and the public, and as with the earlier H&WEHT 'Champions' project, local individuals or groups will be enrolled to take care of the boulders where necessary, and keep the interest alive after the project. Schools and other community groups will be involved and moves are already afoot to identify and contact primary schools situated close to a suitable erratic boulder. We hope that individuals will be willing to delve deep into local records to find chapter and verse about these forlorn and forgotten icons of the past in their own neighbourhoods.

The project's timescale

It is intended to submit the completed NLHF application by March 2020. If successful, it will be a 2 year project starting in July 2020, with recruitment of a project manager and volunteers starting almost immediately. The trails will be launched sequentially through the project, leading to a display in the Lapworth Museum at the end of the project.

It gives me great pleasure to be involved in this project which aims to bring some real geological interpretation to the heart of Birmingham. I'm already dreaming on and seeing the potential of another project in the future to do something similar in the Black Country, where glacial erratics are still incredibly numerous - but of course, this is because most of them belong to the most recent Ice Advance, whereas Birmingham's erratics belong to the much earlier Anglian stage. This is another story, and yet another to compare and contrast the two different Ice Age legacies. ►

BCGS has shown considerable interest in the subject of glacial erratics over the years, as can be seen from the long index below of relevant articles in our Newsletter. For the moment, please let me know if you can find any further references. I want to start collecting as much information as I can - and it's not too early to start sending me information about prospective 'boulder' candidates for the project. I will keep you all informed as the project progresses. ■

Julie Schroder

Index of BCGS Newsletter items on the subject of 'Glacial Erratics'

Newsletter 175 February 2006, p.7, Boulderdash! article by Alan Cutler asking for people to seek and report erratics
Newsletter 179 October 2006, p.8, Peter Twigg on the Calcot Hill boulder, Clent Hills
Newsletter 201 June 2010, p.7, Andy Harrison's report of BCGS field trip to see erratics in Wolverhamption
Newsletter 206 April 2011, p.13, Mike Williams, Nursery Playground erratics
Newsletter 206 April 2011, p.14, Julie Schroder, Birmingham's iconic boulders
Newsletter 207 June 2011, p.9, Roland Kedge, more Birmingham boulders
Newsletter 207 June 2011, p.16, Peter Twigg, further thoughts on the Calcot Hill boulder
Newsletter 208 August 2011, p.13, Bill Groves, erratics in Wombourne and beyond
Newsletter 209 October 2011, p.7, Bill Groves, more erratics - probably
Newsletter 210 December 2011, p.13, Bill Groves on Devensian or Anglian origins of erratics
Newsletter 211 February 2012, p.12, Roland Kedge on raising the profile of erratics
Newsletter 212 April 2012, p. 6, Mike Williams on Lord Avebury and the West Park erratics
Newsletter 213 June 2012, p. 8, Bill Groves on Jerome Harrison, important to the glacial erratics story
Newsletter 215 October 2012, p.8, Mike Williams on the Wolverhampton East Park boulder
Newsletter 216 December 2012, p.13, Bill Groves reporting talk by Jonathan Larwood on a Jerome Harrison-led field visit to Wolverhampton erratics, 1898
Newsletter 240 December 2016, p.6, Roland Kedge on the Great Stone plaque unveiling

Field Meeting Report

Friday 13 to Monday 16 September 2019: BCGS Field Excursion to Dorset - part 2. Led by Alan Holliday, Richard Edmonds and John Scott (Dorset Geologists Association Group, DGAG and Steve Etches (Etches Collection Museum of Jurassic Marine Life, Kimmeridge).

Sunday 15 September: Lulworth Cove and Durdle Door, led by John Scott (DGS)

Overview

Lulworth village lies approximately 14 to 15 miles east of Weymouth. We met John at the Lulworth Cove car park, our first stop for the day at 09.30. Throughout the day the weather was clear, warm and sunny. Here John introduced our itinerary for the day and described the general regional geology. ►

Stair Hole and the Lulworth Crumple

From Lulworth Cove car park, we walked past the heritage centre to Stair Hole for an overview of the area's stratigraphy, structure and general formation. Afterwards, John led us eastwards down into and around Lulworth Cove over chalk and chert shingle beaches, traversing various stratigraphic units. Climbing out of the eastern side of the Cove our final stop was Lulworth's fossil forest, which unfortunately was cordoned off for repairs and safety reasons.

