Detail of the Upper Devonian fish *Holoptychius* from Dura Den, Fife.

Review of Fossil Collections in Scotland

National Museums Scotland

John Ellerman Foundation

Review of Fossil Collections in Scotland

Contents

Detail of the Carboniferous pteridosperm plant *Neuropteris*.
Rebecca Marr © Stromness Museum

Review of Fossil Collections in Scotland

Introduction

National Museums Scotland

John Ellerman Foundation

Introduction

Background

In March 2019, National Museums Scotland began a two-year project, funded by the John Ellerman Foundation, to review natural science collections across Scotland. Although 'natural science' encompasses a range of subjects, consultation with the Scottish museum sector had highlighted particular concern around the care and use of fossil collections. Other geological material with which fossils are normally associated (rocks and minerals) was also noted as requiring attention. However, as rock, mineral and fossil material across Scotland is abundant and widely dispersed it was determined that the collections review would focus on fossil material to achieve the detail necessary to identify areas in need of future work, funding and development in the subject area.

As far back as the 1700s, geology was studied by eminent scientists of the day, notably James Hutton (1726-1797) whose ideas, based on his observations of Scottish geology, provided the foundations for geology as a modern subject. Hutton proposed the concept of deep time after observing the tilted layers of rock at several localities across Scotland, most notably Siccar Point, East Lothian ('Hutton's unconformity'), challenging contemporary thought regarding the age of the Earth. The principle of uniformitarianism, the idea that the Earth has always changed in uniform ways, is summarised in the phrase 'the present is the key to the past'. Rocks across Scotland range from the Lewisian gneisses of the north west, representing metamorphosed rocks from over 4 billion years ago, to the glacial and post-glacial clays of the Clyde and Tay estuaries, indicating the presence of a cold Arctic climate only a few thousand years ago. Almost every geological period between is represented by some form of sedimentary, igneous or metamorphic rock, indicating settings as diverse as desert sand dunes, swamps and great lakes, with tectonic events resulting in continental collisions, mountain building and the opening of oceans at different times.

The extraction of fossils in Scotland also has a long history going back several centuries, often following discovery by local workers who took their finds to nearby collectors. Fossils found their way to key local figures, such as Robert Slimon at Lesmahagow and Patrick Duff in Moray, as well as Roderick Murchison (1792-1871), Charles Lyell (1797-1875), Charles Darwin (1809-1882) and Thomas Henry Huxley (1825-1895) a few names in a long list of scientists, many associated with the Edinburgh, Glasgow and London Geological Societies, who came to collect at increasingly well-known localities. The Swiss scientist Louis Agassiz (1807-1873) was also drawn to Scotland, spending more than 10 years studying fossil fish across the country before moving to America.

Through scientific study, we know several of the fossil-bearing rocks of Scotland represent key stages in Earth's history, such as the early ecosystems of the Devonian and the transition by vertebrates from life in water onto land in the Carboniferous. Scottish fossils have helped to fill gaps in the fossil record, notably an interval known as 'Romer's gap' in the Early Carboniferous and a rare glimpse of Middle Jurassic terrestrial life, including dinosaurs and early mammals. The fossils of Scotland have also played a crucial role in historic scientific discussion. For example, the distribution of fish and reptile fossils from Elgin, Moray, led to the separation of the Devonian 'Old Red Sandstone' from the Permian and Triassic 'New Red Sandstone', at the same time providing support for the then recently proposed theory of evolution.

Today, numerous museum collections contain fossil material that is potentially historically and scientifically important, although repositories of specimens representing specific localities, horizons and species are often poorly known locally, let alone nationally. Furthermore, the importance of fossils, locally and nationally, may have increased since original excavation, especially where exposures have been stripped out, historic localities cannot be found again, or access is now an issue, perhaps due to overgrowth of vegetation, erosion or construction work. The importance of other localities may have been recognised by, for example, inclusion in areas designated as

Geological Conservation Review (GCR) sites, Sites of Special Scientific Interest (SSSI) or similar (see https://www.nature.scot/)

Aims of the Collections Review

1. To investigate fossil material in collections across Scotland and determine the fossil groups, geographic localities and stratigraphic levels represented, with the further intention to document rare and scientifically/historically important material.

2. To assess the current storage conditions for fossil specimens and encourage best practice in collections care to ensure specimens are available in the future.

3. To determine the current use of fossils in public engagement.

The findings will provide an updated account of the locations of fossil material outside the National Collection and will be used to make recommendations for improvements in collections care and use, ensuring the preservation of fossil material and increased public engagement with natural science collections in museums across Scotland.

Methodology

The natural science review project follows two surveys sent to Scottish museums in 2017 and 2018 by the National and International Partnerships team at National Museums Scotland. A total of 35 organisations responded and the data from this research was used to identify the location of natural science collections in Scotland. Funding from the John Ellerman Foundation enabled the employment of the John Ellerman Project Curator (JEPC), Dr Sue Beardmore, to investigate these collections and write the reports. A total of 70 collections were contacted and visited as part of the project, of which 57 hold fossil material.

The collections with fossil material are widely spread across Scotland, in Aberdeen and North East (8), Highlands and Islands (14), Tayside, Central and Fife (11), Edinburgh and Lothians (5), Glasgow and Strathclyde (12) and Scotland South (7) (see Appendix 1). They include academic (9), local authority (27) and independent (21) organisations. Academic organisations are the university collections, represented by institutions such as the University of Edinburgh. Local authority museums are run by councils, for example, the McLean Museum and Art Gallery (Inverclyde Council) or by trusts on behalf of councils, such as ANGUSalive (Montrose Museum) and Shetland Amenity Trust (Shetland Museum and Archives). Independent organisations are managed privately, often reliant on donations and/or admission fees and may be partly or entirely staffed by volunteers. Examples include Stromness Museum, Elgin Museum, the Gem Rock Museum and Timespan.

At March 2021, 40 of the 57 partners were either fully or provisionally accredited under the Accreditation Scheme, the UK industry standard for museums and galleries run in partnership by Arts Council England and Museums Galleries Scotland (MGS). MGS also administers the Recognition Scheme which celebrates, promotes and invests in Nationally Significant Collections in Scotland beyond those held in national museums and galleries. At March 2021, 6 of the 70 partners held Recognised collections containing fossil material: the Fossil Collection at Elgin Museum; the entire collection of Culture Perth and Kinross (including botany/herbarium, fossils and geology); the entire collection of The Hunterian, University of Glasgow (including all natural science subject areas); the entire collection of University of Aberdeen Museums (including geology and zoology collections and herbarium); the entire collection of Glasgow Museums (including all natural science subject areas); and the Scottish Shale Oil collection at Almond Valley Heritage Centre (including fossils).

Collection reviews were undertaken through visits arranged in advance at times convenient to local staff. Most took place in 2019, with a few in early 2020 before the Covid-19 lockdown. The time allotted for each collection review was dependent on the extent and quality of information provided in the original surveys and subsequent email correspondence initiated by the JEPC. The aim of each visit was to see first-hand as many specimens, displays and storage areas as possible. It was useful at every location to tour the areas where natural science materials were located first, to judge the amount of material and time required in each area to complete the review; the actual approach was often determined on the day. Materials on display/in public view could be examined during opening hours and, if necessary, on a subsequent day without staff assistance. Material in storage was only accessible by appointment and was a priority on the arranged day when staff were available, particularly in those organisations where local policy dictated that one, or sometimes two, members of staff be present in the room. Examination of stores was normally completed by moving methodically around a given room, recording material as it was found rather than trying to find all material representing the same subject.

Observations were recorded in note and photographic form and used as the basis for an overview report on each collection/location visited. Although it is apparent that organisations in the Scottish museum sector are constantly changing, it was necessary to consider and record details as a 'snapshot', in the state observed on the day of the visit. Where large collections were present, it was not possible to examine every specimen and attention was therefore paid to any labelling to gain an overview of the range of objects present. At some locations, there were storage areas that could not be accessed either physically or for health and safety reasons. In practice, most reviews took a day or less although several organisations had sufficient material for two full days of work; work was limited to two days as the benefit of additional investigation was not sufficient to justify the additional time and cost.

Apart from the visual investigation, relevant documents or spreadsheet catalogues were consulted (whole or in part, depending on size), either provided on the day or sent by email prior to or following review visits. Organisations also have websites with information varying from details of location and opening hours to examples of objects on display and in collections, events, links to information and related groups (Friends organisations, management organisation, networks, subject background), and online databases. These were used to support observations by the JEPC. Information detailing recent, ongoing or proposed developments was also documented. Previous studies on Scottish fossil and/or natural science materials were reviewed for comparison of the collections over time and to identify further locations. These include the National Museums Scotland publication by Stace *et al* (1987) focusing on botany, geology and zoology, and the Geological Curators Group (GCG) publication by Fothergill (2005) on the state and status of geological collections in museums across the UK.

Terminology

A fossil, by definition, is the remains or evidence of an organism that lived and died millions of years ago, altered by the process of fossilisation into rock over geological time with some exceptions, such as the organisms preserved in amber. For the purposes of this study, a fossil is the remains preserved as a natural mould or cast, an isolated specimen or partially exposed within a rock sample (matrix). Rocks containing fossils can however be classified as sedimentary, for example, where the proportion of fossils (known as bioclasts) greatly exceeds that of the sediment grains forming the surrounding matrix. Such 'clast-supported' specimens are technically geological. However, the separation of fossils and sedimentary rocks containing them is often inconsistent or not well-defined, with fossils being present in geological collections of sedimentary, igneous and metamorphic rock and sedimentary rocks with often fragmentary, mixed and indeterminate (unidentifiable) remains in palaeontology collections. Perhaps the best way to distinguish these is to

consider whether the specimen was collected solely for the fossil(s) (palaeontology) or for the features (lithology, grainsize, bedding, clast composition) of the matrix (geology).

Summary of fossil material

Almost every organisation visited in the search for natural science material has fossil specimens, highlighting past and present interest in the subject. The fossil collections across 57 organisations form extensive resources of Scottish, UK and worldwide material representing a diverse range of species and periods of geological time. Actual numbers of specimens in each collection are inevitably variable, due to the range in size and age of the museums investigated. Obtaining exact numbers of fossils for every collection was problematic due to incomplete onsite documentation, the blurred line of what constitutes a fossil (isolated specimens were often mixed with sedimentary rocks containing fossils) or the fossils being in mixed storage with geology specimens. Values provided for each location are frequently estimates offered by the JEPC following investigation of collections. The total number of fossil specimens in the collections included in this review is estimated to be at least 250,000.

Scottish fossil material – a geological history

Fossil material in Scottish museum collections is representative of the wide range of fossiliferous rocks exposed across Scotland (Fig. 1). Many of these have been crucial for our understanding, globally, of climatic and environmental changes, and the evolution of life through geological time. The following outline is a summary of the material found during investigation but is not an exhaustive record of what is present in collections or exists in outcrops across Scotland. The outline is in relative geological order with formation and locality names provided so they too can be placed in context when encountered. It must be noted that names of fossils, rock units and localities are given as they appeared on associated labels and available documentation, and many have been revised and updated through ongoing scientific study, some of which are also given. Wherever possible, it is suggested the data input process involves an internet search to confirm names are current; many will be returned through Google, with the Paleobiology Database (https://paleobiodb.org/#/) recommended for fossil (taxonomic) names and British Geological Survey (BGS) Rock Lexicon (https://webapps.bgs.ac.uk/lexicon/) for rock (lithographic) units (see Appendix 7).

Although fossilised life and evidence of it has been found in rocks of Precambrian age, it does not occur in abundance in Scottish rocks. The oldest fossils in Scottish collections are therefore the basal Cambrian Pipe Rock from the north west Highlands, representing infilled worm burrows in beach sediments.

Fossils from the Ordovician tend to represent deep water, open-ocean environments within the Iapetus Ocean, although some sediments were deposited in shallow water carbonate facies. The classic Upper Ordovician (Caradoc-Ashgill, now the Sandbian-Hirnantian) section at Girvan, Ayrshire, is comprised of the Ardmillan Series divided into the Ardwell, Whitehouse and Drummock groups. These are well known for graptolites and a diverse fauna of brachiopods, trilobites, crinoids and tentaculitids among other invertebrates, entrained in mudslides that flowed down an ancient underwater cliff. Rapid burial led to preservation of a complete fauna with several rare and unusual organisms, notably in the Starfish Beds in the Lady Burn Formation (Drummock Group). Another classic locality is Dob's Linn (=Dobbs Linn) near Moffat, Dumfries and Galloway, where the Glenkiln and Hartfell shales are typically black or dark-coloured mudstones with abundant graptolites. The lower part of the Birkhill Shale is also Ordovician, although the occurrence of the graptolite *Monograptus* in the upper part indicates a Silurian age. This transition is the global stratotype – the best example worldwide - of the Ordovician-Silurian boundary.

Rocks from the Silurian of Scotland document the shrinking of the Iapetus Ocean and the Grampian Orogeny, the first in a series of collisional, mountain-building events. Material labelled as being from Lesmahagow documents a Llandovery-Wenlock transition from marine to terrestrial settings (rivers, lakes and deltas). The name 'Lesmahagow' is used for several contemporaneous localities between Lesmahagow (Lanarkshire) and Muirkirk (Ayrshire), referred to as the Lesmahagow Inlier, containing a fauna of arthropods (eurypterids, horseshoe crabs and 'pod-shrimp' crustaceans) and fish. First discovered during the 1840s along Logan Water, the fossils were soon being excavated scientifically. Important localities include Dunside (Blaeberry Formation, Waterhead Group), the type locality for eight eurypterid species and the primitive thelodont fish *Loganellia* (not to be confused with *Loganiella*, a sponge) and *Thelodus*, Slot Burn and Birkenhead Burn (Slot Burn Formation, Waterhead Group), and Birk Knowes (Patrick Burn Formation, Priesthill Group). The *Jamoytius* Horizon in the Patrick Burn Formation at Birk Knowes has revealed the oldest complete vertebrate in the world, the jawless fish *Jamoytius kerwoodi*, and *Ainiktozoon*, the possible link between vertebrates and their more primitive ancestors although some authors consider it an arthropod.

Layers providing similar fossil faunas have been found in the Hagshaw Hills Inlier. The Fish Bed Formation (Glenbuck Group) of Shiel Burn contains relatively abundant fish, perhaps in numbers representing mortality events, with eurypterids, crustaceans and algae; fossiliferous exposures of the Fish Bed Formation also occur at Ree Burn and Glenbuck Loch. In the Pentland Hills, Silurian rocks comprise the Reservoir, Deerhope, Wether Law Linn and Henshaw formations of the North Esk, Bavelaw Castle and Loganlee inliers. The Reservoir Formation is for the most part unfossiliferous although a Graptolite Bed is noted in some guides. The Eurypterid Bed and Starfish Beds previously considered part of the Reservoir Formation are now placed within the Deerhope Formation, also noted for a coral bed and shelly faunas (brachiopods, gastropods, crinoids, trilobites, etc). Fossils in the Wether Law Linn Formation tend to be benthic organisms that lived on the seabed but were probably transported to where they were buried. Beds in the Henshaw Formation are noted as the source of eurypterids with the primitive jawless fish *Ateleaspis* (the oldest known cephalaspid), *Birkenia* and *Lasanius* found in the Lyne Water Fish Bed.

By the Devonian, the Iapetus Ocean had closed, bringing several continental fragments together as a large landmass with a generally hot, arid climate. The extensive mountain belt built by this Caledonian Orogeny was eroded with sediments transported into broad depositional basins. In Scotland, river sediments of the Lochkovian Cowie Formation from Stonehaven preserve fish, crustaceans (*Dictyocaris* and *Ceratiocaris*), eurypterids and millipedes (*Pneumodesmus newmani* and *Cowiedesmus eroticopodus*) with the Port Dubh fish beds on the island of Kerrera, Argyll and Bute, containing fish (*Cephalaspis*), millipedes (*Kampecaris obanensis*), plant fragments and trace fossils. *Pneumodesmus* was until recently thought to be the oldest example of air-breathing terrestrial life. This was based on the age of the Cowie Formation being Wenlock (Middle Silurian), which has now been revised to a date between 5 and 20 million years younger in the Lochkovian, Lower Devonian (Shillito and Davies 2017). The millipede *Casiogrammus ichthyeros* from the Middle Silurian of the Hagshaw Hills is now considered to be the oldest terrestrial arthropod, although its age is based on an association with terrestrial plant spores and the fossil does not preserve the crucial spiracles used to breathe air out of water. The first direct evidence of spiracles, is found in *Pneumodesmus* at least making it the oldest arthropod shown to be capable of breathing air on land.

The Rhynie Chert of Aberdeenshire is more certainly ascribed to the Lower Devonian (Pragian). It contains the remains of a terrestrial peat bed ecosystem, flooded by silica-rich water from a possible hot-spring source similar to the geysers of Yellowstone National Park, USA. As the hot fluids cooled the silica in the water crystallised, preserving early land plants (*Rhynia*), crustaceans (*Lepidocaris*), insects (*Rhyniella*) and arachnids (*Paleocharinus*), among other life, with rare, highly detailed soft tissue structures.

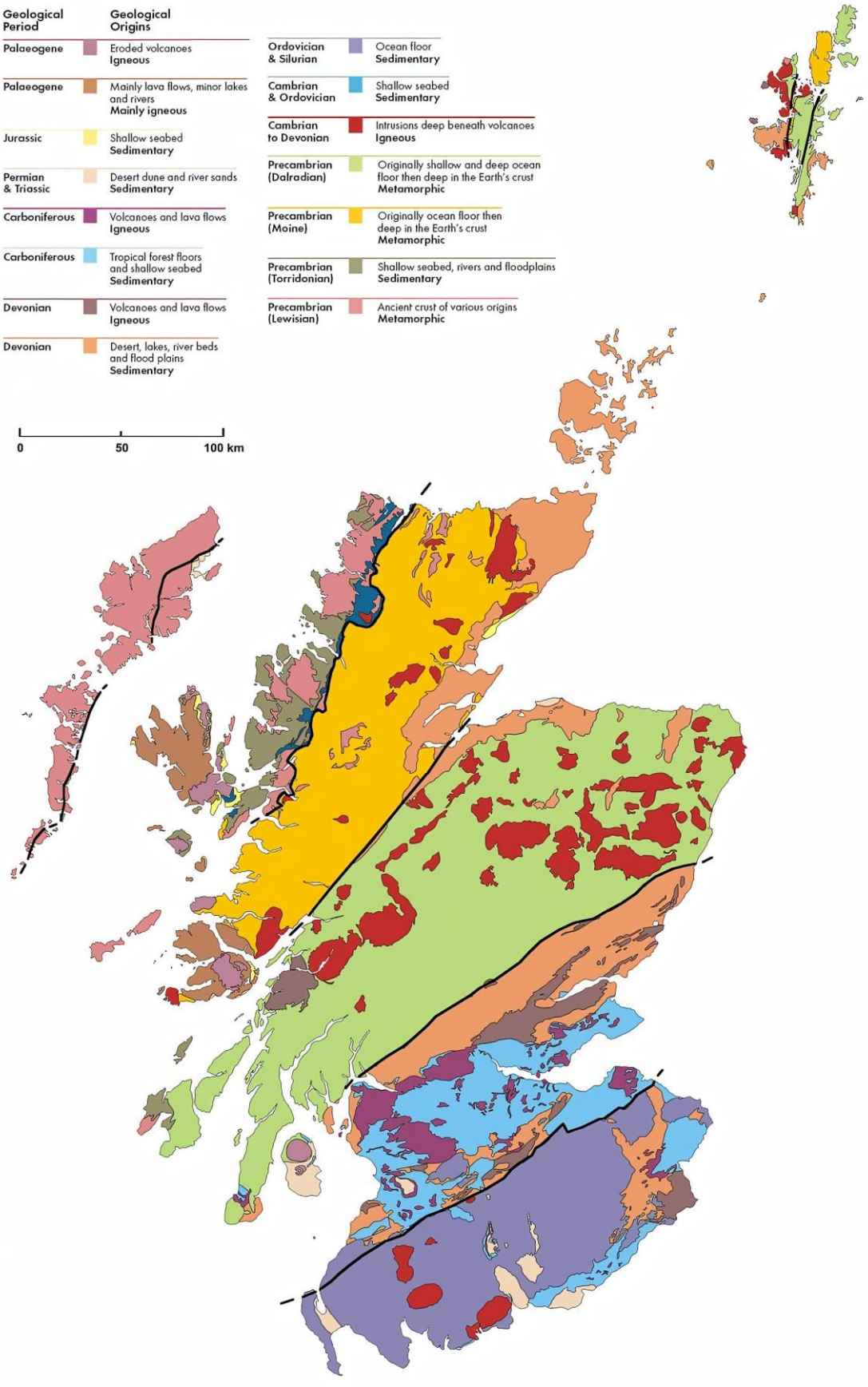

Figure 1: Simplified geological map of Scotland showing major faults (black lines)

Other rocks of the Devonian were deposited across Scotland in expansive depressions. The Forfar Basin covered the Forfar-Letham-Brechin area of Angus, with dark olive-green mudstones of the Tillywhandland Fish Bed (Dundee Flagstone Formation, Arbuthnott Group) providing a fauna of fish (*Cephalaspis*, *Climatius*, *Mesacanthus*, *Parexus* and *Pteraspis* among others), plants (*Psilophyton*, *Zoosterophyllum* and algae *Parka decipiens*), the millipede *Kampecaris forfarensis* and various eurypterids (*Pterygotus*). Several localities are important such as 'Turin Hill', used to refer to the wider area of Turin Hill and Tillywhandland, and Carmyllie, Monikie, Farnell, Ferryden, Canterland Den and Den of Dun. The Dundee Flagstone Formation exposed to the southwest at Tealing, Balruddery Den, Whitehouse Den and Rossie Den, is known for a similar fossil fauna. Further east, the Scone Sandstone Formation (Arbuthnott Group) at Wolf's Hole Quarry, Bridge of Allan, has provided a range of fish fossils, notably, *Pteraspis*, *Cephalapis* and two species of *Securiaspis* that occur nowhere else; the quarry has been designated as the type locality for the latter.

The more typical Devonian rocks, particularly in Scotland, are sandstones: the 'Old Red Sandstone'. In the Middle Devonian (Eifelian-Givetian), wetter climatic intervals led to the formation of a lake and river system across the north east of Scotland, focused on the freshwater Lake Orcadie. Several beds are well-known for diverse and often well-preserved fish fossils, notably the Sandwick Fish Bed of Orkney, Achanarras Limestone of Caithness, and the Melby, Sumburgh Head, Exnaboe, Sandwick, Mousa, Ness of Sound and Bressay Fish Beds of Shetland. Around the Moray Firth, fish fossils have been found in riverbanks and small quarries, notably Tynet Burn, Dipple Brae and Quarrywood to the west of Elgin in Moray, at Lethen (=Lethen Bar) in the adjacent Nairn, and Cromarty as the Edderton or Black Park Fish Bed. The Upper Devonian is represented by fossils of the fish *Holoptychius*, *Bothriolepis* and *Asterolepis*. Rocks yielding these are the Scaat Craig and Rosebrae beds in the Elgin area (Moray), the Boghole and Alves beds at Kingsteps, Clune and Alves on Nairnside, the sandstones of Clashbenny (Errol) in Perthshire and Dura Den Sandstone Formation at Dura Den, Fife, with rarer fish material from the Jedburgh area in the Scottish Borders.

The Carboniferous saw further continental collisions in the Variscan Orogeny and deposition alternating between shallow marine and terrestrial settings. Vertebrate life was emerging from shallow lagoons and equatorial swamps onto a humid and vegetated landscape, a stage in tetrapod evolution well represented by the fossil material in Scottish collections and the subject of the TW:eed project (http://www.tetrapods.org/). The Ballagan Formation (Tournasian) at Dumbarton revealed the 345 million-year-old remains of the amphibian *Pederpes finneyae* with a range of vertebrates, notably *Aytonerpeton*, *Ossirarus*, *Diploradus*, *Perritodus*, *Koilops* and *Mesonerpeton* from the same formation at localities across East Lothian and the Scottish Borders, for example, Chirnside and Burnmouth. Near Bathgate, West Lothian, the 338 million-year-old freshwater East Kirkton Limestone (Viséan) has provided fossils of several vertebrates, notably *Balanerpeton*, an early amphibian, and the stem amniote *Westlothiana*, alongside early terrestrial scorpions and a harvestman spider (*Brigantibunum*). Specimen labels, particularly in collections in the south of Scotland, highlight the Visean Calciferous Sandstone Series (or Measures) deposited in various marine and non-marine settings. Notably, the Lower and Upper Oil Shales were extracted as a fuel source and include a number of shell and marine bands used for correlation across the Midland Valley.

The Lower Oil Shales, representing a freshwater or brackish lake, include the Granton Shrimp Bed at Granton preserving densely packed crustaceans (shrimps *Waterstonella*, *Crangopsis* and rare *Tealliocaris*), occasional palaeoniscid fish, bivalves, ostracods and several species of the soft-bodied conodont animal, otherwise known only from teeth. The Gullane Shrimp Bed of East Lothian, containing shrimps (mainly *Tealliocaris*), ostracods, fish scales and plant remains, was probably deposited laterally in the same lake. The Hopetoun Member of the Upper Oil Shale includes the Wardie Shale (Gullane Formation; Asbian, Visean), Burdiehouse Limestone (Brigantian, Visean), and Bone Bed Limestone (also known as the Gilmerton Limestone; Brigantian, Visean). These contain fossils of ostracods, abundant plants and vertebrates, the latter including the fish *Strepsodus*, *Rhadinichthys* and *Elonichthys*. Several sharks from Wardie are preserved three-dimensionally making them suitable for studies of jaw mechanics. More widely, specimens of the

rhizodont fish *Rhizodus hibberti* comprise large isolated conical teeth, jaws with teeth still embedded and other rare skeletal elements, with *Megalichthys* represented by teeth and diamond-shaped scales with concentric ornamentation.

Above the Calciferous Sandstone Series is the Lower Limestone Formation represented in several collections by marine fossils (brachiopods of productid, strophomenid and lingulid type) from the Hurlet Limestone, another marker bed, and its lateral equivalents. Fossils of the large brachiopod *Gigantoproductus giganteus* are from several localities across Scotland, although many are from the Corrie Limestone, Isle of Arran. At Bearsden near Glasgow, the 330 million-year-old Shrimp Member (Manse Burn Formation; Namurian) is a mix of marine and non-marine sediments known for several rare fossils: a complete shark *Akmonistion*, 'rat fish' *Deltoptychius*, a 'flying shark' - the only example found outside America - and the ray-finned fish *Mesopoma carriki* found nowhere else. Fossils of the shrimp *Palaemysis* show rare and extremely detailed preservation of tiny blood vessels and muscles. The Limestone Coal Formation is followed by the Upper Limestone Formation, with an abundance of shallow marine fossils in limestone similar to the Lower Limestone Formation, and the Passage Formation. The Coal Measures (Westphalian A and B, Upper Carboniferous), exposed around Edinburgh, Glasgow and in areas of Ayrshire and Fife, provide abundant remains of various tree trunks, roots, leaves and seeds. Fossils are very limited in the 'barren' uppermost part of the Carboniferous (Westphalian C).

By the Permian and Triassic, the amalgamation of continental masses had formed the Pangean Supercontinent. Scotland was still emergent with hot, arid, desert conditions - the 'New Red Sandstone'. Areas of shifting sand dunes were present with a minimal but sufficient amount of moisture to dampen the sediments and preserve vertebrate footprints and trackways, often in the absence of actual 'body' fossils. In southern Scotland, the Lower Permian Locharbriggs and Corncockle Sandstone formations, exposed around Lochmabon, Dumfries, preserve more than 20 different types of footprints, including the ichnospecies *Chelichnus*, *Saurichnus*, *Prochirotherium* and *Loxodactylus*. Similar conditions across Moray led to the deposition of the Hopeman Sandstone Formation (and equivalent Cutties Hillock Sandstone), well known for several hundred different types of footprint that suggest a diverse reptile fauna. The formation has also revealed the extremely rare skeletal remains of the pareiasaur *Elginia*, the dicynodonts *Geikia* and *Gordonian*, and a further dicynodont described as 'the fossil that isn't there'. Vertebrate body fossils are known from the Triassic Lossiemouth Sandstone Formation (previously the sandstones of Lossiemouth, Spynie and Findrassie) in Moray: The variably sized 'Elgin reptiles' *Stagonolepis*, *Ornithosuchus*, *Hyperodapedon*, *Leptopleuron*, *Brachyrhinodon*, *Scleromochlus* and *Saltopus*. That otherwise similar sandstones in the Elgin area contained fish in places and reptiles in others helped to prove the presence of separate 'Old' and 'New' Red Sandstone divisions of time, and simultaneously provided evidence for the then new theory of evolution.

Fossils from the Scottish Jurassic originate from two main areas, the Inner Hebrides and the east coast. On the Isle of Skye, the Lower Liassic Broadford Beds (Hettangian-Sinemurian) represent a shallow marine setting with horizons of abundant bivalves (oysters, *Gryphaea*), corals, ammonites, and rare dinosaur bones. The Bearreraig Sandstone (Toarcian-Bajocian) has also yielded dinosaur remains (stegosaur or ankylosaur) and trackways suggesting land temporarily emerged from an otherwise shallow water setting. Water became shallower during deposition of the Great Estuarine Group (Bajocian-Bathonian), which formed in brackish lagoons and deltas with bivalves (monospecific (*Praeexogyra*) oyster-beds), ostracods and fish; a notable bed is the '*Estheria*' Shale. The Duntulm and Kilmaluag formations have recently revealed dinosaur footprint and trackway traces, as well as ichthyosaur remains, with the Kilmaluag Formation providing skeletal remains of fish (often whole bodies), turtles, amphibians, crocodiles, dinosaurs and mammals and invertebrate fossils. Many of these Jurassic rock units are also found along the north west coast and islands, notably Eigg where there is the potential for further dinosaur material; vertebrate fossil-bearing rocks from the Middle Jurassic are otherwise rare worldwide. The rocks along the east coast around Brora and Helmsdale represent mainly aquatic settings deposited during several stages of the Jurassic (Liassic, Bathonian, Callovian, Oxfordian, Kimmeridgian). Most rock units contain fossils of both

invertebrates (ammonites and belemnites) and vertebrates (fragments of ichthyosaurs and plesiosaurs), notably the Clynelish Quarry Sandstone, which has also yielded plants.

Toward the end of the Cretaceous and into the Cenozoic, the area that would become the Atlantic Ocean began to rift, leading to extensive volcanic activity in the north west of Scotland. This 'Tertiary Volcanic district' saw outpourings of lava at the surface and intrusions of igneous rocks deep underground, either as dykes and sills that never reached the surface (hyperbyssal rocks) or magma chambers where lava was stored (plutonic rocks). Few fossiliferous rocks are present from this time, although lavas themselves have preserved plant material across Greenland and the Arctic that indicate a terrestrial setting with sub-tropical climate. Important Scottish fossils are from the Paleocene Ardtun Leaf Beds of Mull, discovered by Lord George Douglas Campbell, (1823-1900), the 8th Duke of Argyll, and his son, Lord Archibald Campbell (1846-1912); presumed donations of this material is found in various Scottish museums. An impressive feature on Mull itself is MacCulloch's tree, a 12-metre-tall tube lined with charred woody remains at the base of a cliff of columnar basalt, representing a tree engulfed in lava millions of years ago.

The most recent fossils from Scotland are found in Pleistocene Arctic clays deposited as glacial ice melted and retreated, and post-glacial sediments deposited in the Holocene-Recent as the climate became relatively warmer. The main Arctic clay deposits in Scotland, the 'Errol Clay' (Errol Clay Formation) across the Firth and Tay Estuaries, notably at Inchcoonans Pit, Errol, and the 'Clyde Beds' (now the Clyde Clay Formation divided into various members) across the Firth of Clyde, are dated to the late Devensian, less than 15,000 years ago. The Arctic clays contain rare fossils with several species of bivalve collected alongside ostracods, brittle stars, foraminifera and more unusual and very rare vertebrate remains, such as the seal *Phoca*, an eider duck, bear and mammoth. Historic studies of the Arctic clays revealed a record of the alternations between colder glacial periods with coverings of ice, and warmer interglacial intervals. In particular, it was noted that the Arctic clay bivalves from 13,000 years ago were similar to those found in cold, marine waters today at a higher latitude, suggesting a shift in climate since the last glaciation. The Arctic clay fossils continue to be important for studies of climatic change. Post-glacial sediments include the Carse Clay Formation (Pleistocene-Holocene) in the Forth and Tay Estuaries, comprised of marine and estuarine sediments, which also contains molluscs. A range of clays deposited during the Devensian were suitable for production of tiles and bricks and extracted in the past as 'brick clays' from sites around Montrose, Brora, Bridge of Allan, Aberdeenshire, etc.

Fossils from the rest of the UK

Fossils from localities outside Scotland, but still within the UK, are present in Scottish museum collections. These might have been collected for comparison, being the equivalents to material exposed in Scotland. Material from stratigraphic levels not present or common across Scotland was perhaps collected for reference. Noted material includes:

- Precambrian Ediacaran fossils from Charnwood Forest, Leicestershire, representing early metazoan (multi-celled) life (Cockburn Museum, Paisley Museum).
- Lower Palaeozoic graptolitic shales from Wales, the Welsh Borderlands and the Lake District (Drygill Shale, Skiddaw Slate) comparable to those of southern Scotland (Perth Museum and Art Gallery, Paisley Museum, Cockburn Museum, Glasgow Museums Resource Centre, Fife Collections Centre, University of Aberdeen Museums, The McManus: Dundee's Art Gallery and Museum).
- Fragmentary fish remains (scales and spines) from the Ludlow Bone Bed (Pridoli Series, Silurian) at Ludford Corner, Ludlow (University of Aberdeen Museums, Cockburn Museum, Tweeddale Museum).
- Lower Devonian fish in dark mudstones from Abergavenny, Wales (Montrose Museum).

- Carboniferous plant material from various coal fields: Coseley, Barnsley and Manchester area, Radstock in Somerset, etc (Museums of the University of St Andrews, University of Aberdeen Museums, Cockburn Museum, Paisley Museum).
- Fish from the Permian Marl Shale at East Thickley, Ferry Hill, Frislington Quarry and Crime Rig Quarry, County Durham (Cockburn Museum, McLean Museum and Art Gallery, University of Aberdeen Museums, Hawick Museum).
- Triassic rhynchosaurs from Cheshire (Dick Institute), and samples of the Rhaetian Bone Bed from Aust Cliff, Gloucestershire (University of Aberdeen Museums, Tweeddale Museum).
- Liassic (Jurassic) fossils from England (notably, Lyme Regis and Whitby), including marine reptiles (ichthyosaurs, plesiosaurs), fish and cephalopods (ammonites, belemnites), with similar material from inland quarries across Warwickshire, Somerset and Gloucestershire (Inverness Museum and Art Gallery, Paisley Museum, Cockburn Museum, University of Aberdeen Museums, The McManus: Dundee's Art Gallery and Museum, Museums of the University of St Andrews, St Andrews Museum, McLean Museum and Art Gallery, Hawick Museum).
- Vertebrates (shark teeth) from the Stonesfield Slate (Inferior Oolite, Jurassic) (The Discovery Centre, Montrose Museum, Cockburn Museum, University of Aberdeen Museums).
- Sponges from the Cretaceous Faringdon Sponge Gravel of Oxfordshire (Perth Museum and Art Gallery, University of Dundee Museum Collections, Cockburn Museum, University of Aberdeen Museums, Stromness Museum, Fife Collections Centre).
- Cretaceous Chalk containing invertebrates (echinoids, cephalopods, brachiopods, arthropods) and vertebrates (fish) (Nairn Museum, Falconer Museum, The Discovery Centre, University of Aberdeen Museums, Orkney Fossil and Heritage Centre, Hugh Miller's Birthplace Cottage and Museum, Stirling Smith Art Gallery and Museum, Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, Montrose Museum, Fife Collections Centre, Cockburn Museum, McLean Museum and Art Gallery, Paisley Museum, Kelvingrove Art Gallery and Museum, Hawick Museum, Tweeddale Museum).
- Fossils from the London and Hampshire basins: Paleocene Thanet Sands, and Eocene Barton Beds, Bracklesham Beds, London Clay, etc (University of Aberdeen Museums, Stromness Museum, The McManus: Dundee's Art Gallery and Museum, Montrose Museum, Fife Collections Centre, Cockburn Museum, Paisley Museum, Glasgow Museums Resource Centre, Kelvingrove Art Gallery and Museum, Hawick Museum).
- Cave material, notably from Happaway Caves, Devon (McLean Museum and Art Gallery).

Fossils from outside the UK

Perhaps surprising is the amount and variety of fossil material in Scottish collections from outside the UK. Many sources are well-known, usually because of an abundance and/or diversity of fossils, as a source of specific groups of fossils, features of exceptional preservation (soft tissue structures and other features not normally present in the fossil record) or fossils illustrating key moments in the history of life. Scientific publications are available for most, although some literature has not been revised since first discovery, which in some cases is as far back as the early 1800s. The scientific and historic importance of others is however unclear, providing the opportunity for research and study. Worldwide material includes:

- Cambrian trilobites from Utah and Mount Stephen, British Columbia, Canada (Falconer Museum, Museums of the University of St Andrews, Fife Collections Centre).
- Ordovician graptolites from the Rocky Mountains, Quebec (Quebec Group) and Australia (University of Aberdeen Museums, Cockburn Museum, Stirling Smith Art Gallery and Museum).
- Palaeozoic invertebrates from North America representing the Ordovician Deepkill Shale of New York State, Ordovician Oakdale Formation of Connecticut, Ordovician of Kentucky, Silurian Guelph Limestone of Ohio, Devonian of Cinncinati and Canadigua, New York State, and Carboniferous of Michigan and New York State; a Permian vertebrate (lungfish *Gnathorhoriza*),

from the Wellington Formation of Black Bear Creek, Oaklahoma (Paisley Museum, Fife Collections Centre, University of Dundee Museum Collections, Cockburn Museum).

- Palaeozoic fossils from Canada: fish *Bothriolepis* from Scaumenac Bay, New Brunswick, and invertebrates *Favosites* from the Silurian Niagara Limestone of Ontario, Silurian bivalves (*Ambonchyia* and *Hodiolopsis*) from western Canada, Devonian *Spirifer*, Carboniferous corals (*Diphyllum*) from Wainfleet, Walpole and Port Colborne, etc, Ontario; several fossils are from Elora (*Megalomus*; Silurian coral *Amplexus*) and Arkona (*Cystiophyllum* from the Devonian Hamilton Series, coral limestone), Ontario (Cockburn Museum, University of Aberdeen Museums, McLean Museum and Art Gallery, University of Dundee Museum Collections).
- Australia is represented by fossils from the Silurian Hume Limestone of Tasmania, Silurian Barrandella Shale Member of Yass, New South Wales, Devonian *Receptaculites* Limestone of New South Wales, Shoalhaven River (*Bothriolepis*), Ordovician Stairway Formation of Mount Watt near Alice Springs (*Arandaspis*) and Triassic of the West Pennant Hills (*Leptolepis talborgensis*) with examples of 3.5 billion-year-old (Precambrian) stromatolites (University of Aberdeen Museums, Fife Collections Centre, Cockburn Museum, Hawick Museum).
- Carboniferous plant fossils from Mazon Creek (Illinois), Cape Breton (Sydney, Australia), Piesberg (Germany) and New Zealand (University of Dundee Museum Collections, The McManus: Dundee's Art Gallery and Museum, Orkney Fossil and Heritage Centre).
- Palaeoniscid fish from the Permian Kupferschiefer Formation of Germany and Bohemia (Museums of the University of St Andrews, University of Aberdeen Museums, McLean Museum and Art Gallery, Cockburn Museum).
- Triassic reptiles including the cynodont *Diademodon* (University of Dundee Museum Collections).
- Fossils from the Jurassic Solnhofen Lithographic Limestone of Bavaria, Germany, most famously *Archaeopteryx* (present as casts in University of Dundee Museum Collections, Museums of the University of St Andrews, Fife Collections Centre, McLean Museum and Art Gallery, Zoology Museum (University of Glasgow), Glasgow Museums Resource Centre, The Hunterian, Kelvingrove Art Gallery and Museum) but also a range of invertebrate, vertebrate, plant and trace fossils (Falconer Museum, University of Aberdeen Museums, Orkney Fossil and Heritage Centre, Treasures of the Earth, Paisley Museum, Montrose Museum, University of Dundee Museum Collections, McLean Museum and Art Gallery, Cockburn Museum, The Hunterian, Kelvingrove Art Gallery and Museum, Hawick Museum).
- Ichthyosaurs from the Toarcian (Jurassic) Posidonia Shale/Posidonienschiefer Formation of Holzmaden, Germany (University of Dundee Museum Collections, Perth Museum and Art Gallery, Kelvingrove Art Gallery and Museum, Paisley Museum).
- Cretaceous fish and arthropods (decapod) in 'White Limestone' from Lebanon (Falconer Museum, The Discovery Centre, University of Aberdeen Museums, The McManus: Dundee's Art Gallery and Museum, Museums of the University of St Andrews, Paisley Museum, The Hunterian).
- Cretaceous molluscs from Naarbrook and Berg en Terblijt, Netherlands, potentially a type section or boundary stratotype locality (Inverness Museum and Art Gallery).
- Cretaceous fossils of *Bourgettiocrinus* in chalk from Petersby (Maastrict) (Montrose Museum).
- Eocene fossils from the Green River Formation (Wyoming), Monte Bolca (Verona, Italy) and Grube Messel (Germany), with a rare fish from the Green River Shale at Dairy Fork, Utah (The McManus: Dundee's Art Gallery and Museum, Treasures of the Earth, Cockburn Museum, Museums of the University of St Andrews, The Hunterian, McLean Museum and Art Gallery, Hawick Museum, Nairn Museum, Falconer Museum, Fife Collections Centre, Orkney Fossil and Heritage Centre).
- Cenozoic (Oligocene-Pleistocene) mammal and crocodile fossils from the Siwalik Hills of India and Pakistan, collected by Hugh Falconer and colleague Proby Cautley (Falconer Museum, Nairn Museum, University of Aberdeen Museums, John Pollock Collection Centre).
- Cenozoic mammals (*Merycoidodon, Eporeodon*) from North America (White River Fauna) and *Palaeotherium* from Vaucleuse, France (University of Dundee Museum Collections, Paisley Museum, Glasgow Museums Resource Centre, Treasures of the Earth).

- Bone breccia from Eyzies, Dordogne (dated 1863), Mentone Cave deposits (deer bone fragments) from France and bone breccia from Bustchaafs, South Africa (Falconer Museum, Anatomical Museum (University of Edinburgh Collections), The McManus: Dundee's Art Gallery and Museum).

Influences on collections

Objects acquired to form any collection are subject to a variety of influences. The fossil collections across Scotland are no exception, being influenced by factors such as the underlying geology of the specific area, the presence of local collectors and the uses to which collections were put.

Underlying geology

The location of fossils in Scottish museum collections is strongly influenced by the type and age of rocks forming the underlying geology (Fig. 1). As many fossiliferous localities were discovered before widespread long-distance travel, the material collected tended to remain in the local area. One example is the fossils collected from the Devonian of Balruddery Den in Angus which, apart from examples in the collection of National Museums Scotland, are almost entirely limited to collections at The McManus: Dundee's Art Gallery and Museum and Perth Museum and Art Gallery. On the other hand, there are areas of Scotland underlain by volcanic and metamorphic rocks in which fossils do not tend to occur, or by sedimentary rocks deposited before life became evident or abundant. In museums in such areas it is still possible to find collections of fossils highlighting interest at the time, although these tend to comprise specimens from much further afield with many purchased through dealers.

A further and related influence is the distribution of rocks extracted economically, excavated on such a scale that fossil material was perhaps noted where present but not retained until its value was realised by collectors or scientists and a market developed. Areas with extensive coal mining, around Glasgow, Edinburgh and Fife, etc, are evident from the higher number of various invertebrate, plant and fish and other vertebrate remains from the Carboniferous (the geological period when the coal was formed), although the occurrence of plant fossils in museums not underlain by coal measures suggests they were probably also collected by hobbyists and/or exchanged.

Staff, visitors and collectors

Fossils from historic sites discovered in the early-mid 1800s were often first spotted by local people with limited knowledge but a keen interest in natural science. The subsequent fame of such localities was reliant on local figures with the necessary specialist knowledge to appreciate their importance and the means and connections to promote them. An example is James Fallow, the farmhand who discovered fossils near Lesmahagow in the 1840s and took them to local expert Dr Robert Slimon who excavated the source of the first fossils, retrieving an important assemblage of invertebrate, fish and plant fossils. He then expanded his search, leading to the discovery of several more equally productive sites.

Some areas of Scotland were so productive that collectors literally filled their homes and any other storage available to accommodate the fossils they found. It became necessary to build suitable, long-term storage where some of the material could be displayed. Local collectors came together to form societies that would manage the planning and construction of museums and ongoing administration once the buildings were open. Notable examples were the Moray Society (Elgin Museum), the Orkney Natural History Society (Stromness Museum) and the Buteshire Natural

History Society (Bute Museum). This in turn provided somewhere for other collectors to donate specimens or collections, leading to what was probably a fairly rapid initial accumulation.

Many of the founding societies are still in existence in one form or another and have contributed greatly since their formation to the fossil and other collections present in their respective museums. In Scotland many workers were linked to the Geological Society of Glasgow (notably Peach, Horne and MacNair, whose interest in Lesmahagow was sparked by the fossils Dr Slimon collected), the Edinburgh Geological Society and the Royal Society of Edinburgh, Scottish universities and, more widely, the Geological Society of London and the Royal Society of London. The work of local field clubs and similar groups is also apparent (Inverness Field Club, Glenfield Ramblers, etc).

Use of specimens

As the study of geology and palaeontology gathered momentum, fossils were collected for specific uses. Specimens for reference tend to comprise a limited number of 'typical' fossils from 'classic' localities or well-known stratigraphic levels, for example, Carboniferous plants, Jurassic ammonites, fragments of Mesozoic marine reptiles, Cretaceous Chalk echinoids, Eocene molluscs (gastropods and bivalves) and often a mammoth tooth. Many of the younger (Cenozoic) specimens are from rocks not found in Scotland and examples were perhaps acquired for their novelty. A collector might want a particular type of fossil, especially one that was rare. If the intended use was for display, preference would be for specimens pleasing to the eye or in some way unusual in order to draw in visitors. Token specimens from what are still sought-after localities today, especially those where exceptionally well-preserved fossils have been recovered, such as the Jurassic Solnhofen Limestone, Cretaceous Lebanon fish beds and Eocene Green River Formation, were probably purchased from dealers, such as F and A Krantz.

Fossils collected for study tend to comprise a moderate to large amount of material with a particular focus and are typically found in university collections or attributed to a specific collector: the corals of the Braidwood Collection (Dick Institute), the marine reptiles of the Alfred Nicholson Leeds Collection (The Hunterian), and Devonian fish from Shetland, Orkney, Caithness, Sutherland and Moray (Stromness Museum, Shetland Museum and Archives, Inverness Museum and Art Gallery, Nairn Museum, Elgin Museum, University of Aberdeen Museums). The distance from source and distribution across museum collections, Scottish or otherwise, is a measure of the importance placed on a particular fossil, fossiliferous rock or locality. For example, specimens of Devonian fish from north east Scotland were sent around the globe and documented by eminent scientists at the time; today, they are still present in collections worldwide. Other material later found to be of insufficient quality may have been used for teaching instead.

An important part of scientific study is comparison of specimens, which may explain the occurrence of fossils from outside Scotland. For example, Ordovician graptolites from the Rocky Mountains and Australia would have taken considerable effort to acquire, especially in the 1800s, and were probably collected for comparison to Ordovician graptolites from Dob's Linn in southern Scotland. Low numbers of invertebrates (brachiopods, corals, etc) from the Lower Palaeozoic of North America and Canada are also noted; the corals in particular, although from the Silurian and Devonian, could have been acquired for comparison with the variety of Carboniferous corals found across Scotland. In several anatomy museums across Scotland, modern examples of various invertebrate (bivalves, echinoids, sponges, corals) and vertebrate (reptile, mammal, bird, fish) groups are presented next to their ancient fossil counterparts with the specific intention of allowing visitors to compare the morphological features across the expanse of geological time. Such displays tend to include the echinoid *Clypeaster* from Egypt, often compared to modern sand dollars, and the less familiar disc-shaped foraminifera *Nummulities*, also notably from Egypt, which, at up to 6cm across, are particularly impressive for what is classified as a microfossil.

Collections development policy

A more recent influence on object acquisition is collections development policy which has been tightened at many organisations, especially those that are smaller and limited by space and resources. Preference now tends to be for objects from the local area and with a link or relevance to local history. Actual sites are also subject to stricter collection laws, for example on land included in SSSIs, with safe and legal collection of fossils promoted by the Fossil Code. Recent collection of material from historic sites and generally for scientific purposes tends to be undertaken through research projects at academic organisations.

Detail of the Late Triassic reptile *Leptopleuron lacertinum* from the Lossiemouth Sandstone Formation, Moray. Elgin Museum.© Davide Foffa

Review of Fossil Collections in Scotland

Aberdeen and North East

National Museums Scotland

John Ellerman Foundation

Aberdeen and North East

Elgin Museum (Moray Society)
Falconer Museum (Moray Council)
Stonehaven Tolbooth Museum
The Discovery Centre (Live Life Aberdeenshire)
Arbuthnot Museum (Live Life Aberdeenshire)
Zoology Museum (University of Aberdeen Museums)
Meston Science Building (University of Aberdeen Museums)
Blairs Museum

Elgin Museum (Moray Society)

Collection Type: Independent
Accreditation: 2019
Recognised Collection of Fossils: 2008

1 High Street, Elgin, Moray, IV30 1EQ
Contact: curator@elginmuseum.org.uk

Location of collections
In 1836 a group of local figures, notably Reverend Dr George Gordon of Birnie (1801-1893), town clerk Patrick Duff (1791-1861), Rear Admiral Archibald Duff (1773-1858), banker John Lawson (1799-1852) and Isaac Forsyth (1768-1859), formed the Elgin Scientific Society with the intention of providing Elgin with a museum to preserve the growing collection of fossils from the surrounding area. Previous accommodation for the early collection included the town jail and rooms in various other buildings across the town. Elgin Museum was built on the High Street and opened in 1843. The first curator was John Martin (1800-1881) and a keeper, William Ingram (ca.1800-1873), lived onsite. Today, the Museum is still run independently by the same society, now known as the Moray Society. In 2008, Elgin Museum's collection of fossils was Recognised by Museums Galleries Scotland as Nationally Significant to Scotland. Fossils are present onsite in displays and a dedicated storeroom.

Size of collections
1,500-1,600 fossils.

Onsite records
Fossils are listed in a Microsoft Excel spreadsheet, compiled as part of a 2014-2015 Recognition Fund project to review and document the Recognised Collection and other fossil material onsite, with information also on MDA cards. A considerable archive also forms part of the Recognised Collection.

Collection highlights
1. Devonian fish from historically and scientifically important localities in the local area.
2. 'Elgin reptile' fossils from the Permian and Triassic, collected from quarries near Elgin.
3. Examples of diverse Permian vertebrate trace fossils.
4. Fossils linked to founding members of the Elgin Scientific Society.
5. Fossils linked to local figures, notably Lady Eliza Gordon Cummings of Altyre (ca.1798-1842) and William Taylor (1849-1921).
6. Triassic reptile fossils studied by Thomas Henry Huxley (1825-1895).
7. Nine fish and reptile type specimens.

Published information
Agassiz, L. (1844–1845). *Monographie de poissons fossiles des Vieux Gres Rouges ou Systeme Dévonien (Old Red Sandstone) des Îles Britanniques et de Russie.* Neuchâtel: Soleure, chez Jent and Gassmann.
Andrews, S.M. (1982). *The discovery of fossil fishes in Scotland up to 1845*. Edinburgh: Royal Scottish Museum Studies.
Ahlberg, P.E. (1998). Postcranial stem tetrapod remains from the Devonian of Scat Craig, Morayshire, Scotland. *Zoological Journal of the Linnean Society*. 122:99-141.
von Baczko, M.B., and M.D. Ezcurra. (2016). Taxonomy of the archosaur *Ornithosuchus*: reassessing *Ornithosuchus woodwardi* Newton, 1894 and *Dasygnathoides longidens* (Huxley 1877). *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*. 106:199-205.
Bennett, S.C. (2020). Reassessment of the Triassic archosauriform *Scleromochlus taylori*: neither runner nor biped, but hopper. *PeerJ*. 8:e8418.