Lulworth's fossil forest

Leaving Lulworth Cove, we drove west and stopped for lunch at Durdle Door car park. After a quick overview overlooking Man O'War beach, we spent the afternoon walking along the sandy and shingle beaches of this locality *towards Bat's Head to the west of the beach. Ed. (See front cover photo).* The beaches filled with people enjoying the fine weather.

Stratigraphy

The same rock sequence can be seen at both Lulworth Cove and Durdle Door. The day before, we had explored the various units belonging to the Middle and Upper Jurassic. Today, (our second full day) was spent exploring the rocks representing the top of the Jurassic and the Cretaceous.

The oldest rocks seen at these locations belong to the upper-most Jurassic-Cretaceous Portland and Purbeck Groups, which we caught a glimpse of the day before on the Isle of Portland. The Portland-Purbeck environment was one of freshwater lagoons with fringing forests of Monkey puzzle and Cyprid forests occasionally inundated by the sea. The result was interbedded limestone and mudstone sequences containing evaporites with salt pseudomorphs, fossil forests defined by algal (stromatolite) mounds around living and fallen trees, and dinosaur footprints.

Chalk Cliffs at Lulworth Cove

The 'Great Dirt Bed' sitting at the base of the Purbeck Group is a black fossil soil that is taken to be the Jurassic-Cretaceous boundary. The 'Cinder Bed', within this group contains abundant fossil oysters (*Praexogyra distorta*) and rare sea-urchins (*Hemicidaris purbeckensis*). It represents the first major marine incursion into this lagoonal environment. At the top of the group is the Purbeck Marble, packed with small characteristic *Viviparis* freshwater gastropods and the Unio (a bivalve) Beds.

Overlying the Purbeck Group is the Wealden Group. The stratum thickens markedly towards the east from Durdle Door to Lulworth Cove, a result of Cretaceous tectonic movements. The group comprises fluviatile coarse sands / grits and clays containing tourmaline, vein quartz and radiolarian cherts derived from Dartmoor. The middle Wealden unit (Coarse Quartz Grit) is particularly well exposed at Worbarrow Bay, further east along the coast.

The Lower Greensand directly overlies the Wealden Group and marks the re-establishment of marine conditions. As the name suggests it consists of greenish sands rich in the mineral glauconite which gives the sand its colour, and brackish water bivalves. This stratum is absent at Durdle Door and only a 0.5m thick layer has been recorded on the east side of Lulworth Cove. ►

Unconformably overlying the Lower Greensand are the Gault Clay and the Upper Greensand. These strata mark a major marine transgression towards the latter part of the Lower Cretaceous. The Gault Clay comprises black and dark green glauconitic fossiliferous sandy clays. Fossils predominantly include serpulid worms and bivalves. The Upper Greensand generally consists of fine green sands with variable amounts of carbonate cementation. The unconformity is greater towards the west with a major overstep onto the Jurassic and Triassic strata of west Dorset and Devon.

During the Upper Cretaceous, sea levels rose by up to 300m above present levels, covering much of Britain. This allowed for the deposition of the Chalk Group, which includes the lower Grey and upper White Chalk subgroups.

Durdle Door

The Chalk sits unconformably over the Upper Greensand. Between the two units is a glauconitic marl and heavily bored conglomerate representing an Upper Greensand hardground, over which the Chalk was deposited.

The Grey Chalk subgroup includes the West Melbury Marly Chalk and the Zig Zag Chalk Formations. The West Melbury Marly Chalk is not represented at Lulworth Cove or Durdle Door. The base of the Zig Zag Chalk was replaced by a diachronous phosphatic conglomerate almost indistinguishable from the underlying Upper Greensand apart from palaeontological differences. The Grey Chalk subgroup gets its name from its off-white (greyish) colour. However, like the White Chalk subgroup it is made up of calcite platelets, or coccoliths, from planktonic algae known as coccospheres. Chalk layers are interbedded with flint beds and marl seams, some of volcanic origin, and also include fossil foraminifera, ostracods, echinoids, bryozoans, corals, brachiopods and bivalves.

The White Chalk subgroup is up to 385m thick and includes the Hollywell Nodular Chalk, New Pit Chalk, Lewes Nodular Chalk, Seaford and Newhaven Chalk, Culver, Portsdown and Studland Chalk Formations. All comprise white-coloured rock with parallel horizons containing flint, fossils, burrows and marl. The Chalk has been tectonically hardened and contains numerous conjugate faults and slip planes. At Lulworth Cove and Durdle Door the beds progress from a shallow dip to being vertical and overturned.

Structure

The Durdle Door-Lulworth Cove coastline is a classic area for studying structural geology on a regional and more localised scale. Regionally, the coastline is situated on the northern limb of the east-west trending Purbeck Anticline, which dips towards the east. Upper Jurassic rocks (Corallian Group, Kimmeridge Clay and Portland Group) sit at the Purbeck Anticline's core and Cretaceous strata (Purbeck Group to Chalk) form the northern limb. Traversing the stratigraphic sequence at Lulworth Cove and Durdle Door, the beds show a marked change in dip from around 10°/15° (Portland Group) to sub-vertical / vertical and overturned in the Chalk Group. To the north-west sits the asymmetric Weymouth Anticline with its beds gently dipping at approximately 2° on the south side and to 45° on the northern side. To the south of the Isle of Portland is the Shambles Syncline. Folding becomes less severe northwards and inland from the coast. ►

Numerous north-south trending faults cut across the Purbeck Anticline limbs. Cutting through the back wall of Lulworth Cove is a roughly east-west trending fault known as the 'Purbeck Fault'. This structure represents one of several such discontinuous east-west trending faults that have been extremely influential in shaping the local landscape. Movements along the Purbeck Fault have pushed the Gault Clay, Upper Greensand and Chalk Group up into a parallel faulted monocline.

On a smaller scale the Portland, Purbeck and Wealden Rocks at Lulworth Cove have been heavily contorted into a feature known as the 'Lulworth Crumple'. The Chalk Beds at both Lulworth Cove and Durdle Door are noticeably faulted with conjugate faults that show evidence of slickensiding and are indicative of Palaeogene / Neogene earth movements.

Tectonics

The tectonic history along the Durdle Door-Lulworth Cove coastline is complicated and according to John has been subjected to various interpretations in books and papers.

Tectonic forces acting from the south during the Variscan (Hercynian / Armorican) Orogeny, deformed earlier Devonian (phyllite) and Carboniferous (limestone) strata into several east-west trending structures, including deep-seated thrust faults. With the formation of Pangaea, the Permian and early Triassic saw much erosion of the post-Variscan landscape. The opening Atlantic in the Late Triassic, approximately 200 Ma, caused relaxation along existing fault plains, such as the Purbeck Fault, as earlier compressional forces became extensional. Penecontemporaneous reverse movements resulted along the pre-existing fault planes, leading to a complex sequence of basinal subsidence (syn-rifting) and uplift through the Late Jurassic into the Early Cretaceous. Tectonic subsidence along the Purbeck Fault formed a deep basin to the south that rapidly filled with sediments (Kimmeridge Clay). Sediment depositional rates exceeding subsidence rates led to the lagoonal environments, under which the Portland and Purbeck Groups were deposited.

The group at the end of the day

Further subsidence along the Purbeck Fault led to eventual marine inundations to the freshwater Wealden Lagoons. Uplift in the west, faulting, and concurrent erosion as the Wealden Group was deposited, led to this stratum being thicker in the east (Lulworth Cove) and thinner in the west (Durdle Door). It also created unconformities throughout this stratum. Continuing subsidence re-established marine conditions leading to the deposition of the Lower Greensand. Unequal faulting and tilting also caused this stratum to thin towards the west.