Benton, M.J., and A.D. Walker. (1985). Palaeoecology, taphonomy and dating of Permo-Triassic reptiles from Elgin, North-East Scotland. *Palaeontology*. 28:207-234.
Collie, M. (1991). Huxley the Public Figure. In *Huxley at Work*. London: Palgrave Macmillan.
Collie, M., and S. Bennett. (1996). *George Gordon: An annotated catalogue of his scientific correspondence*. Scolar Press.
Dróżdż, D. (2018). Osteology of a forelimb of an aetosaur *Stagonolepis olenkae* (Archosauria: Pseudosuchia: Aetosauria) from the Krasiejów locality in Poland and its probable adaptations for a scratch-digging behavior. *PeerJ*. 6:e5595
Friedman, M. (2007). Cranial structure in the Devonian lungfish *Soederberghia groenlandica* and its implications for the interrelationships of 'rhynchodipterids'. *Transactions of the Royal Society of Edinburgh: Earth Sciences*. 98:179-198.
Groome, F. (ed.). (1882-1884). *Ordnance Gazetteer: Elginshire*. Edinburgh: Thomas C Jack.
Kammerer, C.F., K.D. Angielszyk, and J. Frobisch. (2011). A comprehensive taxonomic revision of Dicynodon (Therapsida, Anomodontia) and its implications for dicynodont phylogeny, biogeography and biostratigraphy. *Journal of Vertebrate Palaeontology*. 31 (Supplement 1):1-158
Keeble, E., and M.J. Benton. (2020). Three-dimensional tomographic study of dermal armour from the tail of the Triassic aetosaur *Stagonolepis robertsoni*. *Scottish Journal of Geology*. 56:55-62.
Mantell, G.A. (1852). Description of *Telerpeton elginense*, a fossil reptile recently discovered in the Old Red Sandstone of Moray: with observation on the supposed fossil ova of batrachians in the Lower Devonian strata of Forfarshire. *Quarterly Journal of the Geological Society, London*. 8:100-109.
Parker, W.G. (2018). Anatomical notes and discussion of the first described aetosaur *Stagonolepis robertsoni* (Archosauria: Suchia) from the Upper Triassic of Europe, and the use of plesiomorphies in aetosaur biochronology. *PeerJ*. 6:e5455.
Peacock, J.D. (1968). Geology of the Elgin District. *Memoirs of the Geological Survey Scotland*. Edinburgh: HM Stationery Office.
Säilä, L. K. (2010). Osteology of *Leptopleuron lacertinum* Owen, a procolophonoid parareptile from the Upper Triassic of Scotland, with remarks on ontogeny, ecology and affinities. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh.* 101:1-25.
Trewin, N.H. (2013). *Scottish Fossils*. Edinburgh: Dunedin Academic Press.

Collection overview

The geology collection is divided into a larger part designated as a Recognised Collection and smaller part that is not Recognised. Fossils of the Recognised Collection are from three main stratigraphic levels: the Devonian (entirely fish), Permian (trace fossils and rare body fossils) and Triassic (reptile body fossils). Fossils from the Middle Devonian are *Coccosteus, Pterichthyodes*, *Mesacanthus*, *Cheiracanthus*, *Diplacanthus*, *Cheirolepis* and *Glyptolepis* and *Gyroptychius* from Tynet Burn, Lethen Bar and Dipple Bray. Examples of *Dipterus* from Achanarras are also present. Upper Devonian fish are *Asteroplepis*, *Psammosteus*, *Glyptopomus*, *Rhynchodipterus*, *Phaneropleuron*, *Bothriolepis* and *Holoptychius* from Kingsteps, Alves and nearby Carden Moor, Bishopmill, Pluscarden, the Quarrywood area west of Elgin (Rosebrae, Newton, Laverocklock) and Scaat Craig to the south of Elgin. The Permian is represented by the reptiles *Gordonia*, *Geikia* and *Elginia* and the Triassic by *Hyperodapedon*, *Stagonolepis*, *Ornithosuchus*, *Brachyrhinodon, Leptopleuron* (Fig. 2)*, Scleromochlus* and *Saltopus*, collected from quarries at Lossiemouth, Spynie and Findrassie; many fossils of these taxa are now located in other collections (Natural History Museum, London, and British Geological Survey, Keyworth). The dicynodont skull model ('the fossil that isn't there') represents a void in a block from the Permian Hopeman Sandstone Formation of Clashach Quarry, found in 1997. The block was CT and MRI scanned, then cast in 3-D by researchers at the University of Glasgow. The original block is on display in Elgin Museum with a Recognition-funded cast of the skull including the lower jaw; The Hunterian also displays a copy of the model. The Recognised Collection also includes Permian footprint and trackway fossils from Clashach Quarry, and other local sites, some in large slabs. Research by Carol Hopkins (unpublished) describes the traces as comparable in terms of abundance and diversity to those in equivalent rocks of Dumfries (Locharbriggs and Corncockle Sandstones formations), Germany (Cornberger Sandstein) and Arizona (Coconino Sandstone). The part of the collection not

Recognised comprises approximately 100 mostly invertebrate and plant fossils, many of which are not from the local area. Examples are Ordovician trilobites, Silurian corals, slabs of Silurian Much Wenlock Limestone Formation and Devonian Rhynie Chert, Carboniferous *Neuropteris*, *Calamites* and *Alethopteris* with *Mariopteris*, cephalopods (several ammonites, fragments of belemnites and a polished nautiloid), *Gryphaea* bivalves (Jurassic), echinoids (Jurassic and Cretaceous), shark teeth (Eocene), a brittle star from Spynie (in Devensian Spynie Clay), fossil wood and other loose, isolated invertebrates (brachiopod, bivalve, crinoid). A large ammonite fossil is labelled as transported to the area by a glacier.

Figure 2: Skeleton of the Triassic procolophonid reptile *Leptopleuron lacertinum* from Lossiemouth, Moray (Elgin Museum)

Research/collection links

Although many of the reptiles and fish from the collections were studied soon after their discovery, recent work using improved techniques and higher resolution, for example on *Leptopleuron* and the re-study of the upper Devonian lungfish *Rhynchodipterus,* highlight their continuing scientific potential. Recent research visitors have included palaeontologists from Venezuela (Neto), Poland (Dróżdż), National Museums Scotland (Foffa, Panciroli, Zaher) and Birmingham (Henderson), underlining the national and international importance of the Elgin fauna. Three-dimensional tomographic studies of reptile fossils have proved particularly useful in the identification of additional (and hitherto unknown) features (see Keeble & Benton, 2020) and active research is being undertaken by Foffa at National Museums Scotland: https://royalcommission1851.org/elgin-reptiles-the-origins-of-the-modern-terrestrial-fauna. Studies of the Triassic vertebrate trace fossils from Clashach near Hopeman, undertaken in the 1990s-2000s, have not been published in academic literature, although accounts by Carol Hopkins have appeared in the 2007 Elgin Museum *Sea to Sand Conference Proceedings* and in articles published by The Geologists Association magazine *Earth Heritage*. The quarries at Clashach (Permian) and Spynie (Triassic) are SSSIs, although they continue to be worked for building stone with the potential for ongoing study. As indicated above, researchers are publishing on topics relating to fossil species found in Moray with material in Elgin Museum but are not necessarily referencing this material. Similarly, information appears about Permian trackways without the authors having visited Moray or referencing the collection or the work of Carol Hopkins at Clashach. The Elgin Museum Geology Group has considerable knowledge of local palaeontology, its history and the find sites and is always willing to assist with any research enquiries or visits.

Falconer Museum (Moray Council)

Collection Type: Local authority
Accreditation: 2017

Tolbooth Street, Forres, Moray, IV36 1PH
Contact: museum.forres@moray.gov.uk

Location of collections
The Falconer Museum, located close to the main street, was founded in 1871 at the bequest of locally-born Alexander Falconer (1797-1856) for a public museum in Forres. His younger brother Hugh (1808-1865) is also credited as a founder, and to whom many objects in the collection are linked. Both brothers spent time in India. Collections are displayed in the Museum with a separate offsite store a short distance away.

Size of collections
500-1,000 fossils.

Onsite records
The fossils are accessioned with entries in an Adlib CMS. A paper catalogue contains identification and origin information.

Collection highlights
1. Miocene fossils from the Siwalik Hills, India, linked to Hugh Falconer (1808-1865).
2. Vertebrate, invertebrate and plant fossils from Scottish, UK and Worldwide localities.

Published information
Agassiz, L. (1844–1845). *Monographie de poissons fossiles des Vieux Gres Rouges ou Systeme Dévonien (Old Red Sandstone) des Îles Britanniques et de Russie.* Neuchâtel: Soleure, chez Jent and Gassmann.
Falconer, H., and P. T. Cautley. (1847). *Fauna Antiqua Sivalensis*. London: Smith, Elder and Co.
Falconer, H. (1863). *On the American Fossil elephant of the regions bordering the Gulf of Mexico (E. Columbi, Falc.): With General Observations on the Living and Extinct Species*. Natural History Review 3:43-114.

Collection overview
Most of the material (more than 300 specimens) is vertebrate (mammal and crocodile) bone fragments and plants from the Siwalik Hills (Fig. 3), collected by Hugh Falconer in the early-mid 1800s. Fossils are typically described as being from the Miocene of India, although the Siwalik Hills today includes part of Pakistan, and the Siwalik Group, representing fluvial environments, is thought to cover a wider interval of Cenozoic time from the Oligocene to Pleistocene. Specimens demonstrating the diversity of the fossils are on display: a buffalo skull and jaw, second buffalo skull, large leaf fossil, elephant tusk, two pieces of hippo skull and a hippo ankle bone, with an extensive collection of material in storage. It is possible that some fossils might have been illustrated in *Fauna Antiqua Sivalensis* (1847), a catalogue of the finds produced at the time. The collection also includes fossil wood from the same locality. A mammoth tooth in the collection is also linked to Hugh Falconer and his work on American elephants, which he published in a monograph (Falconer 1863).

The remaining part of the fossil collection is more diverse in terms of origin. A limited number of specimens are from the Devonian locally, including fish (acanthodians, placoderms, *Holoptychius*) and indeterminate plant fragments. The collection otherwise comprises a range of fossils from beyond the local area, such as the Devonian fish *Diplopterus* from Orkney and '*Estheria*' from Thurso, Carboniferous fish (*Rhizodus*, *Megalichthys, Psammodus* from Armagh) and plants (*Cyclopterus* from Coalbrookdale, Shropshire), and Permian fish (*Palaeoniscum* from East Thickley,

Durham). The Jurassic is represented by bivalves (*Pinna* from Dundry, *Gryphaea*), ammonites (*Cardioceras*), belemnites and gastropods (Inferior Oolite of France), plants (*Williamsonia* from Scarborough) and an *Ichthyosaurus* rostrum from Bushley, Gloucestershire. Fossils from the Chalk are mainly echinoids (*Cidaris*, *Clypea*, *Clypeaster*, *Echinocorys*) and there are examples of leaves in tufa that may be from the Paleocene Ardtun leaf beds of Mull. The diversity and wide-ranging origins of specimens is emphasised by trilobites from Mount Stephen (Canada), *Pecopteris* from the Carboniferous of Illinois, coral from Ontario (Canada), *Diplomystus* from the Cretaceous of Syria, Eocene foraminifera from Egypt, fish from the Eocene Monte Bolca of Italy (*Myripristis*) and Jurassic Solnhofen Limestone of Germany (*Leptopteris*), and a bone breccia from Les Eyzies, Dordogne, France. The label for a specimen of the fish *Mesopoma mantelli* from the Chalk of southern England references a publication by Agassiz, suggesting it is figured. Blocks of wood with hand-written taxonomic, stratigraphic and geographic information and nails at strategic points, a former method of labelling and storage/display, are associated with most of the fossils.

Figure 3: A Miocene crocodile skull from the Siwalik Hills (Falconer Museum)

Research/collection links

The material from the Siwalik Hills is important historically and still of interest; the fossils were examined as recently as late 2019 by a researcher from India. Although most of the vertebrate specimens from the Siwalik Hills are fragmentary, many are distinct enough to be identified taxonomically and have been described as rare and significant by a researcher (Oxford University Museum of Natural History; JEPC Pers. Comm.). The Siwalik material in the Falconer Museum is effectively unknown and therefore unstudied; it could provide enough material for a masters-level project, or higher, if investigated alongside material in other Scottish collections that is also perhaps not known scientifically (for example, fossils housed in the Meston Science Building (University of Aberdeen Museums) and Nairn Museum). Thorough examination of the collection of other fossils onsite would be worthwhile.

Stonehaven Tolbooth Museum

Collection Type: Independent

Old Pier, Stonehaven Harbour, Aberdeenshire, AB39 2JU
Contact: enquiries@stonehaventolbooth.co.uk

Location of collections
The Museum is located at Stonehaven Harbour in a building dating from the 1500s. The Museum opened on the site in 1975 and was under the management of Aberdeenshire Council until 2011. It is now run by the local community. The collections, including fossils, are on display.

Size of collections
11 fossils.

Onsite records
The collection is documented in an Excel spreadsheet.

Collection highlights
1. Variety of arthropod fossils and a model of the millipede *Pneumodesmus*.

Published information
Wilson, H.M., and L.I. Anderson. (2004). Morphology and taxonomy of paleozoic millipedes (Diplopoda: Chilognatha: Archipolypoda) from Scotland. *Journal of Paleontology*. 78:169-184.

Collection overview
Material is variable and attributed to an unknown, but still active, local collector: A slab with two Devonian fossil fish (Orkney), a Devonian eurypterid and approximately 4 examples of the extinct crustacean *Dictyocaris* (shown with illustrations of the similar *Ceratiocaris*) found locally at Cowie. The fossils in the 300 million-year-old coal-bearing limestones of Fife include crinoid and plant fragments. In the same case are polished orthoconic nautiloids from Morocco. Displays describe the millipede *Pneumodesmus newmani* from the Cowie Formation exposed nearby at Cowie, thought until recently to be the oldest air-breathing animal known; the rocks have since been re-dated to 414 million years old with other millipedes now known from older sediments, although *Pnemodesmus* is the oldest fossil shown to possess spiracles necessary to breath air out of water. The specimen on display is a model; the original fossil is in the National Museums Scotland collection, although there is an imprint of a *Pneumodesmus newmani* fossil in the display, under a magnifying glass.

The Discovery Centre (Live Life Aberdeenshire)

Collection Type: Local authority (Live Life Aberdeenshire)
Accreditation: 2018

Station Road, Mintlaw, Aberdeenshire, AB42 5EE
Contact: museums@aberdeenshire.gov.uk

Location of collections
The Discovery Centre facility in Mintlaw was purpose-built in 2004 to house the stored collections of the Aberdeenshire Museums Service.

Size of collections
1,000-2,000 fossils.

Onsite records
Collection information is in an Excel inventory and Adlib CMS. The fossils are not catalogued although they have been examined and organised by a volunteer with palaeontological knowledge. MDA cards filling 30 or so metal filing cabinets are in the main storeroom, recording every specimen onsite and material transferred to the location, notably 'Ex Banff'. Documentation is still being reviewed and revised. An online catalogue is available at: http://aberdeen-asp.adlibhosting.com/.

Collection highlights
1. Devonian fossil fish from the north east of Scotland.
2. Fossil fish linked to HMS *Vernon* are potentially historically important.
3. Brachiopod fossils from Linksfield, Elgin, potentially linked to John Lawson (1799-1852).

Published information
Davidson, R.G., and N.H. Trewin. (2005). Unusual preservation of the internal organs of acanthodian and actinopterygian fish in the Middle Devonian of Scotland. *Scottish Journal of Geology*. 41:29-134.
Jolly, W. (1870). Notes on the geology of Southerness, Kirkcudbrightshire. *Transactions of the Edinburgh Geological Society*. 1:278-284.

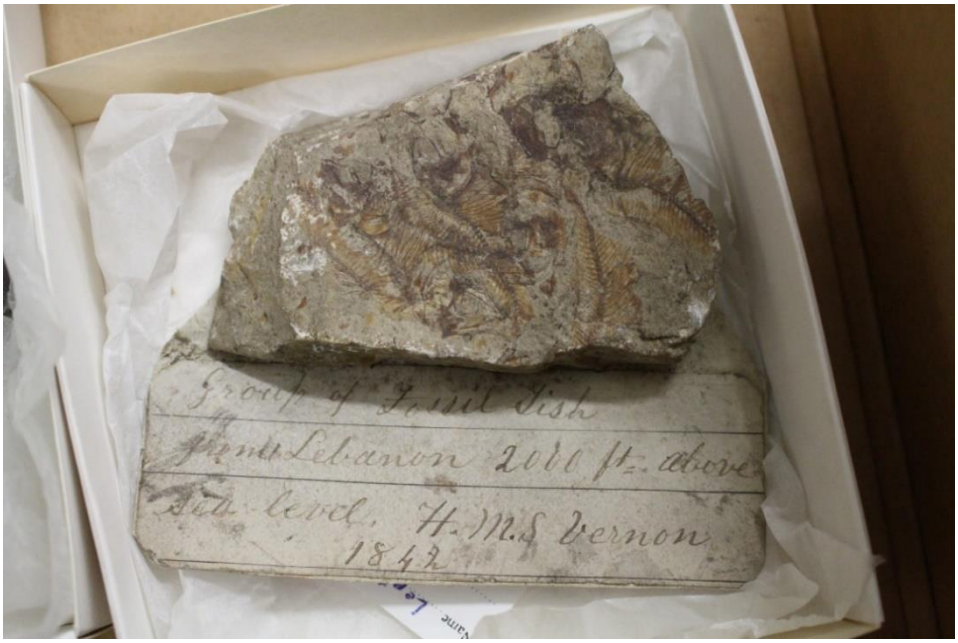

Figure 4: Cretaceous fish from Lebanon collected on an HMS *Vernon* voyage (The Discovery Centre, Aberdeenshire Museums Service)

Collection overview
The collection includes material originating in Scotland, the UK and worldwide. Most of the vertebrates are fish from north east Scotland. Middle Devonian specimens include *Osteolepis* (Caithness, Lethen, Orkney, Tynet Burn, Cruaday in Orkney), *Coccosteus* (Lethen, Clune, Edderton), *Cheirolepis* and *Glyptolepis* (Tynet Burn, Gamrie/Corbie Burn), *Gyroptychius* (Edderton), *Dipterus*, *Acanthodes* and *Cheirocanthus* (Tynet Burn), *Pterichthys*, *Pterichthyodes* (Lethen Bar, Tynet Burn, Gamrie) and *Palaeospondylus* (Achanarras). Upper Devonian specimens are of *Bothriolepis* (Clune, Whitemire) and *Asterolepis* (Whitemire); some specimens assigned to Lethen (Middle Devonian) are perhaps from Altyre Burn (Upper Devonian). A Devonian coprolite was found among other indeterminate fragments. A *Dipterus* is described as the 'impression of fish in clay slate from near Thurso Mr A Robertson 1839' and possibly linked to Alexander Robertson (1816-1854) who visited Orkney among other places across Scotland to study geology; several fish also have labels indicating identification by Bob Davidson in 1999. A 360 million-year-old *Osteolepis* from Cruaday is a former 'object of the month', the taxon highlighted as a distant relative of tetrapods that first crawled onto land.

Fish specimens from other levels include several *Rhizodus* teeth and *Megalichthys* from the Carboniferous, a *Lepidotus* scale (Jurassic), the Lower Liassic (Jurassic) fish *Pholidophorus* from Lyme Regis (label reading 'From Bryce M Wright, 90 Great Russell Street, London'), the fish *Mallotus* in a nodule (no age could be determined but relatively recent), various shark teeth (origins include Malta) and vertebrae of unknown age and origin. A shark tooth is labelled as being an Eocene *Carcharodon* tooth, although this taxon did not appear until slightly later, during the Miocene. An interesting specimen is labelled as a 'group of fossil fish from Lebanon 2000ft above sea level HMS *Vernon* 1842' (a frigate launched in 1832); the fish might be Cretaceous (Fig. 4). Other fossils are an ichthyosaur vertebra ('James Wallace esq.' named on the label), a second smaller vertebra, bison astragalus (Windy Knoll, Castleton), horse tooth from the River Thames and a tusk. A box labelled as 'non-fish' with the name 'Brown' contains a mammoth tooth.

Invertebrate fossils from Scotland include sponges dredged from the Moray Firth dated 1893, solitary and colonial corals (*Lithostrotion* from the Carboniferous of Beith and Southerness, Dumfries, the latter perhaps linked to William Jolly), bivalves (many from the Carboniferous, including mussel bands), Jurassic molluscs (Clynelish, Sutherland), Jurassic gastropods and belemnites (Brora, Eathie Haven, 'Port an Righ 1972'). Ammonites are from Eathie (Cromarty) and Blackpots Clay Pit (White Hills) with several dredged from the Moray Firth or collected from Plady (Aberdeen shore). A greater proportion of invertebrates is from outside Scotland. Palaeozoic fossils include graptolites, trilobites, bryozoans, crinoids, brachiopods, bivalves (Carboniferous *Anthracoma* from Bradford; *Anthracosia* from Whaley Bridge) and gastropods (*Euomphalus*). Fossil brachiopods, the coral *Halysites* and a range of other invertebrates are from the Silurian Much Wenlock Limestone Formation (Dudley and Shropshire). Several fossils (fish from Cromarty, belemnites from Brora) have labels attributing them to AA Woodham (possibly Anthony A Woodham, a former keeper of the National Museum of Antiquities of Scotland, Edinburgh, and member of the Society of Antiquaries of Scotland) collected during archaeological excavations. A small collection of brachiopods from Linksfield near Elgin is potentially linked to John Lawson, one of the founders of Elgin Museum, who visited quarries in the Elgin area to collect fossils and presented studies of them in lectures to the Elgin Scientific Society, of which he was president.

Invertebrates from the Mesozoic are almost entirely from outside Scotland and organised by stratigraphic stage. For example, Jurassic fossils are stored in boxes labelled Liassic, Bajocian, Bathonian, Callovian, Oxfordian, Kimmeridgian and Portlandian with the contents including echinoids (*Clypeaster*, flint echinoid), ammonites and aptychi, vertebrae, reptile 'paddles' and the bivalves *Plagiostoma, Gryphaea,* various oysters, inoceramids and *Trigonia* from the Stonesfield Slate of Oxfordshire. A box labelled as Aptian represents the Cretaceous with a number of fossils elsewhere in Cretaceous Chalk. Material representing the Cenozoic originates from several well-known localities, such as the Eocene Bracklesham Beds of Hampshire (gastropod *Athleta*).

Plant fossils include material from the Devonian Rhynie Chert of Aberdeenshire, *Adianites hibernicus* and fossil ferns in Devonian sandstone from Kiltorcan (County Kilkenny, Ireland, Fig. 5), *Psilophyton*, and other indeterminate plant fragments. Many plant fossils are typical of the Carboniferous: *Lepidodendron*, *Stigmaria*, *Sphenopteris*, *Calamites* (one from St Helens), *Sigillaria* (Bishop Aukland), *Stigmaria* (Durham), with fossil ferns and other fragments from coal fields (notably at Burdiehouse and Glasgow (one dated 1877)), and 'ferns Castle Carry' possibly from Castlecary near Glasgow. Labels reading 'Natural History Collection of James Gaul', a collector in Edinburgh, are found on several fossils, including a *Calamites*. An example of fossil wood is from Dysart, Fife.

Figure 5: Frond of the Devonian plant *Adianites hibernicus* from Kiltorcan, County Kilkenny, Ireland (The Discovery Centre, Aberdeenshire Museums Service)

Research/collection links

A box labelled 'Huntly Fish' would be worth investigating as this origin/collection has not been noted elsewhere. A box containing fish from Tynet Burn is labelled as 'Figured' although the reference is not apparent; several boxes contain unsplit nodules from Tynet Burn which have the potential for scientific study especially as the exposures are now inaccessible. The fossils linked to the frigate HMS *Vernon* and the brachiopods from Linksfield, Elgin, could be investigated to determine their historic/scientific value.

Arbuthnot Museum (Live Life Aberdeenshire)

Collection Type: Local authority (Live Life Aberdeenshire)
Accreditation: 2018

St Peter Street, Peterhead, Aberdeenshire, AB42 1QD
Contact: museums@aberdeenshire.gov.uk

Location of collections
The Arbuthnot Collection was founded in the home of local merchant Adam Arbuthnot (1773-1850) on Jamaica Street and was well known by 1837. Following his death in 1850 the collection was bequeathed to the town of Peterhead and moved to several locations before the building of a museum, which opened in 1893. The Arbuthnot Museum is a few minutes from the town centre on the first floor of a building shared with the community library. Collections are displayed in the Museum with storage located offsite at The Discovery Centre, Mintlaw.

Size of collections
5 fossils.

Onsite records
Electronic information is managed from The Discovery Centre, Mintlaw.

Collection overview
Fossils are displayed in drawers in the family-focused Mr Arbuthnot's Gallery. These are a *Dactylioceras* ammonite from the Jurassic of Yorkshire (probably Whitby), shark tooth labelled *Carcharodon* from Malta, fragment of fossil wood (Carboniferous *Stigmaria*) from a coal mine in Wemyss, Fife, an *Inoceramus* bivalve in flint from south east England and another fragment of fossil wood brought back from Egypt by Captain Lawrie.

Zoology Museum (University of Aberdeen Museums)

Collection Type: University
Accreditation: 2017
Recognised Collection: 2007

Tillydrone Avenue, Aberdeen, AB24 2TZ
Contact: museum@abdn.ac.uk

Location of collections
The Zoology Museum is located in the Zoology Department and is the display area for zoological specimens from the University of Aberdeen Museums collection. Specimens were amassed through 200 years of teaching and research activities by staff and students and donations from graduates and friends of the University. Collections at the Museum are part of the University of Aberdeen Collection Recognised in its entirety by Museums Galleries Scotland as Nationally Significant to Scotland. The collection includes fossils located throughout displays.