Late Cretaceous times saw a major marine transgression with the Gault Clay being unconformably deposited over earlier rocks. As sea levels rose to 300m above present day levels the Chalk Group was deposited. ►

The Palaeogene introduced a structural inversion. Palaeogene / Neogene Alpine-Pyrenean movements, between approximately 50Ma and 15Ma, resulted in renewed compressional tectonic forces acting from the south. The forces caused movements on previously normal faults to reverse direction, resulting in variable deformation of earlier strata. Unconsolidated plastic Portland and Wealden beds became squeezed toward the west, as seen at Durdle Door. At Lulworth Cove the same strata were contorted into the structure known as the 'Lulworth Crumple'. The overlying Gault Clay, Upper Greensand and Chalk strata were faulted and pushed up into a monoclinal structure with the beds to the north tilted almost vertical or overturned compared to the more gently tilted beds to the south.

We walked back to the Durdle Door car park not long after 4.00 and said farewell to John before heading back into Weymouth and dinner. I would like to thank John for his assistance and time to make this a very interesting visit. ■

For more information about the Jurassic Coast see:

- Geologists Association Guide No. 22: 'The Geology of the Dorset Coast', J. C. W. Cope. 2nd Edition.
- Geology of the Wessex Coast by I. M. West: www.southampton.ac.uk/~imw/;
- BGS Map Sheet 342 / 343: Swanage, 1:50,000 Series, Solid and Drift, dated 2000.

Andy Harrison

Mike's Musings No. 24, The Eyes Have It - Part 2

In 'The Eyes Have It - Part 1', (Musing No. 23, Newsletter 257) I introduced the very concept of 'vision' and my source of information for much of this material - Richard Dawkins' book 'Climbing Mount Improbable'. A ***simple eye*** *(or* ***ocellus****) and the development of the* ***retina*** *was described before moving on to show how a* ***concave*** *arrangement of retinal cells (****camera eye****) together with a restricted opening (****pinhole eye****) could further improve vision. Finally, the benefits of introducing a simple* ***lens*** *just in front of the retina was examined.*

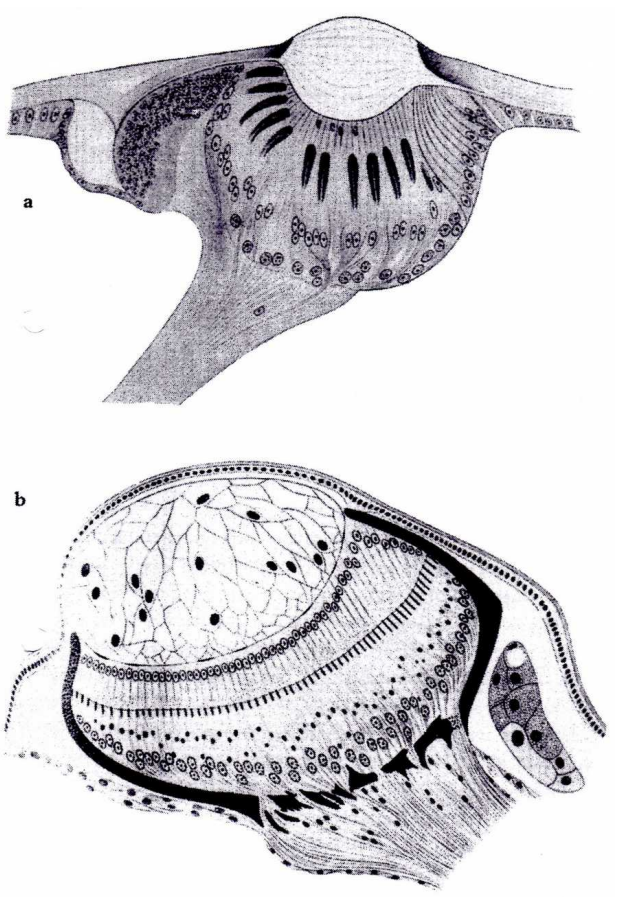


Figure 5.16 *Two different ways for insect lenses to develop: (a) sawfly larva; (b) mayfly. 'Simple lenses'.*

A better design is to allow for the *lens and retina to be set apart* from one another, the key point being that the lens should have a higher refractive index than the intervening 'vitreous matter'. Further improvements come from a *complex lens* of varying refractive power, which is found in fish, octopuses and many 'higher animals'. Computer simulations programmed to 'evolve' the design of a flat, *three-layered retina* (opaque backing layer - central photoreceptor layer - outer transparent layer) have demonstrated that a fully functioning fish-eye could arise in less than half a million generations by tweaking the design little by little with each generation, even under the most pessimistic of circumstances. This translates into less than a million years - no time at all geologically speaking. ►

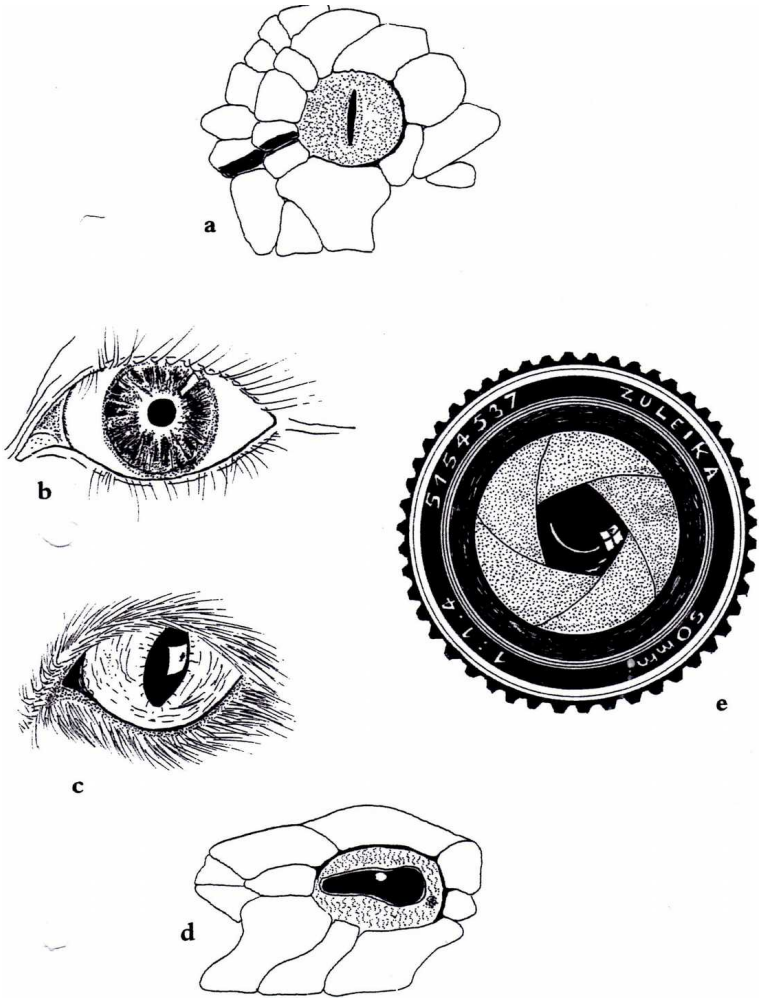


Figure 5.15 *Various pupils including that of a camera. The exact shape of a pupil doesn't matter, which is why it is allowed to be so variable: (a) reticulated python; (b) human; (c) cat; (d) long-nosed tree snake; (e) camera.*

To evolve other features of a **sophisticated camera eye**, would require a little longer, but be entirely within the capability of the evolutionary process envisaged by Darwin. The *focus of a lens* can be improved by varying its shape, which can in turn be achieved by improved muscular control. Thus any muscle fibre in the vicinity of our ancestral '*blob-of-vitreous-matter*' could be hijacked to serve such a purpose. Similarly, it is very useful to be able to control the amount of light entering the eye to avoid being dazzled by too much of it. The *size of the aperture (pupil)* can again be controlled by suitable musculature allied to some kind of light-metering device, and the shape of the pupil can be varied to make muscle control more straightforward, as in the slit-like pupils many 'lower' creatures (especially snakes) have. The human *iris diaphragm* is more complicated, but simply represents a different evolutionary path towards serving this particular end **(Fig. 5.15)**. Equally important is the *sensitivity* of the pupil - how quickly it responds to changing light levels. This is a matter of better *neural regulation*, which can again be accommodated by stepwise improvements in the nervous system.