Size of collections
50-70 fossils.

Onsite records
There are MDA cards for every specimen with a third of these so far transferred to a Calm CMS. Information is also in ABDUS, a version of CARD Box. Old RN numbers indicate specimens that have at some time been located in Marischal College. An online catalogue including fossil specimens is available at: https://www.abdn.ac.uk/museums/collections/index.php.

Collection highlights
1. Diversity of fossils used to complement modern representatives.
2. Fossils from important localities: Rhynie, Hopeman, etc.

Collection overview
As the Museum's displays and collections focus on zoology, fossil specimens are included with their modern representatives for comparison and to illustrate important features of the respective group. For example, displays with interpretation for Echinodermata, Brachiopoda and Bryozoa include fossils of echinoids (*Cidaris*, *Spatangia*, *Clypeaster*, *Micraster* and several sand dollars), crinoids (*Pentacrinus*, *Encrinus, Marsupites*) and crinoidal limestone (from the Carboniferous and Ordovician), brachiopods (small groups of *Rhynchonella*, *Terebratula*, *Strophomena* and *Spirifera* affixed to boards and several brachiopods in limestone, many probably from the Silurian Much Wenlock Limestone Formation, and a boxed *Waldheimia*), and a rock sample with the bryozoan *Fenestella*.

Molluscs include fossilised cephalopods (Fig. 6), mostly ammonites listed as *Phylloceras*, *Hildoceras*, *Dactylioceras*, *Stephanoceras*, and several 'Ammonita' sp., *Nautilus*, *Orthoceras*, and belemnites, including one from the Oxford Clay and two with rare preservation of ink sacs. Two large samples of driftwood are extensively bored by the bivalve *Teredo navalus*. A single specimen represents fossilised crustaceans: the crab *Oxystomata* with other arthropod fossils including the anterior half of a large eurypterid and the trilobites *Encrinurus*, *Calymene*, *Phacops* and *Odontochile*. The next cabinet shows tubes from the worm *Serpula sulcata* on a bivalve. Corals include two *Heliolites* (one polished), *Calceola*, *Blothrophyllum* and *Lithostrotion* displayed in boxes, two *Cyathophyllum* on small stands, corallites in rock matrix cut to show internal structures, a sample of the fan coral *Gorgonia* (Venus sea fan) and two *Favosite*s representing the Palaeozoic and Recent. A specimen is labelled as *Brachyphyllum*, now listed as a plant fossil. Sponges are illustrated by *Selicothon*, *Siphonia*, *Doryderma*, *Rhabdonema* and *Ventriculites*. Protozoa include large examples of the foraminifera *Nummulites* from Egypt (several almost 6cm across) and China

Sea (0.5cm). Other fossils are the *megalodon* teeth among fish in alcohol and a *Mastodon* tooth next to a modern elephant tooth. A relevant themed display case shows a model of a *Coelacanth*.

The entrance area includes several cases containing samples of Rhynie Chert, ammonites and trilobites, Carboniferous *Sigillaria* and *Protaxites* trunk, trackway from the Permian Hopeman Sandstone Formation, Moray, two additional trackways, bivalves from the Cretaceous Greensand, a slab of Upper Devonian sandstone with fish from Dura Den and an algal stromatolite.

Figure 6: A display of cephalopods comparing modern and fossil specimens
(Zoology Museum, University of Aberdeen)

Meston Science Building (University of Aberdeen Museums)

Collection Type: University

Recognised Collection: 2007

32 Elphinstone Road, University of Aberdeen, Aberdeen, AB24 3EU
Contact: museum@abdn.ac.uk

Location of collections
The University of Aberdeen Collections were founded in 1751 with objects accumulated since through teaching and research activities by staff and students and donations from graduates and friends of the University. It now comprises an estimated 300,000 objects. The entire University of Aberdeen Collection is Recognised by Museums Galleries Scotland as Nationally Significant to Scotland. Fossils are located throughout the Meston Science Building in two basement rooms, a teaching store and displays in department corridors.

Size of collections
12,000 fossils.

Onsite records
Collection information is on a Calm CMS; only part of the fossil collection is documented. MDA cards for the fossils are present in one of the basement rooms. All specimens with numbers belong to the Museum Collection; teaching specimens are not numbered. An online catalogue is available at: https://www.abdn.ac.uk/museums/collections/index.php.

Collection highlights
1. Samples of Rhynie Chert.
2. Invertebrate trace fossils from worldwide, linked to Nigel Trewin (1944-2017).
3. Triassic vertebrate trackways from Moray.
4. Collection of Devonian fish from the north east of Scotland.
5. Miocene vertebrate fossils from the Siwalik Hills, India.
6. Fossils of the Triassic reptile *Stagonolepis*, some linked to James Nicol (1810-1879).
7. Trace fossils, Devonian plants and fossil assemblages from the Pentland Hills, linked to Professor Henry Alleyne Nicholson (1844-1899).
8. Carboniferous shark type material from the Mendips linked to Gordon M Walkden.
9. Carboniferous fossils attributed to John Baird Simpson (1894-1960) and A[dam] W Whyte.
10. Solnhofen fossils linked to Carl Friedrich Häberlein (1787-1871) and/or his son Ernst Häberlein (1819-1886).

Published information (selected)
Aldiss, D.T., and E.J. Edwards. (1999). *The geology of the Falkland Islands*. British Geological Survey Technical Report. WC/99/10.
Benton, M.J. and A.D. Walker. (1985). Palaeoecology, taphonomy, and dating of Permo-Triassic reptiles from Elgin. *Palaeontology*. 28:207-234.
Carroll, S., and N.H. Trewin. (1995). *Cornulatichnus*: a new trace fossil from the Old Red Sandstone of Orkney. *Scottish Journal of Geology*. 31:37-41.
Davidson, R.G., and N.H. Trewin. (2005). Unusual preservation of the internal organs of acanthodian and actinopterygian fish in the Middle Devonian of Scotland. *Scottish Journal of Geology*. 41:129-134.
Fraser, N.C. (1982). A new rhynchocephalian from the British Upper Triassic. *Palaeontology*. 25:109-725.
Fraser, N.C. (1986). New Triassic sphenodontids from south-west England and a review of their classification. *Palaeontology.* 29:165-186.

Fraser, N.C. (1988). The Osteology and Relationships of *Clevosaurus* (Reptilia: Sphenodontida). *Philosophical Transactions of the Royal Society B*. 321(1204):125-178.
Fraser, N.C., and S. Renesto. (2005). Additional drepanosaur elements from the Triassic fissure infills of Cromhall Quarry, England. *Jeffersonia*. 15:1-16.
MacLennan, A.M., and N.H. Trewin. (1989). Palaeoenvironments of the late Bathonian to mid-Callovian in the Inner Moray Firth. In Batten, D.J., and M.C. Keen. (eds.). *Northwest European Micropalaeontology and Palynology*. Chichester: Ellis, Horwood.
Newman, M.J. and N.H. Trewin. (2001). A new jawless vertebrate from the Middle Devonian of Scotland. *Palaeontology*. 44:43-51.
Nicholson, H.A. (1872). Contributions to the study of the errant annelides of the older Palaeozoic rocks. *Proceedings of the Royal Society of London*. 21:288-290.
Ogilvie, S., K. Glennie, and C. Hopkins. (2000). Excursion guide 13: The Permo-Triassic sandstones of Morayshire, Scotland. *Geology Today*. 16:185-190.
Renesto, S., and N.C. Fraser. (2003). Drepanosaurid (Reptilia: Diapsida) remains from a Late Triassic fissure infilling at Cromhall Quarry (Avon, Great Britain). *Journal of Vertebrate Paleontology*. 23:703-705.
Rice, C.M., N.H. Trewin, and L.I. Anderson. (2002). Geological setting of the Early Devonian Rhynie cherts, Aberdeenshire, Scotland: an early terrestrial hot spring system. *Journal of the Geological Society*. 159:203-214.
Trewin, N.H. (1975). *Isopodichnus* in a trace fossil assemblage from the Old Red Sandstone. *Lethaia*. 9:29-37.
Trewin, N.H. (1976). Correlation of the Achanarras and Sandwick Fish Beds, Middle Old Red Sandstone, Scotland. *Scottish Journal of Geology*. 12:205-208.
Trewin, N.H. (1986). Palaeoecology and sedimentology of the Achanarras fish bed of the Middle Old Red Sandstone, Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 77:21-46.
Trewin, N.H. (2000). The ichnogenus Undichna, with examples from the Permian of the Falkland Islands. *Palaeontology*. 43:979-997.
Trewin, N.H. (2013). *Scottish Fossils*. Edinburgh: Dunedin Academic Press.
Trewin, N.H., P.R. Gurr, R.B. Jones, and P. Gavin. (2012). The biota, depositional environment and age of the Old Red Sandstone of the island of Kerrera, Scotland. *Scottish Journal of Geology*. 48:77-90.
Trewin, N.H., and K.J. McNamara. (1994). Arthropods invade the land: trace fossils and palaeoenvironments of the Tumblagooda Sandstone (? late Silurian) of Kalbarri, Western Australia. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh.* 85:177-210.
Trewin, N.H., and S.R. Fayers. (2016). Macro to micro aspects of the plant preservation in the Early Devonian Rhynie cherts, Aberdeenshire, Scotland. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*. 106:67-80.
Trewin, N.H., and H. Kerp. (2017). The Rhynie and Windyfield cherts, Early Devonian, Rhynie, Scotland. In Fraser, N.C., and Sues, H-D. (eds.). *Terrestrial conservation Lagerstätten—windows into the evolution of life on land*. Edinburgh: Dunedin Academic Press.
Walker, A.D. (1961). Triassic reptiles from the Elgin area: *Stagonolepis*, *Dasygnathus* and their allies. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*. 244:103-204.

Collection overview

The collection reflects the research interests of staff throughout the department's history, notably James Nicol (1810-1879), Professor Henry Alleyne Nicholson (1844-1899) and, more recently, Nigel Trewin (1944-2017). There are fossils sampling localities in Scotland, with as many originating from the wider UK and worldwide. The collection includes historic, research and teaching specimens. Accession numbers are written on coloured dots on the specimens: blue dots indicate palaeontological specimens, as opposed to rock (white) or mineral (yellow). Red dots indicate inclusion in what was a former teaching collection displayed in Marischal College until the early 1990s. Some fossils have both blue and red numbers.

Specimens with red dots tend to represent historic localities from around the world, although the ages of some rock units and taxonomic affinities have changed since original description/addition. The collection is organised stratigraphically. Cambrian fossils are *Orthis lenticularis* from the (St Davids-Merioneth) Upper *Lingula* Flags and *Girvanella* from Girvan. Silurian fossils are eurypterids (*Erretopterus*, *Slimonia*, etc) from Logan Water, Lesmahagow, the trace fossil *Skolithos canadensis* from the Stiperstones, Shropshire, *Crossopodia scotica* from the Gala Group of Thornylee, Peebles, various invertebrate fossils from the Much Wenlock Limestone Formation of Shropshire and Dudley, fish remains from the Ludlow Bone Bed, Shropshire, Llandovery Government rock with *Pentamerus* brachiopods, Shropshire, and a *Megalomus* from Elora, Ontario (Canada). Devonian fossils are mostly fish from the north east of Scotland (Tynet Burn, Gamrie) and Fife (Dura Den), and *Parka decipiens* from Canterland Den, Fife. Carboniferous fossils are predominantly of plants (*Annularia*, *Asterophyllum*, *Sphenopteris*, *Cordaites*, *Neuropteris*, *Stigmaria* as examples) from localities including Barnsley and Radstock, with bivalves from the mussel band at Cumnock, relatively large crinoid stems from Roscobie and Chapel, Fife (dated 1907, Fig. 7), brachiopods (notably large productids), and numerous solitary and colonial corals. One cut block of coral reef debris is from the Creek bed, Jefferson County, Illinois. A vertebrate specimen is labelled as the ‘scales of *Palaeoniscus,* a bony fish Burdiehouse Limestone Burntisland, Fife’.

Figure 7: Sections of Carboniferous Crinoid stems from Roscobie, Fife
(Meston Science Building)

Triassic fossils are from the Rhaetian Bone Bed of Aust Cliff, Gloucestershire, with several bone fragments and impressions of the reptile *Stagonolepis* from the Triassic of Moray. A fragment of *Stagonolepis robertsoni* is associated with a fragile label reading ‘J Nicol 1877’ in a glass vial. Jurassic fossils are mainly marine reptiles (vertebrae from ichthyosaurs and a plesiosaur) and a small fish skeleton surrounded by manganese dendrites from the Solnhofen Limestone of Germany. The Cretaceous is represented by invertebrate fossils, notably flint echinoids, various ammonites, inoceramid bivalves and sponges from the Upper Chalk of localities including Bridlington. Fossils from the Cenozoic are invertebrates typical of the Eocene London Clay from the London Basin and Pliocene Coralline Crag from Suffolk, with more unusual fossils of ‘a plant *Cinnamonium*

polymorphyum Oligocene Priessen, Bohemia', radiolarian chert from Abington, and fossil wood from Ghizeh, Antigua and Netluarsuk Waigat Strait, North Greenland. Additional specimens of interest are the Triassic trace fossil described as jellyfish impressions, four Middle Permian *Ullmania* trace fossils from Hilton/Frankenberg, one mentioning Dr F Krantz, Berlin, and an approximately two-metre long framed cast of a eurypterid (figured in Trewin 2013).

The Research collection includes a large amount of variably sized Rhynie and Windyfield Chert samples from Aberdeenshire, collected for the remains of early plants, fungus, lichens and invertebrates in a resistant silicified rock. Labels on the front of drawers containing Windyfield Chert highlight systematic excavation ('Rhynie Research Project, Trench 03/T1 Trewin & Fayers 'Moray Firth' Trench material C.M. Rice Published material') over several years (1997, 2000, 2016, 2017).

Trace fossils are from the Devonian, Permian and Triassic, with many mentioning Nigel Trewin (initials NHT) as the collector and/or co-author on research. Origins include Kerrera, Staffin, Cadh'an Righ, and Brora. There are several Devonian traces (*Siskemia*, *Diplichnus*), including holotype and paratype material of *Isopodichnus stromnessi* from the Stromness Flags of Breck Ness, *Nereites* in turbiditic sediments from the Carboniferous of Cabo de Favaritx, Minorca (Fig. 8), *Lockeia* with burrows of the bivalve *Neomiodon* from the Jurassic Great Estuarine Series of Trotternish, Skye, and traces labelled 'NHT from the M ORS nr Birsay, Orkney, collected with Steve Andrews June 12 2006' with notes describing these as unusual and unique. Fossils of the trace *Cornulatichnus* from Inganess Bay (Kirkwall, Orkney) and Calf Sound (lighthouse, Eday, Orkney) are noted as figured and paratype material. An interesting specimen preserves a drag mark with a *Pterichthyodes* fish at the end, figured in Trewin (1986). Trace fossils from the Silurian are of *Dictyodora* from Thornylee Quarry and *Cardiolites* from Grieston Quarry (both Innerleithen). Permian trace fossils are *Undichna*, *Umfolozia, Longula* and *Siskemia* from localities in the Falkland Islands, such as Sealion Island, Camilla Creek, Fox Bay and Cantera Coast. Trace fossils without visible locality information include *Planolites*, *Diplocraterion*, *Spirodesmos*, *Cochlichnus*, *Haplotichnus*, *Treptichnus*, *Scovenia, Mermia* and additional annelid traces, arthropod resting traces and drag marks. Trackways from the Triassic Hopeman Sandstone Formation of Moray demonstrate diversity comparable to coeval rock units in Germany (Cornberger Sandstein) and Arizona (Coconino Sandstone) (unpublished research by Carol Hopkins).

There is also an extensive collection of Devonian fish mostly attributed to Nigel Trewin and colleagues/students. Lower Devonian fossils include *Parexus* from the Dundee Flagstone Formation of Carmyllie Quarry, Letham, Angus, also the source of arthropods and rare plants. Middle Devonian fossils are *Osteolepis* and *Gyroptychius* from the Sandwick Fish Bed (Cruaday Hill and Orkney generally) and *Dipterus* and numerous *Palaeospondylus* from Achanarras. Upper Devonian fossils are *Asterolepis* from Kingsteps near Nairn and fish from Dura Den. A fish skull bone from Helmsdale is in rock visually more consistent with Devonian, as opposed to Jurassic, outcrops locally and would be worth investigating. Carboniferous fish include *Euphyacanthus*, several *Ctenacanthus* (one from Busbie), *Rhizodus* (teeth and scales) and *Strepsodus* teeth among many others from these and other stratigraphic ages. Permian fossils are of the fish *Palaeoniscum freieslebeni* from the Kupferschiefer of Freisleben, Saxony, Germany, and *Palaeoniscum* from the Marl Slate of Frislington Quarry, County Durham. Labels read '*Palaeoniscus'*, an incorrect spelling introduced some time ago and still widely present in literature and collections.

A cabinet labelled as 'type and figured' contains vertebrate material from Cromhall Quarry, Gloucestershire. This material was not examined by the JEPC, although a literature search found publications on Triassic reptiles from fissure fill deposits, authored by Dr Nick Fraser (National Museums Scotland) and Silvio Renesto (a researcher in northern Italy) among others.

The remainder of the fossil collection is herein described as reference/teaching. Sponges are diverse in comparison to other collections with examples of Ordovician *Astylospongia* (Estonia), Carboniferous *Petraia* (Mulloch Hill), *Fasciculophyllum* (Fife) and *Plocoscyphia* (Folkestone), Jurassic *Gypellia* (Bavaria), Cretaceous *Siphonia*, *Thamnospongia* and *Raphidonema* (the latter

specifically from the Faringdon Sponge gravel), with other localities including Hanover. Bryozoan fossils are also diverse (*Monticulipora*, *Favositella*, *Fascicularia*, *Heteropora* among others) with many held in drawers labelled as 'type'. The source of *Ascodictyo*n specimens is also given as the Hamilton Group of Ontario, with *Ceramopora* from Arkona, Ontario; *Monticullipora* and *Ceramopora* are from the Ordovician of Cincinnati, and a label identifies a specimen from Russia. Corals include the Ordovician *Streptolasma*, many examples from the Silurian Much Wenlock Limestone Formation (*Ptychophyllum* (*Westrogothia*), *Favosites*, *Cyathophyllum* and *Zaphrentis*) Silurian *Goniophyllum* from the Visby Marls of Gotland, Devonian *Pleurodictyum* and *Actinoistroma* from the Koblenz Beds of Gerolstein, Eifel, and Carboniferous *Lithostrotion* (Beith, Bristol, Kendal, Derbyshire) and *Caninia* (Fife). Canada is the source of several corals: *Favosites* from the Silurian Niagara Limestone, *Cystiophyllum* from the Devonian Hamilton Series of Arkona, Ontario and *Diphyphyllum* from the Carboniferous of Wainfleet, Walpole, and Port Colborne, Ontario.

Stromatolites are from the Carboniferous Randerston Limestone of Kingsbarns, Fife, Shark Bay, Australia, and the Pilbura region of Western Australia, dated to 3.5 billion years ago; stromatoporoids are of the Ordovician alga *Nidulites* from Mulloch Hill, Angus. Graptolites are represented by Ordovician *Dicranograptus* and *Climacograptus* from the Hartfell Shale of Dob's Linn, *Dicranograptus* from the Glenkiln Shale at Abington, *Didymograptus* from the Skiddaw Slate of the Lake District, Abereiddy Bay and the Arenig of the Quebec Group of Point Levis and Carlside Edge, Quebec, and Silurian *Monograptus* from Spengill, Sedburgh.

Figure 8: The Carboniferous invertebrate trace fossil *Nereites* from Cabo de Favaritx, Minorca (Meston Science Building)

Brachiopods include representative fossils from most geological periods, for example, productids from the Carboniferous of Scotland, Fife, Bristol, etc, *Rhynchonella* from the Kimmeridge Clay and terebratulids from the Inferior Oolite, Greensand, Chalk and London Clay. Multiple examples of *Leptaena* are from North America and Canada. Bivalves include typical specimens (*Gryphaea*, oysters, inoceramids) from the UK, with labels for *Posidonella* from the Delaware Creek Member (Caney Shale Formation) of Clarita, Coal County, Oaklahoma. Gastropods are also wide ranging with Palaeozoic examples present, such as *Omphalotrochus* from the Silurian of Ironbridge, although greatly exceeded by those from the Mesozoic and Cenozoic (Eocene Barton and

Woolwich beds (*Melania*), Oligocene Headon Beds, Pliocene Coralline and Red Crag) and Recent (*Murex*); one gastropod might be from the Eocene of Verona, Italy, better known for well-preserved vertebrate fossils. Cephalopods are represented by fossil ammonites (noted localities include Burton Bradstock, Charmouth, Whitby and Brora Clay Pit) and nautiloids including *Orthoceras* from the Carboniferous. Trilobite fossils are present in the collection, although difficult to access; those examined include *Elrathia* from the Cambrian Wheeler Shale Formation of Utah, *Ogygia* from the Cambrian (St David's-Merioneth Series) *Lingula* Flags of Builth, *Harpes* from Bohemia, *Calymene* from the Silurian of Dudley and Niagara, *Goldius* from the Silurian of Lochkow, Bohemia, and *Phacops* from the Devonian of Ontario. Other arthropods include *Caryocaris* (phyllocarid crustacean) from the Ordovician Skiddaw Slate.

Vertebrate fossils include the Carboniferous fish *Rhizodus* (notably a specimen showing a large, complete lower jaw with teeth; the visible part of one tooth anteriorly is more than 10cm in length), fish from the Cretaceous of Lebanon, three fish vertebrae one each from the Eocene London Clay, Wealden (Cretaceous) and Red Crag (Pliocene), and a *Dapedius* from the Liassic of Lyme Regis in a wooden frame. A *Leptopteris* from the Solnhofen Limestone has a label mentioning the Häberlein Collection. Carl Friedrich Häberlein (1787-1871) was a doctor in Pappenheim who collected fossils from the Solnhofen Limestone and received an *Archaeopteryx* specimen as payment for medical treatment which he sold with other fossils to the British Museum - the London specimen. His son Ernst Häberlein (1819-1886) was also a collector and in 1877 obtained the second *Archaeopteryx* which became the Munich specimen. Other fossils are a *Plesiosaurus* vertebra with bivalve encrustation from the Liassic of Lyme Regis, two larger vertebrae labelled as *Ichthyosaurus* from Lyme Regis, fragments of an elephant jaw labelled as Siwalik Hills (usually described as being Miocene from India, although deposits are now noted to have a wider stratigraphic (Oligocene-Pleistocene) and geographic (India and Pakistan) range), proximal end of a *Bos* femur from the Pleistocene of Siswan, Chandigarh, India, and mastodon tooth from Myanmar.

Plant fossils (some with green numbers) from the Carboniferous are labelled as *Sigillaria*, *Calamites*, branching plant from Burntisland, Fife, *Lepidodendron* (Midcalder Coal Measures), *Cyclopteris* from Dudley, *Plypterocarpus* (seed of *Neuropteris*) from Roystone, Yorkshire, and a small *Sphenophyllum* from the Westphalian donated by Mr Barnes with a label describing similarities to *Telangium* affine (*Sphenopteris* leaf) from Burdiehouse, Edinburgh. Plants from other levels are of *Salix caprea* (willow) from the Quaternary of Taubach (Thuringia), leaf 'impressions' in travertine from Tivoli near Rome, dicotyledon leaves from Burntisland associated with other calcareous remains in Recent tufa, specimens from Mull, a plant with labels mentioning a Lough Neagh plant bed and Christen Collection, and several samples of possible calcareous cave deposits. A collection of small, often indeterminate/unlabelled plant fragments is attributed to John Baird Simpson (1894-1960).

Parts of the collection are represented by material collected for the assemblages of fossils they contain. For example, there are rocks with brachiopods, bivalves, *Nidulites* and gastropods from the Starfish Bed in the Ordovician Drummock Formation of Girvan (South Threave), and brachiopods from the Charlestown Main Limestone of Bishop Hill, Kinross. Pennsylvanian (Carboniferous) brachiopods, coral, bryozoans and gastropod fossils from Oaklahoma and Texas have a distinct yellow label reading 'Museum of Invertebrate Paleontology The University of Kansas'. There are several specimens of 'stretched/disrupted belemnites', in which tectonic extension produced voids later infilled with white crystalline growth that can be used to determine the direction and amount of extension; although speculative, the JEPC is aware of a locality in France where these can be found. Drawer labels highlight numbered sets of fossils used for teaching. These include parts of cidaroid and euchinoid echinoids (plates, lanterns, spines), Jurassic and Cretaceous *Cidarus*, *Melonechinus*, *Echinus*, *Salenia*, *Holaster*, *Hemicidaris*, *Pygaster*, *Conulus*, *Clypeaster*, etc, and crinoids (complete animals, ossicles, crinoidal limestone), such as the Jurassic *Pentacrinus* and a slab of well-preserved crinoid stems surrounded by reef debris (notably trilobite) from the Devonian of Canadigua, New York State, America. Labels reading 'the nature of the fossil record' suggest some specimens were used for teaching.

Research/collection links

The findings of studies on the Clashach footprints and trackways have only been presented in a limited number of publications (Ogilvie *et al* 2000; Benton and Walker 1985) and collaboration with Carol Hopkins (through Elgin Museum) would ensure the research is available. Fossils of *Stagonolepis* and mammals from the Siwalik Hills could add information to current knowledge.

Blairs Museum

Collection type: Independent

Blairs College, South Deeside Road, Blairs, Aberdeenshire, AB12 5YQ
Contact: curator@blairsmuseum.org.uk

Collection overview
In 2019 the Museum held approximately 20 fossils, all Devonian fish preserved in nodules from Tynet Burn, Moray, attributed to Canon John Kyle (1828-1917). The fossils are part of a larger collection transferred as a loan to National Museums Scotland (approximately 63 fossils). This entry notes the possible movement of the remaining fossils from Blairs Museum to National Museums Scotland, although ownership would remain with the College. Other fossils are of the Carboniferous coral *Lithostrotion* found on the shore at Arbigland (Fig. 9) and an ammonite, bioclastic rock predominantly made of coral (a type of crag?) and serpulid (worm) tubes, all without information, which formed part of a small teaching collection associated with the former Blairs Seminary.