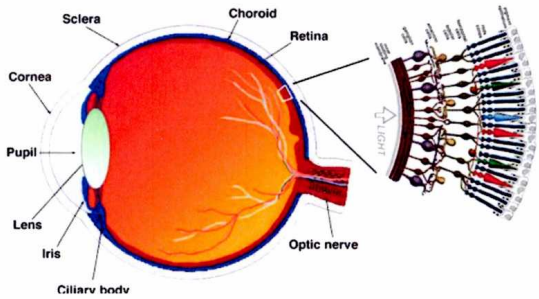
Not only have eyes as a whole evolved many times, so have some of their constituent parts. Returning to the nature of the *lens*, not all lenses developed from a gelatinous 'blob of jelly'. The lens in so-called **simple** eyes of the sawfly larva developed as a thickening in part of the outer protective transparent layer (*cornea*) of a primitive camera-eye. The **simple eye** of the mayfly, by contrast, has a uniform cornea with a lens that developed as an entirely separate mass of transparent cells **(Fig. 5.16,** *above*, *p.15*). ►

The cornea tissue that forms a transparent, curved structure in the front of the eye; refracts light before it enters the eye

The retina a layer of rod and cone cells that respond to light and initiate nerve impulses

Rod cells are very sensitive to light but cannot distinguish between colours
(~ 120 million of them)