Figure 9: The Carboniferous colonial coral *Lithostrotion* from Arbigland (Blairs Museum)

Detail of the nail-like hyoid bone of the Devonian fish *Homostius milleri*, also known as the *Asterolepis* of Stromness. Rebecca Marr © Stromness Museum

Review of Fossil Collections in Scotland

Highlands and Islands

National Museums Scotland

John Ellerman Foundation

Highlands and Islands

Inverness Museum and Art Gallery (High Life Highland)
Nairn Museum
West Highland Museum (West Highland Museum Trust)
Brora Heritage Centre (Brora Heritage Trust)
Dunrobin Castle Museum
Timespan (Timespan Heritage and Arts Society)
Stromness Museum (Orkney Natural History Society)
Orkney Fossil and Heritage Centre
Shetland Museum and Archives (Shetland Amenity Trust)
Bute Museum (Bute Museum Trust)
Hugh Miller's Birthplace Cottage and Museum (National Trust for Scotland)
Treasures of the Earth
Staffin Dinosaur Museum
Gairloch Museum (Gairloch & District Heritage Company Ltd)

Inverness Museum and Art Gallery (High Life Highland)

Collection type: Local authority (High Life Highland)
Accreditation: 2016

Castle Wynd, Inverness, Highland, IV2 3EB
Contact: inverness.museum@highlifehighland.com

Location of collections
The original museum was built in 1881 using funds raised by the Inverness Scientific Society and Field Club after these organisations took on responsibility for the collections in 1876. Previous locations of the collections were the Inverness Royal Academy and the town hall. The current building on Castle Wynd/Bridge Street dates from 1963 with additions in 1982 (café, new permanent galleries and temporary exhibition space) and 2006. The collection is housed in displays illustrating the geological history of the Scottish Highlands and a basement storeroom.

Size of collections
900-1,000 fossils.

Onsite records
Information is on an Adlib CMS, MDA cards and a Windows 3 notepad list; most of the fossils have entries on Adlib and 75% of these include images.

Collection highlights
1. Fish from the Devonian of north east Scotland.
2. Fossils linked to activities of the Inverness Field Club and its members.
3. Fossils linked to Hugh Miller (1802-1856), William Smith (1830-1907), Thomas Davidson Wallace (1841-1926), William Jolly (-1912), Angus John Beaton (1858-1945), James Fraser (1834-1929) and Charles MacLeod (-1919).
4. JMP de Jonge Cretaceous invertebrates from the Netherlands.

Published information
Faulkner, T. and Brazier, V. (2016). Tufa deposits at Inchrory and Glen Suie, Moray, Scotland. *Cave and Karst Science*. 43:17-20.
Jolly, W. (1870). Notes on the geology of Southerness, Kirkcudbrightshire. *Transactions of the Edinburgh Geological Society*. 1:278-284.
Swanston, W. (1893). The Silicified Wood of Lough Neagh (Concluded). *The Irish Naturalist*. *2*:102-106.

Collection overview
A portion of the fossils are from historic and scientifically important Middle Devonian localities: Tynet Burn (*Cheiracanthus*, *Mesacanthus*, *Diplacanthus*, *Osteolepis*, *Glyptolepis*, *Dipterus*, *Pterichthyodes* and *Coccosteus*, labelled as an equivalent to the Sandwick Fish Bed of Orkney), Edderton, Cromarty (*Dipterus*, *Pterichthyodes*, *Coccosteus*), Nairnside (*Dipterus*, *Coccosteus*, *Osteolepis*, *Glyptolepis*), Kingsteps and Lethen/Lethen Bar (*Osteolepis*, *Holoptychius*, *Asterolepis*, *Bothriolepis*), Eathie (*Gyroptychius*, *Dipterus*, *Cheiracanthus*, *Glyptolepis*, *Coccosteus*), Caithness/Orkney (*Osteolepis*, *Dipterus* and *Coccosteus*, with labelled *Dipterus* from Banniskirk, *Palaeospondylus* from Achanarras, and *Dipterus*, *Pterichthyodes* (Fig. 10), *Mesacanthus* and *Osteolepis* from Cruaday Hill Quarry, Orkney). Among these is a stromatolite from Yesnaby (Orkney). Upper Devonian fossils are from Alves (*Holoptychius*), Oakbrae (*Holoptychius*) and Scaat Craig near Elgin, Moray. Devonian plants include fragments from Achanarras and a *Thursophyton milleri* from the Cromarty fish beds, collected by Christine Matheson in 1990. Some of the above were collected/acquired as recently as 1999, and many have yellow labels, provided in the 1990s during review by SM Andrews. Others can be traced back to a donation in 1834 by Hugh Miller to

George Anderson, the then secretary of the Northern Institute. The collections of the Northern Institute were inherited by Inverness Museum and Art Gallery with re-examination in the 2000s confirming as many as seven fish from the original donation. A large proportion of the collection (50) are fossil fish from Nairnside and Caithness collected by Thomas Davidson Wallace (1841-1926), an honorary curator.

Figure 10: The Middle Devonian placoderm fish *Pterichthyodes milleri* from Eathie, Cromarty (Inverness Museum and Art Gallery)

Material from the Carboniferous is relatively extensive: fragmentary spines of the shark *Gyracanthus*, a complete *Elonichthys* (shark), specimens labelled as coprolites, typical plants (*Lepidodendron* including a specimen with a typed label referring to collector William Smith (1830-1907), a civil engineer on the Highland railway, rather than William 'strata' Smith (1769-1839). The fossils include solitary and colonial corals (*Lonsdaleia*), goniatites and brachiopods, notably several large productids, either isolated or in limestone, from sites along the routes of railway lines across the Highlands; dates provided are for and around the 1870s. A series of small fossils (plants (*Lepidodendron*), corals, brachiopods (*Productus*, *Discina*, *Spirifera*, *Lingula*), bivalves (*Nucula*), trilobites, crinoids (*Cyathocrinus*), bryozoan (*Fenestella*), echinoid plates, gastropods (*Pleurotomaria*, *Euomphalus*, *Belleophon*, *Buccinum*) and fish scales) from localities such as Bathgate in West Lothian, Dalry in Ayrshire and Dunfermline are stuck to small pieces of card with handwritten labels noting William Jolly (-1912) as the collector.

The remainder of the collection is almost entirely post-Palaeozoic. Vertebrate material comprises various shark teeth (Pliocene-Recent *Pterolamiops* tooth; *Acrodus* from Lyme Regis), shark vertebrae and spines from the Greensand, coprolites, mammoth teeth, fragments of a plesiosaur shoulder/pelvic bone from Helmsdale, dinosaur vertebra and Jurassic vertebrae from a fish and ichthyosaur. A bone fragment less than 10cm in length has a label handwritten directly onto the surface reading 'Pachydermata' (Fig. 11), a name given to an order of mammals, now obsolete, and the style suggesting an historic specimen. Invertebrate fossils are of corals (Jurassic *Trochocyathus* and *Isastrea*), brachiopods (small isolated terebratulids and rhynchonellids from the Jurassic), gastropods (Jurassic of Brora), bivalves (*Gryphaea* from Scottish localities (Morven, Isle of Skye,

Lochaline), *Ostrea*, *Plagiostoma*; *Lopha*, *Pecten* from the Oolite (Jurassic) of Brora and an assemblage in a slab from Cromarty), echinoids (*Cidaris*, *Micraster* and notable *Clypeaster* from the Eocene near the Egyptian pyramids), and crinoid ossicles and stems in limestone (one from Broxmouth near Dunbar); the few Palaeozoic invertebrate fossils are trilobites (*Olenellus* from Lyn Quarry, Ledmore, and *Calymene* from the Much Wenlock Limestone Formation, Dudley). Cephalopods include belemnites (some labelled Eathie Beach, Cromarty) and numerous ammonites: *Hildoceras* from the Liassic, *Lituites* collected by William Smith at Eathie (collector information as above), cardioceratids and *Korythoceras* from the Oxfordian of Laig Bay, Eigg, *Ludwigia* from Bearreraig Bay, Isle of Skye (collected by a former president of the Inverness Field Club in 1972) and *Clymonia sedgwicki*. Jurassic fossils from Eathie among other localities are attributed to Charles MacLeod. A rock labelled Hallaig Bay, Raasay, is a conglomerate containing ammonites and bivalves with a second assemblage of bivalves (*Inoceramus* and *Nucula*), gastropods and the ammonite *Euhoplites* and other ammonite fragments from the Lower Cretaceous Greensand. Bivalve and gastropod fossils are presented in several distinct styles, attributed to different collectors. A collection of old white boxes tied with string is labelled with taxon (mostly molluscs), age (Eocene (Bracklesham beds, London Clay), Oligocene, Pliocene, Corallian) and locality (Suffolk, Isle of Wight, Isle of Sheppey, Headon Hill); each has the initials 'JAB' and a date of or around 1888. Further round boxes glued to card are a collection of James Fraser molluscs. A third collection is the labelled Upper Cretaceous invertebrates (*Turritella*, *Ostrea*, *Vola*, *Gonioteuthis*, *Belemnitella*) from the Senonian near Noorbeek and Maastrichtian from Berg en Terblijt, both Zuid Limburg, Netherlands, attributed to JMP de Jonge.

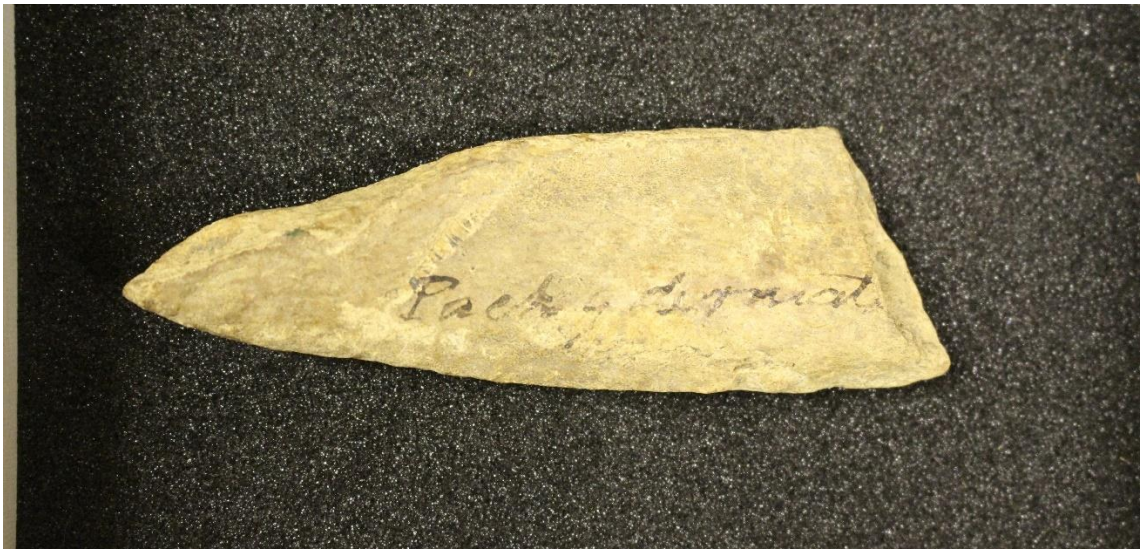

Figure 11: Fragment of bone with a handwritten label reading 'Pachydermata' (Inverness Museum and Art Gallery)

Plant material includes a sample of wood collected by Thomas Davidson Wallace from the submerged forest at Golspie (Jurassic), a large fossil tree trunk from Helmsdale, indeterminate remains from Big Burn near Inverness, Castletown Burn near Nairn and Muckovie Quarry, dated 1877-1880, plant fragments preserved in tufa from Inchrory, Cairngorms (Faulkner and Brazier 2016), and petrified oak from Lough Neagh, Northern Ireland (Swanston 1893).

Research/collection links

There are several interesting plant fossils, notably from Caithness/Sutherland, that could be studied as part of a collaborative project with Timespan and Brora Heritage Centre, where other material is located. It is also not known if the collection includes type and figured specimens; given the origins of several specimens it is likely some are present. It would be worthwhile examining the fossil collection again to determine if such specimens are present and provide a detailed overview for future reference.

Nairn Museum

Collection type: Independent
Accreditation: 2019

Nairn Museum, Viewfield House, Viewfield Drive, Nairn, IV12 4EE
Contact: manager@nairnmuseum.co.uk

Location of collections
Nairn Museum is located in a Georgian mansion house a short distance from the main street, with several exhibition rooms covering topics related to the town and its history. Collections are housed onsite across displays and several storerooms.

Size of collections
200-300 fossils.

Onsite records
Fossils are documented in a paper catalogue with information in an MDA card system. Work is in progress to enter all fossils on to an Adlib Museum Lite database.

Collection highlights
1. Devonian fish from historically and scientifically important localities in the local area.
2. Historical collections, notably the Cawdor Collection.
3. Fossils of the Triassic reptile *Stagonolepis robertsoni* with links to Reverend Dr George Gordon (1801-1893).
4. Miocene fossils from the Siwalik Hills, India, with links to Hugh Falconer (1808-1865).
5. Fossils linked to the founder of the Museum, Dr John Grigor (1814-1886).

Published information
Andrews, S.M. (1982). *The discovery of fossil fishes in Scotland up to 1845*. Edinburgh: Royal Scottish Museum Studies.

Figure 12: The Middle Devonian placoderm fish *Pterichthyodes* showing armour and scales (Nairn Museum)

Collection overview
A reference collection of mostly invertebrate and plant fossils, includes examples of Jurassic ammonites, nautiloids, coral (*Isastrea*), belemnites and bivalves (*Gryphaea,* oysters) and crinoids (*Apiocrinites*, *Pentacrinus*), echinoids from the Cretaceous Chalk and gastropods from the Cenozoic (probably Eocene), which are mostly from localities in southeast England, among other levels. Carboniferous brachiopods (*Spirifer*), crinoids, bivalves and plants (*Lepidodendron*, *Neuropteris*) are more widely sourced with labels for Burntisland, Water of Leith, Kintyre, Clitheroe, Yorkshire, etc.

The larger part of the fossil collection is comprised of fish (Fig. 12) and is assumed to be for scientific study. Approximately 50 Devonian fish (all *Asterolepis*) are from Kingsteps and Clune with the reverse of 'Royal Scottish Museum' labels used by SM Andrews to note which of the robust armour plates is preserved and orientation. The Cawdor Collection comprises approximately 100 Devonian fish from Nairn, Moray and Banff. These were collected in the 1830s by several workers, including William A Stables (?1810-?1890) who is noted as the factor for the Cawdor Estate in 1838. In 1884 part of the collection was donated to Nairn Museum by the 5th Earl of Cawdor; the whereabouts of the other, larger part is not clear. Tightly wrapped fish fossils with laminated labels (taxon, accession numbers) from the Cawdor Collection are likely to be ex-display material. Several boxes, each provided with a list of contents, contain Devonian fish from an unknown collector wrapped loosely in old newspaper (dated 1920s) on which origin is written (Edderton, Gamrie, Lethen, Clune, Cromarty, Caithness); given the localities, these are also likely to have historic/scientific value.

Other vertebrate fossils include a fish from the Eocene Lagerstätte at Monte Bolca, near Verona, Italy, a locality known for its diverse and well-preserved fossils. Several fossils highlight the exchange of material among museums along the Moray Firth. There are 10 fragments of the Triassic reptile *Stagonlepis robertsoni* from the Elgin area, one labelled with the name Reverend Dr George Gordon (a founding member of the Elgin Museum). A vertebrate fragment, labelled as a '*Leptorhynchus gangeticus* muzzle of a lower jaw Siwalik hills India', a crocodile, and part of a second crocodile rostrum (snout), potentially from the same locality, might both be linked to Hugh Falconer (a founder of the Falconer Museum, Forres). The fossils do not have any age details, although they are normally described as Miocene; fossils from the Siwalik Hills were more recently noted to represent a wider interval of time from the Oligocene to Pleistocene and a broader geographic area covering parts of India and Pakistan.

Research/collection links
Potential studies could focus on the Cawdor Collection, investigating the fish taxa and their origin with research into the collection historically and the location of the other part(s). The two vertebrate fragments from the Siwalik Hills, both diagnostic, could add to what is known about the fauna from the locality, with the potential for collaboration with the Falconer Museum and the Natural History Museum, London, and Oxford University Museum of Natural History where large collections of material are held.

West Highland Museum (West Highland Museum Trust)

Collection type: Independent
Accreditation: 2015

Cameron Square, Fort William, PH33 6AJ
Contact: info@westhighlandmuseum.org.uk

Location of collections
The West Highland Museum was founded in 1922 by a local group, led by Hertfordshire-born Victor Hodgson (1875-1929), and constructed in a former branch of the British Linen Bank in 1926 following fundraising. Collections are on display with storage in various cupboards and an attic room.

Size of collections
10-20 fossils.

Onsite records
Information is currently on an Adlib Lite CMS with plans to use Ehive in the future. Fossils were examined recently by Lucy Muir with confirmation/revisions of identifications highlighted on notes associated with relevant specimens.

Collection highlights
1. Fossils from the Scottish islands linked to Alexander Carmichael (1832-1912), the Scottish exciseman, folklorist, antiquarian and author.

Collection overview
Fossils are local: an ammonite from Arisaig, spiral shell found at Achandarroch, Ballachulish, *Gryphaea* from Lochaline, brachiopod without locality, Furid fish (from the taxonomic family: Furidae) found on the east coast of Eigg and block of limestone containing fish fragments. A gastropod, rock, crinoid, bivalve, brachiopod and nodule are listed under one accession number. Samples not on display are labelled as mudstone with ammonites from the Jurassic of Eathie (Cromarty) and a Jurassic shell assemblage from Staffin Beach, Isle of Skye.

Brora Heritage Centre (Brora Heritage Trust)

Collection type: Independent

Coalpit Road, Fascally, Brora, Sutherland, KW9 6LE
Contact: heritagebrora@gmail.com

Location of collections
Fossils are all on display

Size of collections
40-50 fossils.

Onsite records
Object entry forms exist for specimens acquired during the employment of current staff.

Collection highlights
1. Fossils from the local area and historic localities in Sutherland and Caithness.

Collection overview
Fossils were collected from the Jurassic rocks exposed on beaches and in rivers locally. Vertebrates are represented by 7 Devonian fish, one labelled as the placoderm *Pterichthyodes milleri* with fragments of *Osteolepis*, *Glyptolepis* and plates from the head shield of another placoderm, perhaps *Coccosteus*, among others. Invertebrates include orthoconic (straight shelled) nautiloids, internal and external moulds of ammonites, belemnite guard fragments, gastropods, coral (*Isastrea*) and bivalves (*Pholadomya* of various sizes, a *Ctenostreon*, an oyster or *Gryphaea* embedded in rock, a *Plagiostoma* and three examples of *Aequipecten,* (Fig. 13)) from the Jurassic. Plants are represented by a single piece of fossil wood. There are several samples of the Jurassic Brora Coal, used primarily in local industry (salt extraction, brickworks, distillery and woollen mill) rather than in domestic dwellings due to its poor quality and softer consistency than the typical coal from the Carboniferous.

Figure 13: The Jurassic bivalve *Aequipecten* from the Sutherland Coast (Brora Heritage Centre)

Dunrobin Castle Museum

Collection type: Independent

Golspie, Sutherland, KW10 6SF
Contact: info@dunrobincastle.co.uk

Location of collections
The Museum, located in the formal gardens below Dunrobin Castle, was originally built as a summerhouse by William, Earl of Sutherland, with later extension by the 3rd Duke. The Museum is as it was in the Victorian-early 20th century. Fossils in the collection are all on display.

Size of collections
80-100 fossils.

Onsite records
Collections are documented in an index card system and electronic database; information for fossils is present on index cards.

Collection highlights
1. Fossils typical of the geology of Sutherland.
2. Fossils from locally important sites (Clynelish, Brora, Helmsdale).
3. Collection attributed to Sir Humphrey Davy (1778-1829).

Collection overview
The fossils in the Museum reflect the underlying geology of Sutherland and are organised by age (stratigraphically). The first case represents the Devonian with fossils including scales of the fish *Holoptychius* from Dornoch, a slab of Upper Devonian sandstone showing fish from Dura Den, Fife, and a trackway comprising three continuous lines across the surface. Several slabs of sandstone are labelled as 'Ichnites' (an old term used for fossilised footprints) from Tarbatness, dated 1864 and 1865. These are more likely to be sedimentary structures produced in soft sediment under turbulent water (scour marks) and the traces of objects being carried (tool marks).

A wall case labelled as Liassic (Lower Jurassic) contains fossils of ammonites (*Paltchechioceras cf. aplanatum*), bivalves (*Hippopodium*, *Pholadomya* and *Plagiostoma*), belemnites and brachiopods (rhynchonellids), mostly from Dunrobin Bay. A partial fragment of a vertebrate rostrum (snout) labelled as a *Plesiosaurus* has no locality details and is assumed to be from the same area. Rocks of this age represent the Dunrobin Bay Formation/Group (Hettangian-Pliensbachian).

Fossils in a case labelled as Callovian (Upper Jurassic) comprise belemnites (*Cylindroteuthis*), bivalves (*Pholadomya murchinsoni*, *Anisocardia cf. globosa*, *A. tenera*, *Cercomya undulata*, *Pleuromya uniformis, Pinna lanceolota*) and ammonites (*Kosmoceras cf. grossoure*) from localities around Brora (the saltpans, Inverbrora, 'the pit' Brora, and 'the Brickworks' Brora). These probably represent the Brora Brick Clay and other members of the Brora Argillaceous Formation.

The next case is labelled as Oxfordian (Upper Jurassic) with a variety of fossil bivalves (*Chlamys*, *Ctenostreon proboscideum*, *Aequipecten*, *Trigonia*, *Gryphaea*), ammonites (*Euaspidoceras clynelishensis* and indeterminate whorl fragments), gastropods, brachiopods (terebratulid and rhychonellid) and indeterminate fragments. Several fossils are of the plant *Bucklandia milleriana* (Fig. 14) with additional specimens similar in appearance but unlabelled. Many of these specimens have a noted origin of Clynelish Quarry and the light-coloured sediments suggest most are from the Clynelish Quarry Sandstone (Brora Arenaceous Formation), found along the Brora River and previously excavated from quarries to the west of Brora. The Clynelish Quarry Sandstone is

however Callovian (*Quenstedtoceras lamberti* Zone); the cabinet might include fossils from the younger Brora Sandstone, also part of the Brora Arenaceous Formation, which is Oxfordian in age.

Figure 14: The Jurassic plant *Bucklandia milleriana* from Clynelish Quarry (Dunrobin Castle Museum)

The Kimmeridge (Upper Jurassic) is represented by fragments of wood (from Little Ferry Links), plants, ammonites (*Waldheimia* from Port Gower, perisphinctid ammonites from Allt na Cuile), belemnites (*Pachyteuthis abbreviata*; *Cylindroteuthis spicularis* from Wick or Eathie), coral in natural and polished form (*Isastrea oblonga* from Port Gower), brachiopods (*Rhynchonella* from Culgower), echinoids (*Hemicidaris*) and rocks with shell debris. Some of these fossils might be from the Allt na Cuile Sandstone.

Fossils are included in a collection of 67 geological specimens attributed to Sir Humphrey Davy (1778-1829), physicist and chemist. A label in the displays describes the 'Sir Humphrey Davy collection from Sutherland. Made in 1811 and 1812 whilst studying at Dunrobin'.

Research/collection links

A long (more than 70cm), thin triangular-shaped fossil is present that would be worth investigating further. Potential projects might look at the *Bucklandia milleriana* specimens and the origin of the marine reptile fossils. Fossils from the historic Clynelish Quarry are being studied by staff at the Horniman Museum, London, and another project is focusing on a plesiosaur skull.

Timespan (Timespan Heritage and Arts Society)

Collection type: Independent
Accreditation: 2017

Dunrobin Street, Helmsdale, Sutherland, KW8 6JA
Contact: enquiries@timespan.org.uk

Location of collections
Timespan, established in 1986, includes a museum of local history, a café, bakery and shop. The geology and herb gardens in the grounds were set out in 1987. Fossils are on display and in an attic storeroom.

Size of collections
10-20 fossils.

Onsite records
Information is on an Adlib Lite CMS.

Collection highlights
1. Fossils represent the local Devonian and Jurassic, which form part of a SSSI.

Figure 15: Articulated vertebrae of a Jurassic marine reptile from Crakaig, Sutherland (Timespan)

Collection overview
Fossils onsite tend to be of Jurassic age and local origin: fossil wood ranging from trunks to fragmentary pieces, variably sized samples of the coral *Isastrea* in natural and polished form, limestone and mudstone lithologies with water-worn fossils (ammonites, bivalves, etc), ammonites from Clynelish and belemnites (isolated and in matrix) from local beaches. Vertebrate fossils include examples of ichthyosaur vertebrae, one a short, articulated section collected by Michael Dudgeon in 1995 at Crakaig, Loth (Fig. 15), an ichthyosaur caudal vertebra found on the beach at Helmsdale by

David Cowrie in 2017, and an indeterminate small, light brown-coloured bone no more than 15cm in length (Fig. 16). Many fossils are attributed to Margaret Davidson and dated 1987, such as a Jurassic ammonite from Helmsdale beach, a section of fossilised tree trunk cut and polished to show rings, and two samples of the Jurassic coral *Isastrea*. A box containing 20 fish fossils (*Osteolepis*, *Dipterus,* etc) has distinct square labels noting origins of Weydale and Achanarras. Some or all of these were acquired/donated as recently as 2017.

Research/collection links

The small, brown bone could be investigated further to determine identification, origin and context. A potential project could focus on the palaeoecology of the fossils and how life and the environment changed through time, for example, using the structure displayed in Dunrobin Castle Museum; this could be undertaken as a collaboration with Brora Heritage Centre and Dunrobin Castle.

Figure 16: A small bone from the Jurassic of Sutherland (Timespan)

Stromness Museum (Orkney Natural History Society)

Collection type: Independent
Accreditation: 2019

52 Alfred Street, Stromness, Orkney, KW16 3DH
Email: custodian@stromnessmuseum.org.uk

Location of collections
The Orkney Natural History Society was founded in 1837 and the Stromness Museum set up to house their collection. Originally located at 110 Victoria Street, it moved to Flett's Commercial Hotel in 1852 and an upper floor in the new town hall before finally moving to the current building in 1862. The lower floor and adjacent Pilot House were incorporated into the Museum at later dates. Fossils are on display and stored in cupboards and a small store in the office area.

Size of collections
100-200 fossils.

Onsite records
Information is in an Adlib CMS and the Museum's minute books. Fossils are included in an online catalogue at: https://www.stromnessmuseum.org.uk/collections.

Collection highlights
1. Devonian fish from the north east of Scotland.
2. Fossils linked to Reverend Charles Clouston (1800-1884, first president of the Society) and Hugh Miller (1802-1856).
3. Material potentially linked to various explorers with local connections, such as Captain James Cook (1728-1779), Dr John Rae (1813-1893), Dr William Balfour Baikie (1824-1864) and the Victorian naturalist George Ellison (1862-1941).

Published information
Lang, W.H. (1927). XIX. Contributions to the study of the Old Red Sandstone Flora of Scotland. VI. On *Zosterophyllum myretonianum*, Penh., and some other plant-remains from the Carmyllie Beds of the Lower Old Red Sandstone. VII. On a Specimen of *Pseudosporochnus* from the Stromness Beds. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 55:443-455.
Miller, H. (1849). *Foot-prints of the Creator or the Asterolepis of Stromness.* Edinburgh: Johnstone and Hunter.
Flett, J.S. (1900). XIII. The Old Red Sandstone of the Orkneys. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 39:383-424.

Collection overview
A large part of the collection is from the Devonian of Orkney, Shetland, Caithness and Sutherland. Fish are diverse with Middle Devonian fossils of *Dipterus*, *Osteolepis*, *Pentlandia*, *Coccosteus*, *Cheiracanthus*, *Diplacanthus*, *Pterichthyodes*, *Cheiracanthus*, *Diplacanthus*, *Gyroptychius Dickosteus*, *Tristichopterus*, *Cheirolepis*, *Microbrachius*, *Glyptolepis*, *Homostius* and *Diploterus*. Interesting specimens are the lower jaw of a *Thursius* collected by Dr Grant from Stromness, a large complete *Coccosteus*, a partial hyoid bone from Westray, and a near complete *Pterichthyodes* overlain by a complete *Osteolepis* or similar. A complete and well-preserved hyoid bone on display is labelled as a 'Thurso *Asterolepis*' (Fig. 17). Origins include the quarries at Bookan and Gairsty (Sandwick), and Cruaday Hill, West Shore, Furso, Deerness and Point of Ness in the vicinity of Stromness on Mainland, Orkney. A 'nail'-shaped fish bone (Fig. 18) labelled as *Homostius milleri* is referred to, but not the figured specimen, in *Footprints of the Creator* (Miller 1849). A fossil fish with a label reading 'Fossilised fresh-water fish found in Cruaday Quarry, Sandwick, Orkney and

identified by Dr. Douglas Simpson, librarian of King's College, University of Aberdeen, to be of the species Diplopterus aggassizi and to belong to the so-called Lower Old Red Sandstone period…. It was given to me by John Spence, Esq., Hyval, Sandwick, Orkney. Jas. L. Hibbert, 3 Sept. 1961' might be a specimen mentioned in Flett (1900). Plant fossils include samples of *Calamophyton* (Du[nrisdale] Quarry), *Thursophyton* and indeterminate fragments (Quoyloo, Glebe Quarry and Lyking around Sandwick, among other localities) with a fossil of *Pseudosporochnus* from Lyking, Sandwick, labelled as being presented by James Robertson in 1828, appearing in a publication by Lang (1927). Other fossils are the coprolites from various sources, several blocks of stromatolite from West Shore, Stromness, collected by David Fergusson, and a large tree fossil from Inganess Bay, donated by Tom Muir from Kirkwall.

Figure 17: Hyoid bone of a Devonian fish labelled as 'Thurso *Asterolepis*' (Stromness Museum)

The remaining part of the collection comprises fossils from outwith Scotland: *Didymograptus* from localities including Llanvirn (Pembrokeshire) and two *Ogygia* trilobites from the Ordovician, coral *Omphyma* from the Much Wenlock Limestone Formation and an orthoconic nautiloid from the Silurian, the coral *Pachypora* from the Devonian of Torquay, examples of the plants *Lepidodendron*, *Stigmaria*, *Calamites*, and *Neuropteris*, the brachiopod *Spirifer* and two crinoid fragments from the Carboniferous. The Jurassic is represented by the bivalve *Pecten*, echinoid *Cidaris* and brachiopod *Terebratula*. Cretaceous fossils are a sponge in flint from Salisbury, *Raphidonema* from the Faringdon Sponge Gravel, a belemnite, isolated echinoderm spine (perhaps *Cidaris*) and fossil wood from Australia. Cenozoic fossils are an Eocene leaf, a large *Ostrea* from the Eocene Barton Beds with a gastropod *Clavella* probably from the same source, and three *Carcharodon* teeth. Other fossils include Jurassic plesiosaur vertebrae (3 articulated), an ichthyosaur jaw from Wilmcote (near Stratford on Avon), horse teeth from the Neolithic of Meols, Cheshire, and an *Equus* bone from the Neolithic of Leasowe, Cheshire. The Cowan Collection is a random set of fossils, such as graptolites and *Gryphaea* with rocks samples, not from the local area.

Research/collection links

It is assumed that many of the Devonian fish fossils have been examined for scientific study in the past, although only one of the specimens on display is known to be mentioned in a publication, the

Homostius milleri fish bone in *Foot-prints of the Creator* (Miller 1849). Additional historic and scientific links could be investigated in a broader project to re-examine the Stromness collection of Devonian fish and similar material in other collections across Scotland. Some of the fish are interesting in terms of their preservation, such as the two overlapping fish and the large *Coccosteus*. An investigation of the mammal fossils from Cheshire could determine how they came to be in the collection.

Figure 18: The nail-shaped hyoid bone of the Lower Devonian fish *Homostius milleri* (Stromness Museum). Rebecca Marr © Stromness Museum

Orkney Fossil and Heritage Centre

Collection type: Independent

Viewforth, Burray, Orkney, KW17 2SY
Contact: info@orkneyfossilcentre.co.uk

Location of collections
The visitor centre, located in 19th century farm buildings, was opened in 1993 to display objects in the collection of Leslie Firth (1933-2013), a local builder, and his father. In 2000, Leslie Firth gifted the Centre to the community and it became a registered charity. Display space was extended in 2012/13 to house an exhibition on the Churchill Barriers with the *Scapa and the Scuttle* exhibition added in 2019. Fossil fish are also exhibited in the Centre; Leslie Firth was the owner of the Cruaday Quarry, Sandwick, a source of Devonian fish well-known for fossils as far back as the mid 1700s, in which he developed an interest. Fossils are all onsite in displays and stores.

Size of collections
500 fossils in the Museum collection with an additional undocumented collection of local fossil fish.

Onsite records
Information, including notes and comments at the time of entry, in an Excel spreadsheet file is in the process of being transcribed into a Collectibles Organizer Deluxe database with the potential to include images and provide online access in the future.

Collection highlights
1. Range of fossil fish from the Devonian of north east Scotland.
2. Examples of fossils from well-known localities around the world.

Collection overview
Fossils from Scotland are mostly fish from the Devonian, displayed by group. These are lungfish (*Dipterus* from Achanarras and Murkle Bay, Caithness, and Cruaday, Orkney; *Pentlandia* from South Ronaldsay), placoderms (*Coccosteus* and *Pterichthyodes* from Cruaday; *Microbrachius* from South Ronaldsay; *Millerosteus*), acanthodians (*Diplacanthus*, *Mesacanthus* and *Cheirocanthus* from Cruaday; acanthodian from Cromarty), lobe-finned crossopterygians (*Gyroptychius*, *Tristichopterus* and *Osteolepis* from Cruaday; *Thursius* from Murkle Bay; *Glyptolepis* from Achanarras on loan from National Museums Scotland; *Gyroptychius* from Caithness; *Osteolepis* from the Spittal Beds, Caithness) and ray-finned actinopterygians (*Cheirolepis* from Cruaday; *Palaeospondylus* from Achanarras). A number of large slabs of rock show accumulations of several types of fish (*Cheiracanthus*, *Osteolepis*, *Gyroptychius*, *Coccosteus*, *Mesacanthus* and *Diplacanthus*), often with more than one example of each. Devonian material includes fossil worm burrows, stromatolites, plants (*Cooksonia*), indeterminate plant debris from the Devonian of Orkney, and an interesting specimen of a plant preserved with an *Osteolepis*. Other fish are the Silurian jawless fishes (*Thelodus*, *Birkenia* and *Lasanius,* almost certainly from Lesmahagow, Lanarkshire, or Muirkirk, Ayrshire), and *Rhizodus* scales from the Carboniferous Oil Shale of Bathgate, West Lothian. A fossil labelled ‘Hillside Sept 1893’ (but no age) appears to be a sarcopterygian fish shoulder element, which should be investigated. Non-Devonian Scottish fossils are the Cambrian Pipe Rock from Sutherland, Carboniferous rugose corals from East Lothian and algal limestone from Fife collected by William J Baird 1984, and a large slab of Permian sandstone labelled as Elgin, Moray, showing a reptile trackway. Examples of the shrimp *Tealliocaris* are likely to be from the Gullane Shrimp Bed in the Lower Carboniferous Oil Shale Group of East Lothian. Fossils of the eurypterids *Erretopterus* and *Slimonia* and the arthropod *Ceratiocaris* are from the Silurian Lesmahagow Inlier, with the arthropod *Dictyocaris* more specifically from Dunside on Logan Water.

Other fossils onsite are from outwith Scotland. Vertebrates are represented by a *Carcharodon* tooth from Belgium, complete fish in nodules from the Cretaceous Santana Formation of Brazil, a squashed vertebra from the Jurassic of Wyoming labelled *Diplodocus*, a Jurassic coprolite, two dinosaur eggs from the Cretaceous of the Gobi Desert, Mongolia, several Permian coprolites, Permian amphibian (*Apateon*), and large casts of the Permian *Sclerocephalus*, Jurassic ichthyosaur *Stenopterygius* and marine crocodile *Steneosaurus*. Fossils from the Eocene Green River Formation of Wyoming are of the fish *Knightia*, *Gosiutichthys*, *Priscacara*, *Diplomystus* and *Miplosus* with *Leptolepis* representing the Jurassic Solnhofen Limestone. Fossils of the fish *Anthracosteus* and *Amia* from the Eocene Messel of Germany have been set in Perspex. A skeleton of the fish *Amblypterus* from Odernheim, Germany is accompanied by a Permian reptile, *Micromelerpeton*, from the same locality. Another fossil is labelled as 'the larval phase of a large amphibian of the group *Eryops*', the taxon *Eryops* being a semi-aquatic temnospondyl. Mammal fossils include a woolly rhino limb bone, *Mammuthus* (woolly mammoth) tooth, *Palaeoloxodon* ('forest elephant') tooth, third indeterminate tooth, mammoth tusk, and other vertebrae and limb fragments from the Thames Gravel deposits which might be associated with a mammoth tooth and woolly Rhino bone. Miscellaneous material includes shark teeth (*Edestes*) from the coal measures of Illinois and a fragment of vertebrate (mammal or reptile) skull.

Figure 19: Plant fragments from the Carboniferous of Piesburg, Germany
(Orkney Fossil and Heritage Centre)

Invertebrates include the graptolite *Didymograptus* from the Ordovician of Abereidy Bay, Wales, brachiopods (Devonian *Cyrtospirifer* from Belgium; *Stringocephalus* from the Devonian of Germany), bivalves (*Trigonia* from the Cretaceous of Belgium), gastropods, sponges, coral (*Favosites* from the Much Wenlock Limestone Formation of Shropshire and brain coral from the Eifel region, Germany) and echinoderms (crinoids *Eucrinus* from the Triassic of Germany and *Palaeocrinus* from the Jurassic of Dorset; Jurassic brittle star *Ophioderma* from Dorset; echinoids *Micraster*, *Echinocorys* and *Clypeus* from the Jurassic Inferior Oolite and/or Chalk). Trilobites are from the Cambrian of Utah (*Asaphiscus*, *Peronopsis*), Ordovician of the Welsh Borderlands (*Ogyginus* from Builth Wells, *Ogygiocarella* from Shropshire), and Devonian of Morocco and France (*Phacops*). Miscellaneous specimens are a Carboniferous jellyfish and arthropods such as ants,

flies and moths in amber/copal, the lobster *Mechochirus*, shrimp *Aeger*, crab-like *Eryon* and *Mesolimilus* from the Solnhofen Limestone, and crabs *Cyclocancer* and *Coeloma* from the Oligocene of Belgium. Cephalopods are from the Ordovician of Sweden (*Lituites*), Devonian of Morocco (goniatites and nautiloid *Orthoceras*) and Germany (*Cyrtoceras*), non. loc. Triassic (*Cenoceras*), the Jurassic of Germany (*Dactylioceras*, *Salpingoteuthis, Lesueurilla*), Yorkshire (*Phylloceras*), Lincolnshire (*Eparietes*, *Asteroceras*), Dorset (*Ludwigia*, *Pictonia, Promicroceras*, *Epaspidoceras*, *Nautilus*), Somerset (large nautiloid) and Isle of Skye (*Belemnites*, *Megateuthis*), and Cretaceous of Kazakhstan (*Belemnitella*), France (*Anahoplites*, *Douvilleiceras*) and Japan (*Yubariceras*, *Mesopuzosia*). Specimens without locality are the Jurassic *Harpoceras*, *Dactylioceras*, *Hildoceras*, *Androgynoceras*, *Kosmoceras* and *Parkinsonia*.

Plant fossils are mostly Carboniferous: several *Lepidodendron*, 'tree fern' from Warwickshire, *Neuropteris*, *Imparipteris* frond and additional fragments from Piesberg, Germany (Fig. 19), *Neuropteris* and *Annularia/Asterophyllum*, *Neuropteris* from Wigan, and *Bothrodendrum* and *Lepidostrobus* from Crock Hay, Wigan, among others. Other material includes polished sections of cedar, oak and pine, five samples from Madagascar and a section of trunk in a shale that might be Jurassic. Several other fragments are perhaps from the Permian of Germany.

The Centre also houses an extensive collection of fish (perhaps one hundred) from the Devonian of Orkney. Most are complete and at least moderately articulated and, though not labelled, could be identified relatively easily.

Research/collection links

Some of the specimens would be worth investigating further, notably the vertebrate fossil described as similar to *Eryops*. *Lasanius*, *Birkenia* and *Thelodus* are rare fossils known from a very limited number of specimens; there is interest in studying examples of these and a visit was made to the Dick Institute, Kilmarnock, by a researcher at the University of Manchester to see examples there. The fossil labelled 'Hillside Sept 1893' might be important historically.

Shetland Museum and Archives (Shetland Amenity Trust)

Collection type: Local authority (Shetland Amenity Trust)
Accreditation: 2019

Hay's Dock, Lerwick, Shetland, ZE1 0WP
Contact: info@shetlandmuseumandarchives.org.uk

Location of collections
The current Museum opened in 2007, bringing together the museum and archive collections. Fossils are included in displays on local geology with an offsite facility and shipping container for storage several miles away.

Size of collections
50 fossils.

Onsite records
Information for the fossils is on a Calm CMS.

Collection highlights
1. Fossils from Shetland localities.

Published information
Beardmore, S. R. In Review. Shifting continents and a Devonian Lake full of fish: the extraordinary geology of the Shetland UNESCO Global Geopark. Geoconservation Research Special Issue.
Finlay T.M, A.S. Woodward and E.I. White. (1926). XII.—The Old Red Sandstone of Shetland. Part I. South-Eastern Area. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh.* 54:553-572.
Hooker J.D (1853). Note on the fossil plants from the Shetlands. *Quarterly Journal of the Geological Society of London*. 9: 49-50.
Newman M.J, and J.L. Den Blaauwen. (2018). A redescription of the endemic antiarch placoderm *Asterolepis thule* from the Middle Devonian (Givetian) of Shetland and its biostratigraphical horizon. *Scottish Journal of Geology*. 54:69-75.
Peach, B.N. (1877). Notes on the fossil plants found in the Old Red Sandstone of Shetland, Orkney, Caithness, Sutherland and Forfarshire. *Edinburgh Geological Society*. 3:148-152.
Traquair, R.H. (1908). On fossil fish remains from the Old Red Sandstone of Shetland. *Transactions of the Royal Society of Edinburgh*. 46: 321-329.
Watson, D.M.S. (1932). On three new species of fish from the Old Red Sandstone of Orkney and Shetland. *Memoirs of the Geological Survey of Great Britain, Summary of Progress for 1931*. 2:157-165.
Watson, D.M.S. (1934). Report of fossil fish from Sandness, Shetland. *Memoirs of the Geological Survey of Great Britain, Summary of Progress for 1933.* 1:74-76.
Westoll, T.S. (1937). The Old Red Sandstone fishes of the north of Scotland, particularly of Orkney and Shetland. *Proceedings of the Geologists' Association.* 48:13-45.
Woodward, A.S., and E.I. White. (1926). The fossil fishes of the Old Red Sandstone of the Shetland Islands. *Transactions of the Royal Society of Edinburgh: Earth Sciences*. 54:567–571.

Collection overview
Most of the fossils are from Shetland with a strong focus on specimens from the Devonian, one of the few/only fossil bearing levels present. Fish include labelled specimens of *Dipterus*, *Pentlandia*, *Osteolepis*, *Tristichopteris* and *Stegotrachelus*, some identified tentatively, with numerous fragments not identified beyond 'fish' likely to represent these and a wider range of taxa. An important locality is the Exnaboe fish beds (Shingly Geo) at the southern end of Shetland. Exnaboe is the type locality for *Stegotrachelos finlayi* with examples also collected from the Ness of Sound (Woodward and

White 1926; Swartz 2009). Several large (30cm across) associated fossil fragments with an unusually bubbled surface texture are labelled as the Devonian fish *Coccosteus* (perhaps the head, plates of the anterior body and segments of the front fins), although they could equally represent a large eurypterid (the head, body tergites and segments of the clawed chelicerate appendages) (Fig. 20). Plant fossils from the Devonian are also diverse with fragments from Footabrough, Fair Isle (*Dawsonites*), Grutness, North Voe and Huxter. Additional specimens have labels for '*Corduroy* plant' (fragments of stem that are typically 10-15cm across with a distinct striped appearance), *Hostimella* from Leebitton, and *Svalbardia scotica* from the Middle Devonian of Buness, Fair Isle (collected by a palaeobotanist from Bristol University). The Devonian fossils include an example of worm burrows.

Figure 20: Fragments with unusual surface texture labelled as the Devonian placoderm fish *Coccosteus* (Shetland Museum and Archives)

Also present are specimens of crinoidal limestone (Zoar, Hillswick), a fossil shell (Arisdale, Yell) and trace fossil without locality information. A Pleistocene Icelandic clam was collected during dredging. Not from Shetland are a shark tooth and coral *Favosites* with a note stating the identification was provided by Nigel Trewin. Other fossils comprise mixed invertebrate and plant material: ammonites, flint echinoids, brachiopod, *Stigmaria*, belemnites and indeterminate fossil fragments in black or grey limestone matrix. A box of Jurassic fossils includes ammonites (some cut and polished), belemnite fragments, bivalves, brachiopods (several rhynchonellids) and a colonial Carboniferous coral. These are presumably for handling/education with several additional fossils as part of an 'activity desk' in the Museum.

Research/collection links

Potential projects could focus on the Devonian plants and/or trace fossils from Shetland. Further investigation of the large associated pieces labelled as *Coccosteus* is also suggested to confirm identification and origin.

Bute Museum (Bute Museum Trust)

Collection type: Independent
Accreditation: 2016

Stuart Street, Rothesay, Isle of Bute
Contact: info@butemuseum.gmail.com

Location of collections
The Buteshire Natural History Society was founded in 1905 and the current building, purpose-built by the 4th Marquis of Bute, used to house the collection from 1927. In 1992 ownership of the Museum and the collection transferred to the Bute Museum Trust. The collection is housed onsite in displays.

Size of collections
30-50 fossils.

Onsite records
Not known.

Collection highlights
1. Fossils from the Isle of Bute.
2. Arctic clay fossils.

Collection overview
Fossils are from rocks exposed on the Isle of Bute. There is a single fossil from the Devonian, labelled as a fish operculum. Carboniferous fossils are entirely of plants: *Lepidodendron*, *Stigmaria*, *Cordaites*, *Sphenopteris*, *Annularia* and additional specimens labelled as a conelet of clubmoss, leaf stem and leaf litter. Bivalves and gastropods from the Clyde Beds (Clyde Clay Formation), an Arctic clay, are labelled *Astarte sulcata*, *Saxicava rugosa*, *S. norvegica*, *Tellina bathica*, *Cyprina islandica*, *Mya truncate* and *Natica* with additional shells in a display on the origin of the clay deposits. The molluscs in the Clyde Beds are normally indicative of cold water and their occurrence across Bute and the Clyde area is an indication of a cooler climate 10,000 to 12,000 years ago (end of the last Ice Age).

Research/collection links
The fish operculum could be investigated further to confirm identity and origin.

Hugh Miller's Birthplace Cottage and Museum (National Trust for Scotland)

Collection type: Independent
Accreditation: 2016

Church Street, Cromarty, Ross-shire, IV11 8XA
Contact: BalnainHouse@nts.org.uk (Regional Office)

Location of collections
Hugh Miller's Birthplace Cottage and Museum comprises a thatched cottage built in the early 1700s, where Miller was born, and the adjacent Georgian villa, built by his father in 1797. Fossils illustrating local geology are located in both buildings, although the main displays and storage are in the latter.

Size of collections
200-250 fossils.

Onsite records
All fossils have an accession number and object entry form (stored offsite); a Microsoft Excel list was provided by the JEPC to the Museum for future reference.

Collection highlights
1. Fossils linked to Hugh Miller (1802-1853).
2. Several fossils have been figured, notably by Hugh Miller.

Published information
Anderson, L.I. (2005). Hugh Miller: introducing palaeobotany to a wider audience. In: Bowden, A.J, C.V. Burek, and R. Wilding. (eds.). *History of palaeobotany: selected essays. Geological Society, London, Special Publications.* 241:63-84.
Egerton, P.G. (1860). Palichthyologic Notes: No.12. Remarks on the Nomenclature of the Devonian Fishes. *Quarterly Journal of the Geological Society*. 16:119-136.
Miller, H. (1858). *The cruise of the Betsey*; with Rambles of a Geologist'. Edinburgh: Constable.
Miller, H. (1857). *The testimony of the rocks: or, Geology in its bearings on the two theologies, natural and revealed* (Vol. 1). Edinburgh: Shepherd and Elliot.
Miller, H. (1864). *Edinburgh and Its Neighbourhood, Geological and Historical: With the Geology of the Bass Rock*. Edinburgh: Adam and Charles Black.
Miller, H. (1849). *Foot-prints of the Creator or the Asterolepis of Stromness.* Edinburgh: Johnstone and Hunter.
Miller, H. (1859). *Sketch-book of popular geology*. Edinburgh: Constable.
Miller, H. (1841). *The old red sandstone: or, New walks in an old field*. Edinburgh: Johnstone
Taylor, M.A. (2002). Hugh Miller and his fossils - a bicentenary appreciation. *Edinburgh Geologist*. 38:10-19.

Collection overview
The collection comprises a range of fossils from the local area and across the UK. Vertebrates include Lower, Middle and Upper Devonian fish: *Cephalaspis* headshield, *Dipterus, Cheirolepis*, *Pterichthoydes*, *Osteolepis*, *Diplacanthus*, *Mesacanthus*, *Cheiracanthus*, *Coccosteus*, *Palaeospondylus* (donated in 2002 by G Matheson), *Glyptolepis*, *Holoptychius*, *Asterolepis* and acanthodians, from Cromarty (Edderton), Angus, Lethen Bar (Nairn) and Caithness, among other localities. Some of the specimens are preserved in split nodules with part and counterpart pieces (*Glyptopteris*, *Pterichthyodes*, *Diplacanthus*, *Cheiracanthus*). Several specimens of *Coccosteus* from Edderton and *Pterichthyodes* have old labels identifying them as part of Hugh Miller's private collection. Many of the fossil taxa are associated with reconstructions. A plaster cast of a *Coccosteus* cranial buckler from the Middle Devonian of Cromarty, perhaps painted by Hugh Miller

and with an additional label ‘8’, is figured in Egerton (1860). A large cast is of the head of a *Homostius milleri* from the Devonian Spittal Flagstones of Spittal Quarry, Caithness, dated 1886 and representing the first cast from the original. Other vertebrates are various shark teeth, marine reptile bones (vertebrae and ribs), and the tooth and anterior part of a *Rhizodus* jaw from the Carboniferous.

Figure 21: The Lower Devonian alga *Parka decipiens* (Hugh Miller’s Birthplace Cottage and Museum)

Invertebrates include the trilobites *Elrathia* from the Cambrian of Utah, an *Ogygiocarella* or similar in dark mudstone and ‘*Phacops caudatus*’ (= *Dalmanites caudatus*) from the Ledbury tunnel, the sponge *Raphidonema* (from the Cretaceous Faringdon sponge gravels), a rugose coral, *Isastrea* coral from the Upper Jurassic of Helmsdale, Sutherland, *Paraconularia* (taxon thought to be related to Cnidaria, although still under discussion), brachiopods (terebratulids from the Cretaceous Chalk), gastropods, crinoids (including a stem and articulated calyx, and three specimens showing small disarticulated ossicles and sections of articulated stems preserved three-dimensionally in a sandy rock), echinoids (*Micraster*) and various bivalves (inoceramids, *Gryphaea*, *Plagiostoma*, *Pecten* and oysters, including a ‘*Lima gigantea* Oolite near Broadford Skye Sept 1868’ and oyster from Cajamarca, Peru). There are several samples of Much Wenlock Limestone Formation containing invertebrate coral reef debris. A box is labelled as insects in amber, although the specimens seem to be in more recent copal. Cephalopods are represented by fragments of isolated and disarticulated belemnite guards from the local area and Germany, nautiloids, ammonites such as *Hildoceras* from the Liassic of Whitby*, Dactylioceras*, *Amoeboceras* from Eathie, and other fragments labelled as Eathie, an ammonite impression with label reading ‘Col Miller private collection Eathie, Cromarty, 184[]’ (no final number given), and another ‘am altemans von Buck Eathie’. Several specimens are labelled as death assemblages of ammonites killed by an underwater landslide resulting from an earthquake on the Great Glen Fault 165 million years ago (Eathie, Cromarty), a dramatic origin. A box of approximately 25 small ammonites was donated by Nigel Trewin.