Cone cells detect colours
(~6million of them)
mostly near the FOVEA



The Human Eye

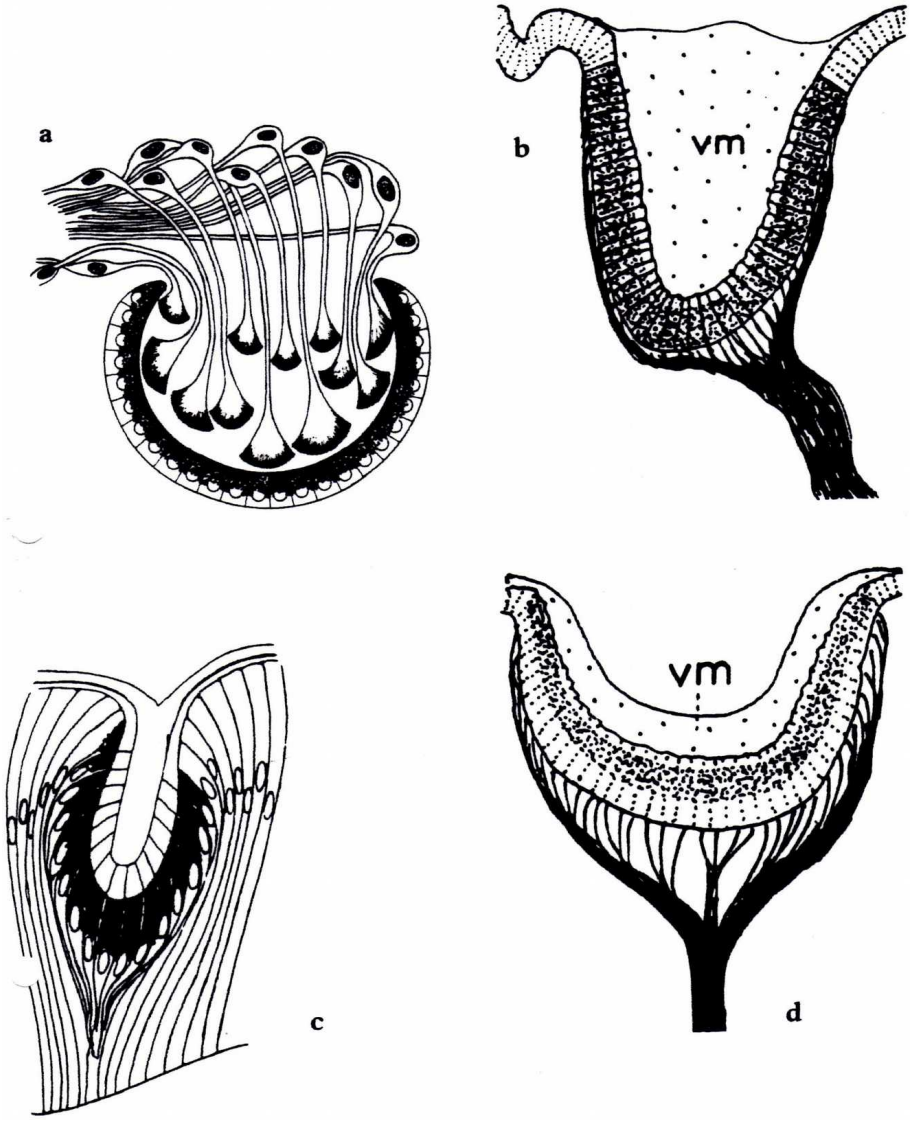


Figure 5.4 *Cup eyes from around the animal kingdom: (a) flatworm; (b) bivalve molusc; (c) polychaet worm; (d) limpet.*

Similarly, *retinas* have varied designs suggestive of multiple origins. Most of the examples mentioned thus far have their *photocells* placed i*n front* of the nerves connecting them to the brain **(Fig. 5.4 b/c/d).** One exception is the simple *cup-eye* of the flatworm **(Fig. 5.4 a).** Their *photocells point backwards*, towards the incoming light. We humans, with our highly evolved vertebrate eye, share that apparently silly, deep ancestral design feature. Recent research suggests that this design actually has the benefit of maintaining a close association between the photocells and the pigmented epithelium lining the retina. In practice it makes very little difference, although it does create a '*blind spot*' at the optic nerve. Where our eyes differ from that of flatworms is in their overall increased sophistication. Our retinas contain umpteen millions of photocells (figures differ from one source to another), divided into *rods* (for low light perception in black and white only) and *cones* (for colour perception in bright light). *Cones* are further divided into ones that capture long, medium and short wavelengths of the visible spectrum.

Eyeballs can be big or small. Much will depend on the size of the creature itself. But bigger eyeballs, and hence larger retinal surface areas, can accommodate more photocells, and hence increase overall quality of vision. That is one reason why a snail could never hope to achieve the visual level of a human. Its eyes would need to be as big as its body! **(Fig. 5.1).** The largest eye yet recorded belongs to the giant squid (37cm. diameter). Imagine carrying a couple of those around in your head, and you can see why a snail would struggle in proportion to a human. The cost of anatomical balance is just too great. ►

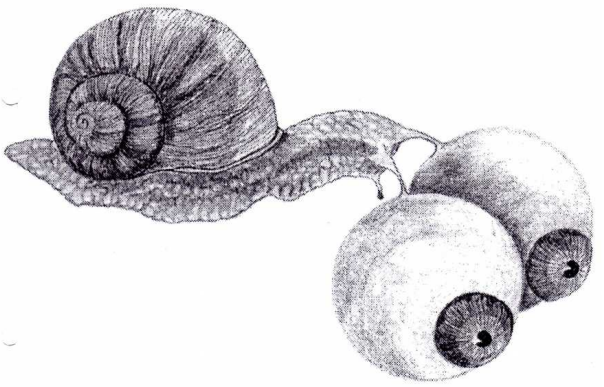


Figure 5.1 *Fantasy snail with eyes large enough to see as well as humans can.*

Remarkably, however, there are ways in which smaller fry can, in effect, make more of a smaller retina. One way is with the **compound eye,** the subject of part 3 *(to follow in the next Newsletter).* Spiders do so in other ways, and the jumping spider has evolved an ingenious way of doing so. Instead of having a wide retina proportionate to its body size, it has reshaped its retina into a long vertical strip with which it 'scans' the area around anything of interest, building up an overall image that has greater resolution than it could otherwise achieve. The closest analogy to this is the greater perception we can achieve with the *cones* we have concentrated around the *fovea* in our eyes, than with the *rods* spread around more generally elsewhere on our retinas. It is also somewhat analogous to our lowly maggots moving their 'blob-like' 'eyes' to see 'better' by steering towards a light source.

The limitations of the **pinhole eye** may also be overcome by means of a *curved mirror*. We see this in the modern world of reflecting telescopes, where a curved mirror is a less weighty, more economical, solution to the problem of gathering more light than by using a correspondingly sized lens **(Fig 5.18 a).** It was once thought that the eye of the crustacean *Gigantocypris* had a **mirror eye (Fig. 5.18 b)** to enable it to pick up sufficient light to see in its deep-sea habitat, but this has been disputed. However, there is greater certainty that the simple scallop incorporates both a mirror and lens into the design of its many eyes. **(Fig. 5.18 c)** Reflections from a mirror situated behind the retina causes the eyes to appear to glow, but more importantly produces a sharp inverted image on a part of the retina abutting the lens in front of it. A simple curved mirror creates the problem of spherical aberration (a distortion effect), but a lens of particular shape can overcome this. The scallop lens is remarkably close to this necessary shape (a Cartesian oval), which one can only imagine arose for this very purpose! **(Fig. 5.18 d/e).**

The application of a curved mirror to produce an image may have initially arisen for another purpose. Many nocturnal creatures have eyes that reflect back at you brightly in a spotlight. Their retinas are backed not by a simple opaque layer, but by a deliberately highly reflective layer known as the *tapetum*. This bounces back any incoming photons missed by the retinal cells, helping to gather more of the limited light present in their night-time surroundings. The *tapetum* may have been around for a very long time, since they are not just present in cuddly cats and cute little bush babies, but in lowly invertebrates as well, including wolf-spiders. It may well be that the *tapetum* evolved before either the *curved mirror* or the *lens*.

*[In the final part we shall consider the **compound-eye**, commonly most associated with insects.]* ■

Mike Allen

Reference: Figures from Chapter 5,
'Climbing Mount Improbable' by Richard Dawkins
Penguin: Popular Science
ISBN-13: 978-0-14-102617-6.

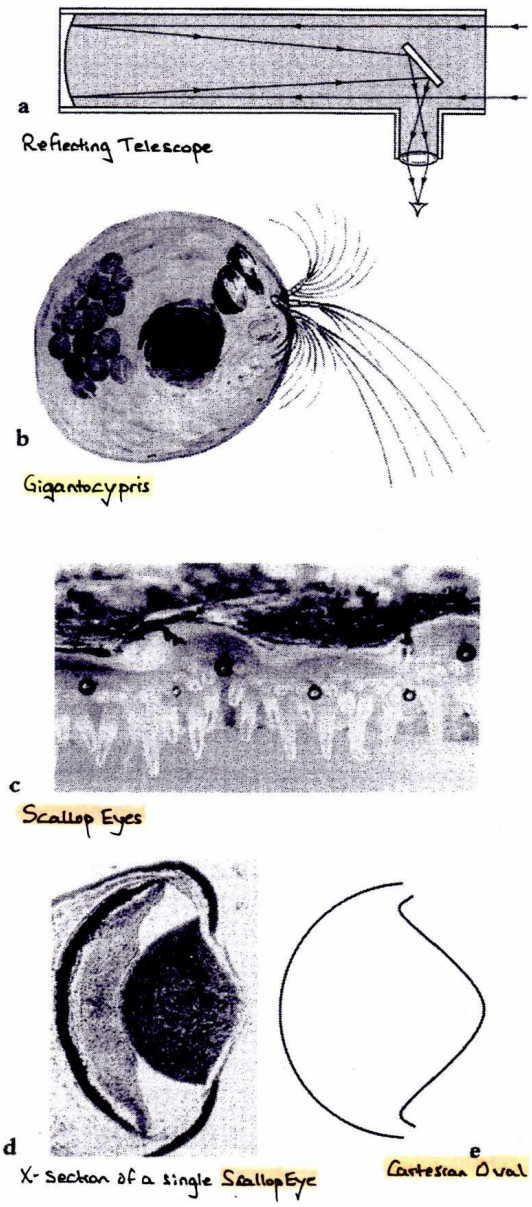


Figure 5.18 *Curved mirror solutions to the problem of forming images*

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