Plant fossils are of *Stigmaria* including one with ‘rootlets’ attached, *Pinities*, *Neuropteris*, and various indeterminate fragments of trunk, ferns (figured), bark impression, and plant root with scale-like patterns. Labels highlight 45 million-year-old (Tertiary) dawn redwood (*Metasequoia*) leaves from

British Columbia, Canada, a section of 135 million-year-old fossil wood from the Kimmeridge (Upper Jurassic) of Helmsdale, Sutherland, 'Bonnyrigg coal pit L.C.M. April 3 1869', '*Sphenopteris* aff. Burdiehouse Limestone Coal measures Dec 1868' and a root of a fossil tree from Bonnyrigg. A further specimen has a label reading 'Edinburgh Museum for Science and Art Natural History No. 82'. Fragments of the Devonian algae *Parka decipiens* are also present (Fig. 21). There are two plaster casts of seed cones, one painted and the other figured. Anderson (2005) figures conifer branches from Eathie Haven, Cromarty.

Specimens provided for handling are Devonian fish (acanthodians, *Osteolepis, Dipterus and Coccosteus*, several of the latter donated by Nigel Trewin) from Eathie, Cromarty, isolated shark teeth, a 160 million-year-old shark tooth (labelled as the great White shark *Carcharocles*, although the age given is too old be this particular taxon), tooth from the Atacama Desert, Peru, and a complete fish in a light-coloured matrix potentially from Lebanon. More unusual is a cave bear tooth from Romania, tortoise egg from the Pleistocene of France and a coprolite. The windowsills of the thatched cottage also hold fossils of Carboniferous plants (*Stigmaria*), ammonites, belemnites, bivalves, corals, Devonian fish (acanthodians) and rocks showing assemblages of ammonites and bivalves, many from the local area.

Research/collection links

Fossil material in displays is on loan from National Museums Scotland, including among others a specimen of the bivalve *Scrobicularia piperata* figured in Taylor (2002) and a specimen of the plant *Cladophlebis denticulata* figured by Hugh Miller (1857).

Treasures of the Earth

Collection type: Independent

Corpach, Fort William, PH33 7JL
Contact: info@treaseuresoftheearth.co.uk

Location of collections
Treasures of the Earth is a private collection founded in 1990 by a father and son interested in geology. The building is a former church with displays on the ground and balcony levels. The fossils are all on display.

Size of collections
30-50 fossils.

Onsite records
Not known.

Collection highlights
1. Examples of fossils from well-known and historic localities worldwide.

Collection overview
The fossils are from well-known sources across Scotland, the UK and worldwide: pterosaur *Pterodactylus* from the Jurassic Solnhofen Limestone of Germany, coprolites dated to 180 million years ago, a complete juvenile *Ichthyosaurus communis* from Lyme Regis, Dorset, a fish from the Cretaceous Santana Formation of Brazil, several shark teeth, and the skulls of a *Smilodon*, *Mesochippus* and *Merycoidodon gracilis* from South Dakota. Several slabs from the Eocene Green River Formation of Wyoming show recognisable fish (*Knightia, Diplomystus*, *Priscacara*) and rays (*Xiphotrygon*), although only examples of *Knightia* are labelled. Casts are of a Devonian placoderm fish, a large fish from Brazil, *Tyrannosaurus rex* skull and a mosasaur skull.

Invertebrate fossils are the Carboniferous arachnid from the West Midlands dated to 300 million years ago, dragonfly from the Family Aeshnidiidae from the Solnhofen Limestone and tar with the beetle *Cybister* from McKithirt Pits, California, dated to 75,000 years ago. Cephalopods are represented by the ammonites *Harpoceras*, *Ludwigia*, *Ranenia*, *Dactylioceras* and *Amoeboceras* collected from the Isle of Skye, large *Titanites* ammonite, and additional ammonites and nautiloids from Morocco. Other fossils are an articulated crinoid calyx and stem, a polished slab from Morocco containing orthoconic nautiloids (labelled as belemnites), sand dollars (echinoids) and trilobites from Morocco (*Elrathia*, *Asaphus*, *Crotacephalina*, *Metacanthina*, *Cyphaspis*, *Zlichoraspis*, *Ceratarges*, *Ogyginus* and *Ductina* with other phacopids). A block from Scotland contains numerous *Gryphaea* and is perhaps from the Jurassic Broadford beds of the Isle of Skye.

Plants include *Lepidodendron*, a single specimen with fragments of leaves, conifer cone and seeds, mostly from the Carboniferous, an *Araucaria* pine seed cone from the Jurassic of Patagonia and a piece of amber. There are pieces of fossil wood, including several trunk sections more than 50cm across, from Washington state and Arizona. Other large samples are described as logs of stone from Portland Down, Dorset.

Staffin Dinosaur Museum

Collection type: Independent

Eillishadder, Culnacnoc, Portree, IV51 9JE, Isle of Skye
Contact: dugaldross@aol.com

Location of collections
The collection was established in 1976 by Dugald Ross, a local crofter, following the discovery of dinosaur bones and trace fossils locally in Jurassic rocks. The collection is displayed and stored in the single room of a croft house on the Trotternish Peninsula.

Size of collections
40-50 fossils.

Onsite records
Provenance of fossils is documented in paper records.

Collection highlights
1. Fossil material from the Middle Jurassic.
2. First evidence of, and the first actual bones of, dinosaurs in Scotland.
3. *Stegosaurus* specimen predating all other fossils of the taxon known to science by 5 million years.

Published information
Andrews, J.E., and J.D. Hudson. (1984). First Jurassic dinosaur footprint from Scotland. *Scottish Journal of Geology*. 20:129-134.
Barrett, P.M. (2006). A sauropod dinosaur tooth from the Middle Jurassic of Skye, Scotland. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*. 97:25-29.
Clark, N.D.L. (2001). Dinosaur tracks, helicopters, and broken bones. *The Geological Curator.* 7:163-166.
Clark, N.D.L., J.D. Boyd, R.J. Dixon, and D.A. Ross. (1995). The first Middle Jurassic dinosaur from Scotland: a cetiosaurid? (Sauropoda) from the Bathonian of the Isle of Skye. *Scottish Journal of Geology.* 31:171-176.
Clark, N.D.L., P. Booth, C. Booth, and D.A. Ross. (2004). Dinosaur footprints from the Duntulm Formation (Bathonian, Jurassic) of the Isle of Skye. *Scottish Journal of Geology*. 40:13-21.
dePolo, P.E., S.L. Brusatte, T.J. Challands, D. Foffa, D.A. Ross, M. Wilkinson, and H.Y. Yi. (2018). A sauropod-dominated tracksite from Rubha nam Brathairean (Brothers' Point), Isle of Skye, Scotland. *Scottish Journal of Geology*. 54:1-12.
Panciroli, E., R.B. Benson, and R.J. Butler. (2018). New partial dentaries of amphitheriid mammal *Palaeoxonodon ooliticus* from Scotland, and posterior dentary morphology in early cladotherians. *Acta Palaeontologica Polonica*. 63:197-206

Collection overview
The fossils are all Jurassic in age and almost entirely from the Isle of Skye, the exceptions being from the Jurassic of Eathie (Cromarty) and Helmsdale (Sutherland). Many footprint and track fossils, often overprinted by mudcracks and/or ripple marks, have been collected as large slabs of sedimentary rock or as casts from annual excavations. Sources are nearby (Valtos, Kilt Rock) with examples being a replica *Megalosaurus* trackway (found Staffin Bay 2001, original left in situ), prints from an unidentified carnivore found in 2002 at Valtos, tracks from a juvenile *Coelophysis* (in a yellow-coloured matrix) found in 2018 at Valtos, three more prints from north of Kilt Rock in 2002 with one labelled as *Coelophysis*, a hadrosaur footprint found in 1982, and a large track with adult and juvenile prints among the examples present. Invertebrate traces have also been collected, such as the worm burrows from Elgol.

Figure 22: Fin spine of the Jurassic shark *Hybodus* from the Isle of Skye (Staffin Dinosaur Museum)

Vertebrate body fossils include a *Stegosaurus* ulna and radius, *Cetiosaurus* tail vertebra, replica of a *Cetiosaurus* femur, teeth (plesiosaur, dinosaur) and original and replica dinosaur tail vertebra. A dorsal fin spine from the shark *Hybodus* (Fig. 22), approximately 15cm in length, originated from the Bathonian of Culnacnoc. A replica of the end of a dinosaur bone and an original section of a long bone found in 1994 are labelled as *Cetiosaurus*; this is the first recorded dinosaur fossil from Scotland. An unusual fossil is the impression of an articulated ichthyosaur jaw with teeth.

Fossils are otherwise mostly cephalopods and bivalves from the Jurassic, many comprising part and counterpart specimens revealed in split nodules: *Stephanoceras*, *Ludwigia*, *Kosmoceras*, *Emilaea* and *Dorsetensia* from Bearreraig, Rigg and Flodigarry; some are labelled as Oxford Clay Beds. Nautiloids include coiled and orthoconic forms, with a large example of the latter, measuring more than 50cm, supported in matrix. Belemnites are preserved as isolated guards and cross sections, with a cluster in rock from Eathie and others identified as *Cylindroteuthis* and *Megateuthis*. Bivalves are represented by several *Gryphaea*, oysters and *Plagiostoma*. Other fossils are assemblages of bivalves and ammonites in matrix, a gastropod, Jurassic coral from Helmsdale, fossil wood of various sizes and a single leaf imprint.

Research/collection links

Work to find, document and publish the various fossils is ongoing and has already helped to recreate the landscape of the area in the Middle Jurassic. The fossils are being studied in a collaboration of staff and researchers at the University of Glasgow, University of Edinburgh and National Museums Scotland.

Gairloch Museum (Gairloch & District Heritage Company Ltd)

Collection type: Independent
Accreditation: 2016

Gairloch, Ross-shire, IV21 2BH
Contact: info@gairlochmuseum.org

Location of collections
Gairloch Museum opened in 1977 to house the growing collection of objects donated by local people. In 2019 the Museum moved to its present location on the main road through Gairloch. Collections are housed onsite in displays and a storeroom.

Size of collections
5 fossils.

Onsite records
Information is in an Adlib CMS.

Collection overview
There are examples of the Jurassic bivalve *Gryphaea* onsite, although their origin is not known. It is possible that they were eroded from the Jurassic rocks on the Isle of Skye and washed to a beach near Gairloch where they were collected. A block of Cambrian Pipe Rock, showing the infilled traces of worm burrows on a beach 550 million years ago, is on display (Fig. 23).

Figure 23: Invertebrate burrows in basal Cambrian Pipe Rock (Gairloch Museum)

Detail of the Lower Devonian jawless, armoured fish *Cephalaspis* from Balruddery Den.

Review of Fossil Collections in Scotland

Tayside, Central and Fife

National Museums Scotland

John Ellerman Foundation

Tayside, Central and Fife

Stirling Smith Art Gallery and Museum
Perth Museum and Art Gallery (Culture Perth and Kinross)
The McManus: Dundee's Art Gallery and Museum (Leisure and Culture Dundee)
Broughty Castle (Leisure and Culture Dundee)
D'Arcy Thompson Zoology Museum and University Herbarium (University of Dundee Museum Collections)
Montrose Museum (Angus Alive)
Museums of the University of St Andrews
Fife Collections Centre (Fife Cultural Trust)
St Andrews Museum (Fife Cultural Trust)
Kirkcaldy Galleries (Fife Cultural Trust)
Falkirk Collections Centre (Falkirk Community Trust)

Stirling Smith Art Gallery and Museum

Collection type: Independent
Accreditation: 2016

Dumbarton Road, Stirling, FK8 2KR
Contact: museum@smithartgalleryandmuseums.co.uk

Location of collections
The Smith Art Gallery and Museum, formerly known as the Smith Institute, was established at the bequest of artist Thomas Stuart Smith (1815-1869) on land supplied by the Burgh of Stirling. The Institute opened in 1874. Fossils are housed onsite in one of several storerooms.

Size of collections
700 fossils.

Onsite records
The CMS has recently been updated to Adlib (Axiel Collection); all fossils have a basic entry with additional details on MDA cards.

Collection highlights
1. Fossils linked to Robert Kidston (1852-1924).
2. Silurian graptolite fossils linked to Professor Henry Alleyne Nicholson (1844-1899).
3. Dura Den fossils linked to Reverend John Anderson (1796-1864).

Published information
Traquair, R.H. (1900). XXXII.—Report on Fossil Fishes collected by the Geological Survey of Scotland in the Silurian Rocks of the South of Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 39:827-864.
Woodward, A.S. (1900). Reviews - Dr. Traquair on Silurian fishes. Report on fossil fishes collected by the geological survey of Scotland in the Silurian rocks of the south of Scotland. By Ramsay H. Traquair, MD (Doctoral dissertation, LL. D., FRS). Earth and Environmental Science Transactions of the Royal Society of Edinburgh. 39:827-864. *Geological Magazine* 7(2):66-72.

Collection overview
Fossils are mixed in with geological specimens with a good proportion reflecting local geology, notably the Carboniferous rocks around Stirling (Sauchie, Bannockburn, Dollar, Dunblane, Ballengeich), the border with Perth and Kinross (Blairingone) and Fife (Roscobie, St Andrews); labels also refer to Midlothian localities such as Calder Hall. Carboniferous specimens include plants (*Lepidodendron*, *Equisetum, Alethopteris, Neuropteris, Calamites, Pinnularia, Stigmaria, Asterophyllites*), corals, various fish elements (notably teeth of *Rhizodus,* either isolated or in rock, and a possible rib), brachiopods (productids and spiriferids), bivalves, crinoids and gastropods (*Euomphalus*); many have the further stratigraphic detail 'Calciferous Sandstone Series' (Lower Carboniferous). Additional fossils include a *Cyathophyllum* coral from Bristol and limestone with shell fragments from Columbia County, New York.

Other stratigraphic levels are represented. Graptolites are from the Ordovician (with labels for Dumfriesshire (Dumfries and Galloway) suggesting Dob's Linn), Garple (East Ayrshire) and the Rocky Mountains, Canada; a graptolite specimen is attributed to Professor Henry Alleyne Nicholson. A label highlights *Eozoon canadensis,* describing it as one of the oldest forms of life, now considered a pseudofossil. The Devonian is represented by the fish *Dipterus* and *Palaeospondylus* from Achanarras, scales of *Holoptychius* from the Upper Devonian of Dura Den (handwritten label mentioning John Anderson), a fish labelled '*L. spinosa* Traq D.S.M. Ayrshire' (*Lanarkia spinosa* perhaps mentioned in a publication by AS Woodward) (Fig. 24), and Devonian worm tubes from

Pendreich. A *Holoptychius* in a dark-coloured matrix has an origin of Gilmerton (Carboniferous). Other fossils include bone, potentially fragments of fish jaw, rib or shoulder. Jurassic fossils are represented by ammonites from the Liassic (*Phylloceras* and *Hildoceras* from Whitby), Inferior Oolite, Oxford Clay and other unspecified levels, such as a *Dactylioceras*, with examples of bivalves (*Gryphaea*, inoceramids), brachiopods (rhynchonellids from the Oolite of Gloucestershire) and belemnites. One belemnite from the Middle Oolite of Whitby shows preservation of an ink sac. There is also a large coprolite in dark mudstone labelled 'Wealdon Oolite S England', with the Cretaceous age confirmed in a label on a second specimen. Cretaceous fossils are mostly echinoids (*Micraster* and *Diodema*), brachiopods, ammonites (*Hoplites* from the Gault), *Turritella* gastropod from the 'Aptian Malta', fossils from the Chalk and shark teeth from the Gault (Dover, Cambridge).

Cenozoic fossils include a bivalve from the 'Tertiary Malta', *Nummulites* from the Eocene at Southampton, Eocene gastropods and bivalves from the London Clay, and shark teeth from the Coral Rag. Material labelled 'Post Glacial Fossils' comprises bivalves (*Ostrea*, *Cardium*), gastropods (*Puroura*, *Belenus*) and trace fossils (*Teredo* bivalve burrows) from Bridge of Allan, distinct in their storage in old, white cardboard trays and/or affixed to wooden boards; some labels refer to the Brick Clay. There are Quaternary fossils from the Devensian loess of Guernsey (dated 1869) and a Moa limb bone from New Zealand. Other geological periods are represented by orthoconic nautiloids, trilobites, ophiuroids, a reptile tooth and fossil wood, etc.

Research/collection links

Vertebrate fossils in black muds from the Carboniferous could be investigated to determine/confirm their identity and context. Fossils in the post-glacial/brick clay sediments from Bridge of Allan and fossils from the Carboniferous are attributed to Robert Kidston and have found use both at the time of collection and, more recently, in climatic studies.

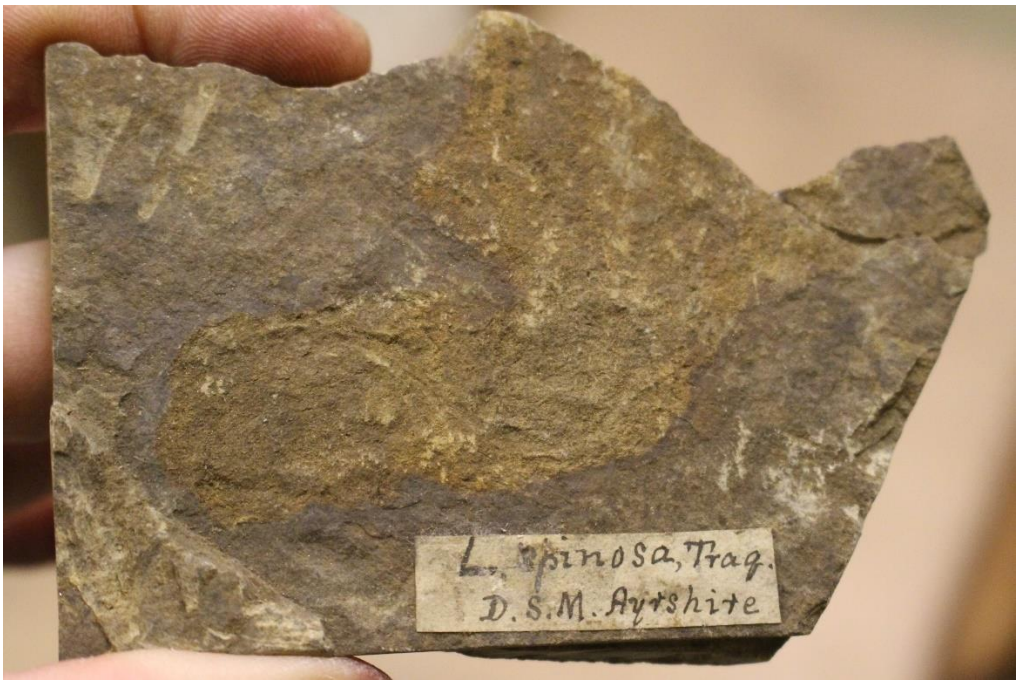

Figure 24: The Devonian jawless thelodont fish *Lanarkia spinosa* from Ayrshire (Stirling Smith Art Gallery and Museum)

Perth Museum and Art Gallery (Culture Perth and Kinross)

Collection type: Local authority (Culture Perth and Kinross)
Accreditation: 2019
Recognised Collection: 2007

78 George St, Perth, PH1 5LB
Contact: museum@culturepk.org.uk

Location of collections
The collection was initiated by the Perthshire Society for Natural Science (PSNS) and housed in a museum on Tay Street, from 1881. It was moved to the present-day Perth Museum and Art Gallery in 1935. The Museum holds the Glenalmond Collection, transferred from Trinity College in 1987 and 2010, and the collection of the Marshall Museum, Kinross, transferred in the 1980s. Both collections include fossils among other geological and natural science specimens. The entire collection of Culture Perth and Kinross is Recognised under the Museums Galleries Scotland Recognition Scheme as a Nationally Significant Collection. The collection includes fossils located onsite in displays and stored in dedicated storage areas.

Size of collections
1,890-2,000 fossils.

Onsite records
Information is in an Adlib CMS, which includes entries for all fossils. Recent labels associated with mainly fish fossils suggest review and identification by SM Andrews (National Museums Scotland) and others. An online collection database also includes fossils: https://www.culturepk.org.uk/museums-galleries/collections/.

Collection highlights
1. Lower Devonian fossils from Fife and Tayside.
2. Fossils from Balruddery Den.
3. Fossils linked to Reverend Hugh Mitchell (1822-1894), Walter McNicoll (1827-1908), Robert Dunlop (1848-1921), Robert Kidston (1852-1924), James B Corr (1855-1931), Peter MacNair (1868-1929) and William Graham-Smith (c1912-2002).
4. Pleistocene invertebrate and vertebrate fossils from the Errol Clay Formation from Tayside.
5. Type specimens of the Devonian fish *Securiaspis waterstoni* and *S. caledonica*.

Published information
Batchelor, R.A., and R.E. Garton. (2013). An occurrence of *Palaeohelcura tridactyla* in the Arbuthnott–Garvock Group, Lower Devonian, at Friarton Quarry, Perth. *Scottish Journal of Geology*. 49:149-152.
Davidson, C.F. (1932). The Arctic clay of Errol, Perthshire. *Transactions and Proceedings of the Perthshire Society of Natural Science*. 9:55-68.
Dawson, J.W.M. (1890). On Certain Devonian Plants from Scotland. *Nature*. 41:537.
Graham, D.K., and D.M. Gregory. (1981). A revision of CF Davidson's Arctic fauna from Inchcoonans Claypit, Errol, held by the Museum and Art Gallery, Perth. *Scottish Journal of Geology*. 17:215-222.
MacNair, P. (1908). *The Geology and Scenery of the Grampians and the Valley of Strathmore (Vol. 2)*. Glasgow: James MacLehose and Sons.
Macgregor, M. (1916). A Jurassic Shore Line. *Transactions of the Geological Society of Glasgow*. 16:75-85.
Kidston, R. (1893). On the Occurrence of Arthostigma Gracile, Dawson, in the Lower Old Red Sandstone of Perthshire. *Proceedings of the Royal Physical Society of Edinburgh*. 12:102-111.

Reid, J., W. Graham, and P. Macnair. (1898). VII. *Parka decipiens*, its Origin, Affinities, and Distribution. *Transactions of the Geological Society of Glasgow*. 11:105-121.
White, E.I. (1963). Notes on *Pteraspis mitchelli* and its associated fauna. *Transactions of the Edinburgh Geological Society*. 19:306-322.

Figure 25: The lobe-finned Upper Devonian fish *Holoptychius* from Dura Den, Fife (Perth Museum and Art Gallery) © Courtesy of Perth Museum & Art Gallery, Perth & Kinross Council

Collection overview

The fossil collection includes 350 specimens of plants, eurypterids, fish and mammals from the Devonian, Carboniferous and Pleistocene of Angus, Perthshire and Fife, a collection considered to be important by palaeontologists studying the localities and fossils following numerous loans for research purposes. For example, Lower Devonian fossils include the rare *Homostius*, *Pteraspis mitchelli* and the type and figured specimens of two species of *Securiaspis* from Bridge of Allan (White 1963). Material from the Lower Devonian of Balruddery Den, preserving a range of invertebrate, vertebrate and plant fossils, is extensive and otherwise present only in the National Museums Scotland and The McManus: Dundee's Art Gallery and Museum collections. The fish are especially important for their diversity and range with examples of *Cephalaspis*, *Mesacanthus* and *Parexus*; a fossil labelled as *Homocanthus arcatus,* now known to be *Vermicomacanthus,* is perhaps from the same locality.

Localities such as Farnell, Turin Hill and Tealing are the source of numerous acanthodians, such as *Climatius*, *Mesacanthus*, *Acanthodes*, *Ichnacanthus* and *Brachyacanthus*. Eurypterids from the Lower Devonian are labelled as *Pterygotus anglicus* (one with the date 1890 collected by James B Corr) and *Erretopterus*, with examples from Tealing attributed to Walter McNicoll (1827-1908) and from Lesmahagow (Silurian) to Peter MacNair (1868-1929); a further name is W Graham-Smith, probably William Graham-Smith (c1912-2002), a researcher at the University Museum of Zoology Cambridge. There is a trace fossil of the Devonian scorpion *Palaeohelcura tridactyla* from Friarton Quarry (Batchelor and Garton, 2013). Plants include *Rhynia* from the Rhynie Chert (with 'Ex Glenalmond Coll' labels and dates of 1926), primitive plants *Zoosterophyllum* and *Psilophyton* from

Myreton, Callander, Hill of Fass (Caithness) and Canada (dated 1898) and the alga *Parka decipiens* from Farnell, some of which are figured (MacNair 1908). Indeterminate plant fragments were collected on several PSNS excursions, dated to 1894 and 1900, with localities including Millhaugh. Fossils are also attributed to Reverend Hugh Mitchell (fossils from Farnell), Robert Kidston (*Psilophyton* from Earn Quarry, Callander, with a date of 1898), James Reid (House of Allan, Blairgowrie, whose fossils were studied by Dawson and Geikie) and William Baird (Lower Devonian plants from Little Glenshee, donated 1991).

The Middle Devonian is represented almost entirely by fish including *Dipterus*, *Mesacanthus*, *Dickosteu*s and *Coccosteus* from Thurso, some donated by Mr McKillop or labelled Ex Glenalmond Collection. Specimens of *Osteolepis* are from the Sandwick Fish Bed and Cruaday Hill, Orkney, *Glyptolepis*, *Pterichthyodes*, *Dipterus* and *Coccosteus* are from Achanarras and a *Thursius* is from Skennet (Caithness). Labels for *Gyroptychius* from Orkney show the names Mrs Christie and Reverend V Slater-Stone with *Dipterus* from the Eday Flags of Deerness, Orkney, labelled J Coates and dated 1906; examples of *Pentlandia*, *Osteolepis* and *Tristichopterus* are from the same locality. There are examples of the conchostracan brachiopod '*Estheria' membranacea* from Thurso. Several fish from Achanarras and examples of '*Estheria'* are attributed to James Reid with dates of around 1895. The identification of some fish fossils has been revised/updated relatively recently by Michael Newman and SM Andrews. Labels highlight information added by Michael A Taylor, former Senior Curator of Natural Sciences at Perth Museum and Art Gallery; further identification, review and documentation was undertaken by Anne Abernethy (former Assistant Keeper of Natural Sciences). Upper Devonian fossils are mainly *Holoptychius* from Dura Den (Fig. 25), many linked to Robert Dunlop and the British Association excavation at the locality in 1915, and a quarry at Glenearn, Perthshire.

Carboniferous fossils are primarily plants: *Neuropteris*, *Alethopteris* (including Calderbrook dated 1886), *Pecopteris* (several from Baillieston), *Annularia*, *Calamites*, *Sphenopteri*s (Burdiehouse), *Lepidostrobus*, *Lepidodendron* frond, *Lepidodendron* bark and *Stigmaria*, several of which are attributed to Robert Kidston. Invertebrate fossils include brachiopods (*Gigantoproductus* from Renfrewshire), bivalves (*Mytilus*, *Nucula*, *Pinna*, *Ctenodonta*), trilobites (*Phillipsia* from Pitscottie, Fife), gastropods (*Bellerophon* and *Pleurotomaria* from Dunfermline and Roscobie, *Loxonema*), crinoid fragments, *Dentalium* from Dunfermline and *Tealliocaris* shrimps from Cheese Bay, Gullane. Invertebrate fossils, notably from Woodmill and Dunfermline, are attributed to Robert Dunlop (1848-1921). Vertebrates include *Megalichthys* from Burdiehouse (one specimen without locality is attributed to Col Ogilvie of Rarmaguzion), *Rhizodus* from Gilmerton, spines from the acanthodian *Gyracanthus* (Hamilton, Lanarkshire) and various shark teeth from localities including Campsie. Two drawers contain 'Carboniferous fossils from Dron. Rev D. Hugh Mitchell'; most fossils are indeterminate although one is labelled as the bivalve *Modiolus*.

Devensian (Pleistocene) fossils from the Errol Clay were collected entirely by Professor CF Davidson. The material includes the bivalves *Hiatella*, *Musculus*, *Pecten*, *Palliolum*, *Portlandia* and *Saxicava*, the gastropod *Lunatia* and brittle star *Ophiolepis*. Most of the collection is cited and/or figured by Graham and Gregory (1981) with a very rare bone of the seal *Phoca vitulina* figured by Davidson (1932). The Clyde beds (Clyde Clay Formation) are represented by the bivalves *Chlamys* and *Arctica*, barnacles and gastropods from localities such as Balnakailly Bay, Bute.

The remaining collection is primarily from localities outwith Scotland. Graptolites are from the Cambrian of Pembrokeshire and Shropshire (Shineton Shales) and Ordovician of Westmorland, Wales and the Welsh Borderlands (notably the Onny Valley). Also represented are trilobites (*Calymene* from Cumberland, trinucleid trilobites), tentaculitids, the trilobite trackway *Cruziana* and brachiopods (*Lingula* and *Lingullela* from North Wales). Hand specimens of Silurian Much Wenlock Limestone from the Welsh Borders and Wren's Nest, Dudley, show fragmentary corals (*Halysites*), brachiopods (*Salopina*, *Leptaena*, *Athyris*, *Atrypa*, *Strophonella*, pentamerids), trilobites (*Calymene*, *Encrinurus*) and gastropods (*Poleumita*). The Carboniferous is represented by corals (solitary and colonial types in limestone, such as *Lithostrotion* from Shropshire, *Zaphrentis* and *Dibunophyllum*

from Ribblesdale), brachiopods (*Chonetes*, *Productus* and *Rhynchonella* from Staffordshire among other localities), plants and bivalves (*Anthracosia* and *Dunbarella* from Fenton near Stoke-on-Trent). More unusual is the fusilinid foraminifera from Nassfield Pass, Karnisch Alps, Austria.

Triassic fossils are limited but include a large *Ceratodus* (lungfish) tooth from the Rhaetian (Fig. 26), a phylloceratid cephalopod from the Halstatt Limestone of Austria and the cast of a Triassic *Cheirotherium* trackway from the Wirral. Fossils from several stages of the Jurassic (Lias, Inferior Oolite from Oxfordshire and Gloucestershire, Oxford Clay, etc) are mostly invertebrate with examples of belemnites, nautiloids, ammonites (many from Whitby and Dorset), bivalves (*Pholaydomya*, *Plagiostoma*, *Gryphaea*, *Modiola, Myacites*, *Trigonia*), brachiopods (*Terebratula*, *Rhynchonella*, *Goniathyris*) and smaller numbers of corals (*Montlivaltia* from the Jurassic of Cheltenham), echinoids (*Clypeus*) and gastropods (*Nerinea*), crinoids and trace fossils. Vertebrate specimens include several isolated vertebrae, an ichthyosaur humerus from Dorset, part of a marine reptile rostrum (snout) from Whitby, a specimen of 3-4 articulated *Plesiosaurus* vertebra (noted as figured, perhaps by MacGregor), *Plesiosaurus* vertebrae from Whitby, two examples of teeth from the shark *Acrodus*, and a ganoid fish from Robin Hood's Bay. Several drawers contain the associated fragments of rib and shoulder bones of a vertebrate from the Oxford Clay near Peterborough dated 1902. A complete *Stenopterygius quadriscissus* ichthyosaur is a cast of a specimen in the Glasgow Museums collection. The Greensand (Cretaceous) is represented by sponges from Blackdown, Devon, and Faringdon Sponge Gravels, echinoids (*Salenia*), brachiopods (*Rhynchonella*), bivalves (*Girvillia*), the crab *Palaeocorystes*, isolated vertebra, teeth of *Saurocephalus* (sword-eel fish) and conical teeth described as ichthyosaur. Fossils from the Gault include well preserved ammonites (some irregularly coiled). Chalk fossils are mostly belemnite fragments, and echinoids (*Micraster*) from Cambridge, Kent, north of Dublin and France, with the fish *Beryx ornatus* from Lewes (label mentioning Brighton Museum) and a *Ptychodus* tooth from Kent.

Figure 26: Tooth-plate of the Triassic lungfish *Ceratodus latissimus* (Perth Museum and Art Gallery)

Eocene fossils are the well-preserved fish *Leptolepis* from Lebanon or Green River Formation, shark teeth, a fish from the Isle of Sheppey, a fish labelled as an ex-Beirut Museum specimen from the Tertiary (Cenozoic) of Syria and Tertiary fish teeth from Otago, New Zealand. A 19th century

cast is labelled as an Eocene bird by Fric (natural history dealer Vaclav Fric of Prague, 1839-1916). Red Crag fossils (assigned to the Pleistocene and Pliocene on labels) are the gastropods *Purpura*, *Trophon*, *Turritella*, *Murex*, *Natica*, *Tellin*, *Artemis* and *Buccinum*, and bivalves *Littorina*, *Unio*, *Cardium* from Suffolk, *Bithynia* from Cambridgeshire. Vertebrates from the Pleistocene are represented by teeth of the sharks *Lamna* and *Oxyrhina*, tooth of a woolly rhinoceros from Kent, several smoothed vertebrae and antlers, and lower jaw of a red deer. Another large tooth transferred from the osteological collection is likely to be a mastodon tooth. Two large vertebrae, found in Cambridgeshire in 1892, are labelled as *Ichthyosaurus* reworked from the Greensand into the Red Crag.

Research/collection links

Investigation of Lower Devonian fossils (fish, eurypterids, plants, etc) from localities in the Forfar area (Turin Hill, Tillywhandland, Farnell, etc) is suggested, mainly to clarify their origin - Turin Hill is used to describe several localities in the area - and study the palaeoecosystem, with the potential for collaboration with other collections holding material from the same area (The McManus: Dundee's Art Gallery and Museum, for example).

The McManus: Dundee's Art Gallery and Museum (Leisure and Culture Dundee)

Collection type: Local authority (Leisure and Culture Dundee)
Accreditation: 2017

Albert Square, Meadowside, Dundee, DD1 1DA
Contact: themcmanus@leisureandculturedundee.com

Location of collections
The Museum is located in the Albert Hall, designed by Sir George Gilbert Scott and commissioned in honour of Prince Albert. It opened in 1867 as the Albert Institute with the Victoria Galleries added in 1889. Extensive renovation took place between 2006 and 2009 and the Museum re-opened in February 2010. Stored collections are located in The McManus Collections Unit in Barrack Street.

Size of collections
2,500 fossils.

Onsite records
Information is present electronically in a KE EMu CMS and on paper in MDA and other card indexes, accession registers, daybook, object entry forms and annual reports. Drives to document information occurred in the 1800s and 1970s; specimens collected before the former date are listed as "ex-collections" or "old Museum Collections".

Collection highlights
1. Fossils from important Devonian localities: Rhynie Chert, Turin Hill, Clashbenny, Balruddery Den and Whitehouse Den.
2. Fossils forming the Kinnaird Collection, obtained from land belonging to Lord Kinnaird (George Kinnaird the 9th Lord Kinnaird, 1807-1878) in the 1800s.
3. Collections attributed to George Stewart Graham-Smith (1875-1950) and William Graham-Smith (c1912-2002).
4. Fossils linked to Reverend John Anderson (1796-1864), Walter McNicoll (1827-1908), James B Corr (1855-1931) and David S Henderson (-2005).
5. A series of bronze models (upright *Iguanodon*, sauropod with tail on ground, *Glyptodont*, elephant, ice age mammal, etc) likely to have scientific and/or historic importance.

Published information
Agassiz, L. (1844–1845). *Monographie de poissons fossiles des Vieux Gres Rouges ou Systeme Dévonien (Old Red Sandstone) des Îles Britanniques et de Russie.* Neuchâtel: Soleure, chez Jent and Gassmann.
Graham-Smith, W. (1938). *The environment, growth and evolution of some Old Red Sandstone fishes.* Unpublished Doctoral dissertation, University of Cambridge.
Huxley, T.H. and J.W. Salter. (1859). On the anatomy and affinities of the genus *Pterygotus* (by Huxley) and description of new species of *Pterygotus* (by Salter). *Memoirs of the Geological Survey of the United Kingdom Monograph.* 1:1-105.
Powrie, J. (1864). On the fossiliferous rocks of Forfarshire and their contents. *Quarterly Journal of the Geological Society*. 20:413-429.
Selden, P.A. (1984). Autecology of Silurian eurypterids. *Special Papers in Palaeontology*. 32:39-54.

Collection overview
The collections have an apparent focus on several stratigraphic levels exposed locally, although fossils representing the Devonian are noticeably numerous. Samples of the Aberdeenshire Rhynie Chert contain the early plants *Psilophyton* and *Rhynia*. Lower Devonian fossils from Turin Hill, Angus, illustrate another ecosystem deposited within the Forfar Basin. These are primarily

arthropods, such as the millipede *Kampecaris forfarensis* and eurypterids including *Pterygotus* and *Tarsopterella* with additional indeterminate fragments. Labels for the latter reference the Arbuthnott Group of Blairgavies Quarry. A specimen of *Erretopterus bilobus*, part of the Kinnaird Collection, has additional notes mentioning William Baird (formerly National Museums Scotland) and research by Paul Selden, formerly at the University of Manchester. Large fragments of the eurypterid *Pterygotus* from Turin Hill and Balruddery Den are shown in displays with a life-size reconstruction. Turin Hill, Balruddery Den and Whitehouse Den are also known for acanthodian fish (*Ischnacanthus*, *Euthacanthus*, *Diplacanthus*, *Brachyacanthus* and *Parexus*) and trace fossils. Specimens of *Euthacanthus* and *Climatius scutiger* are among the fish donated by Miss McNicoll (also spelt 'McNicol' in labels) in 1939. The collection includes specimens and casts of cephalaspids (*Cephalspis lyelli* collected by Mr F Gray without locality) with a specimen of the osteolepid fish *Glyptolamus kinnairdi*. Early plants are represented by *Psilophyton* (Pitairlie Quarry, Monikie) and the alga *Parka decipiens* (Turin Hill, Carmyllie and Tealing; a specimen from Tealing is also attributed to Miss McNicol). Most of this material is part of the Kinnaird Collection, which has been the subject of research. Fossils are attributed to George Stewart Graham-Smith (1875-1950, University of Cambridge); labels also indicate specimens collected by W Graham-Smith, his son William (c1912-2002), a researcher at the University Museum of Zoology, Cambridge. One or both Graham-Smiths excavated and published details of fossils from Fithie Burn, Duntrune, which was at the time a new locality.

Figure 27: A large bone from the Carboniferous fish *Rhizodus* from Gilmerton
(The McManus: Dundee's Art Gallery and Museum)

Fish fossils from the Middle Devonian originate from localities across north east Scotland in what is referred to as the Orcadian Basin: *Cheiracanthus*, and *Glyptolepis* from Tynet Burn, Moray, *Diplacanthus*, *Coccosteus*, *Cheirolepis* from Lethen Bar, Moray, *Pterichthyodes* and *Pterichthys* from Cromarty, *Dipterus*, *Pterichthyodes*, *Osteolepis*, *Coccosteus*, *Millerosteus* and *Brachypycopterus* from Caithness (some linked to David Henderson and dated to the 20th century) with *Dipterus* and *Pterichthyodes* specifically from Achanarras, and *Diplacanthus* from Stromness; additional fossils without obvious locality information are likely to be from the above. Middle Devonian corals *Pachypora* and *Favosites* illustrate differences in palaeoenvironment between Scotland (rivers and lakes) and the southern part of England (shallow marine water). The Upper Devonian is represented by scales of *Holoptychius* from Clashbenny showing detailed ornament

and slabs of Dura Den sandstone with *Holoptychius* and *Osteolepis* among other fish, some attributed to Rev John Anderson. Additional Devonian fish include *Phaneropleuron* and *Bothriolepis* (Ferniehurst, Jedburgh). Several rocks noted as erratics (transported by glaciers) contain Devonian fish scales.

Carboniferous fossils include the typical plants *Stigmaria* and *Lepidodendron*, with *Calamites* (one labelled as Cape Breton, Sydney), *Lepidostrobus* (Burdiehouse), the fern *Adiantites hibernicus* and numerous other fragments (one noted as Rotherham). Brachiopods are represented by *Productus* and other productids (*Gigantoproductus*), *Spirifera* and *Rhynchonella*, the bryozoan *Fenestella* from Halkyn Mountain (North Wales) and fragments of the stem and calyx of crinoids. Fish fossils show teeth, complete jaws and a shoulder girdle of *Rhizodus* (Fig. 27), and fragments labelled as *Holoptychius* from Burdiehouse and Gilmerton in Edinburgh among others. Some of these fossils are linked to James B Corr. Another tooth from Airdrie shows distinct curvature and is probably *Strepsodus*. Labels with invertebrates give origins as widely dispersed as Devon (bivalve *Posidonia*), Yorkshire (Settle, Bowland in Lancashire), Derbyshire and Durham.

Ice age fossils are a mammoth tooth from St Fort gravel quarry with molluscs and an eroded bone from the Devensian (Pleistocene) Errol Clay Formation. Additional invertebrate specimens (bivalves *Saxicava* and *Modiolaris*, etc) are part of the Kinnaird Collection.

Fossils from other stratigraphic levels are broader in their origin. The Ordovician is represented by trilobites from the Hartfell Shale (Dumfries), *Phacops* from Horderley (Shropshire) and a complete *Ogygia guettardi* (now *Ogygites guettardi*) from the transition clay slate of the Netherlands (Fig. 28), graptolites from the Drygill Shale of the Lake District and a coral from Michigan, USA. The Silurian is represented by eurypterids, notably *Slimonia* and *Erettopterus* from the Lesmahagow Inlier, associated with notes suggesting they have been studied. Mesozoic specimens are not generally local and include ammonites (mostly labelled as '*Ammonites*', from the Liassic, Greensand and other levels), belemnites, nautiloids, bivalves (*Trigonia*, *Gryphaea*), brachiopods, echinoids (*Clypeaus*), sponges (*Siphonia* from the Cretaceous of Blackdown), gastropods (*Pleurotomaria*) and scaphopods (*Dentalium* from Cambridge), with the occasional fish (*Mesodon* from the Great Oolite; James B Corr bequest 1937) and reptile remains. Representing the Triassic are several partial specimens of the reptile *Stagonolepis* from Elgin showing scutes and disarticulated bones, linked to Reverend John Anderson. There are numerous isolated marine reptile vertebrae, perhaps Jurassic, a block with 10 or more partly articulated ichthyosaur vertebrae and arches, a second specimen of slightly larger centra piled together and a possible cast of an *Ichthyosaurus* front paddle. Another specimen is labelled as a ribcage but a sclerotic ring from the eye is visible suggesting it might be a skull or contain skull elements. Fish include a Liassic (Jurassic) *Aechinodus, Pholidophorus* from Lyme Regis and *Beryx* from the Chalk. There is a sample of tuff containing bones from Bustchaafs, South Africa, and a set of approximately 10 smoothed agate-like pebbles labelled as dinosaur gastroliths from Wyoming.

Cenozoic fossils from Scotland are limited to two specimens of tufa with leaf impressions, potentially from Mull, each associated with notes mentioning Mr Duncan, one dated 1927. Most of the Cenozoic fossils are from outwith Scotland. For example, the Eocene is represented by fossils from the London Clay (molluscs and crustaceans), Barton Beds, Headon Hill Formation (*Erodona*), Bracklesham Beds of Bracklesham Bay (*Fusinus*) representing the London and Hampshire basins, and other unknown localities (bivalves and gastropods (*Buccinum*, *Turritella*, *Voluta*)). Examples of the Eocene foraminifera *Nummulites* are present, either isolated or in limestone matrix, with France given as the origin of some. The gastropods *Voluta* and *Natica* are from the Eocene of the Paris Basin with a specimen of *Hinia* labelled as the same area but from the Pliocene. Many of these were collected by Dr A Dalgetty, James B Corr or workers from the Geological Survey. Further Eocene fossils are shrimps and fish labelled as from Lebanon, fish and plant fossils from Monte Bolca, Italy, and fish from the Eocene Green River Formation of America. The Pleistocene Red Crag from East Anglia (Felixstowe, etc) is represented by numerous bivalves (*Nassa*), gastropods (*Neptunea*, *Turritella*, *Natica*, *Venus*) and shark teeth (*Otodus*), with some linked to Lady Kinnaird. A

box of 40 fish bone fragments is from the Norwich Crag (Pleistocene) at Easton Bavents, Southwold, Suffolk.

Vertebrate fossils include several mammoth, horse and deer teeth, a cave bear mandible, an antler fragment, various tusks and horns, shark teeth (many worn, perhaps by water), the end of a vertebrate limb bone with a label ‘Dr Blair Tayport’ and a modern bird’s nest with five eggs preserved in cave deposits from Jamaica. Miscellaneous specimens without age or locality details are a dragonfly on a rock covered with red crystalline growth, possibly a cave deposit, and fossil wood from Antigua, Hobart (Tasmania) and other localities.

Figure 28: An Ordovician trilobite *Ogygites guettardi* from the Netherlands (The McManus: Dundee’s Art Gallery and Museum)

Research/collection links

A collection of Lower Devonian fossils from Fithie Burn, Duntrune, is attributed to George Stewart Graham-Smith (1875-1950, University of Cambridge) and/or his son William (c1912-2002), a researcher at the University Museum of Zoology, Cambridge. The specimen labelled *Adiantites hibernicus*, a fern, could be from the Devonian of Dura Den or Carboniferous and it would be worth investigating. Fish from the Carboniferous could be studied as part of a collaborative project, with the aim of documenting material in more detail. The origin of the ichthyosaur fossils could also be studied, as some specimens include enough diagnostic elements to look at their taxonomy.

Broughty Castle (Leisure and Culture Dundee)

Collection type: Local authority (Leisure and Culture Dundee)
Accreditation: 2017

Castle Approach, Broughty Ferry, Dundee, DD5 2TF
Contact: broughty@leisureandculturedundee.com

Location of collections
The Museum is located in a castle built on the River Tay in the 1490s and in ruins by the 1800s. In 1860 it was converted into an artillery defence in case of French invasion with its use continuing through both World Wars. The museum moved into the castle in 1969. The collections at the site are managed by Leisure and Culture Dundee on behalf of Dundee City Council. Fossils are on display; all stored specimens are in The McManus Collections Unit.

Size of collections
11 fossils.

Onsite records
Fossils are included in documentation at The McManus: Dundee's Art Gallery and Museum.

Collection highlights
1. Fossils from the local area.

Collection overview
The collection includes Devonian fish, such as the Lower Devonian *Cephalapis* found near Broughty Ferry and acanthodians *Acanthodes* and *Parexus*, and *Holoptychius* in a slab of Upper Devonian sandstone from Dura Den, Fife. Plant fossils are of *Parka decipiens* described as the spores of an early (Devonian) land plant preserved with other fragments (now considered an alga), an example of the Devonian *Psilophyton* and the 400 million-year-old Carboniferous plant *Sigillaria*. The youngest fossils on display are a fragment of mammoth tusk and femur, and a sample of Pleistocene Arctic clay with the bivalve *Hiatella arctica* from Errol, Perthshire.

D’Arcy Thompson Zoology Museum and University Herbarium (University of Dundee Museum Collections)

Collection type: University
Accreditation: 2016

University of Dundee, Dundee, DD1 4HN
Contact: museum@dundee.ac.uk

Location of collections
The University of Dundee holds two fossil collections. The first is linked to Professor D’Arcy Wentworth Thompson (1860-1948) who built up a large Museum of Zoology from 1885. Thompson moved to the University of St Andrews in 1917 after which the museum was cared for by his successor Alexander Peacock (1886-1976). On his retirement in 1956 the building housing the museum and the Natural History department was demolished and the collection dispersed, with only parts being retained in Dundee – these have been redisplayed in the new D’Arcy Thompson Zoology Museum which opened in 2008. The second collection is that of the former Botany department, originally founded by Patrick Geddes (1854-1932). This is housed in the University Herbarium in the museum stores in Hawkhill House.

Size of collections
159 fossils.

Onsite records
Information is in a KE Emu CMS and a system called ‘Inca’, created by John Faithfull at the University of Glasgow. A small number of fossils are included in an online collection database at: https://www.dundee.ac.uk/museum/collections/zoology/collections/.

Collection highlights
1. Cast linked to Richard Owen (1804-1892).
2. Range of vertebrate fossils, many from well-known localities.

Published information
Edwards, D. (1972). A *Zosterophyllum* fructification from the Lower Old Red Sandstone of Scotland. *Review of Palaeobotany and Palynology*. 14:77-83.
Walton, J. (1964). On the morphology of *Zosterophyllum* and some other early Devonian plants. *Phytomorphology*. 14:155-160.
Edwards, D. (1970). Fertile *Rhyniophyta* from the Lower Devonian of Britain. *Palaeontology*. 13:451-461.
Thompson, D.W. (1879). Some Bones of a Fossil Seal from the Post-Tertiary Clay at Dunbar. *Journal of Anatomy and Physiology*. 13:318-321.
Owen, R. (1884). On the skull and dentition of a Triassic mammal (*Tritylodon longævus*, Owen) from South Africa. *Quarterly Journal of the Geological Society*. 40:146-152.

Collection overview
The collection includes material from well-known/important localities with a wide geographic and stratigraphic range, indicating that specimens were probably acquired randomly with zoological specimens, by donation and through specialist excursions. Vertebrates are numerous and include examples of the fish *Dipterus* in Devonian sandstone from Caithness, two *Palaeospondylus* from Achanarras linked to Prof Thomas Stanley Westoll (1912-1995), Kings College, Newcastle upon Tyne, a poorly preserved placoderm *Pterichthyodes*, *Rhizodus* jaw fragment with several teeth, indeterminate pieces of a crossopterygian fish that might be Carboniferous *Megalichthys* or similar, a complete *Dapedium* fish from the Jurassic and a part and counterpart fish fossil in light-coloured rock, perhaps from the Solnhofen Limestone of Germany. Casts include a Devonian placoderm

head shield, painted and marked to show the outlines of various plates and other features, a model of *Pterichthys* with detail of the scales, plates and movable front fins, and a cast of a Devonian *Cephalaspis*.

Reptile fossils include a scute impression from the Triassic *Stagonolepis*, a bone from the Triassic cynodont *Diademodon*, a three-dimensionally preserved Upper Liassic (Jurassic) *Ichthyosaurus* skull from Whitby with sclerotic rings but missing most of the rostrum, disarticulated bones from the front limb and ribcage of an ichthyosaur (humerus, radius, ulna, ribs, gastralia), a framed *Ichthyosaurus quadriscissus* (now *Stenopterygius quadriscissus*) labelled as 'B. Hauff, Holzmaden, Germany' (Fig. 29), two near-complete tortoise shells in light-coloured rock, a neural arch from an indeterminate mammal or reptile and a crocodile vertebra. Casts include a half-size cast of the marine reptile *Thalassiodracon* (acquired by D'Arcy Thompson for the Zoology Museum in 1898; the original, found in Street in the 1830s, is now in the Natural History Museum, London), an *Archaeopteryx* (Berlin specimen), a partly painted skeleton of a dinosaur similar to *Compsognathus*, and a black model in a wooden frame showing a skull viewed from above with labels reading: 'The model was made from a drawing of a specimen in the Hancock Museum, Newcastle upon Tyne, where it is named *Loxomma allmanni* Huxley. The specimen was found in the Low Main, Newsham, Northumberland, shortly before 1870', 'The *Stegocephalia* were mostly giant amphibia which flourished in the Carboniferous period. They comprised forms which were the earliest vertebrates to adapt themselves to a terrestrial life', and 'Amphibia. Model of a skull, dorsal aspect, of the embolomerous stegocephalian *Orthosaurus pachycephalus* Barkas. Actual size. A.M. Black'. A similar model/cast was observed in the Bell Pettigrew Museum (Museums of the University of St Andrews), although this was painted black.

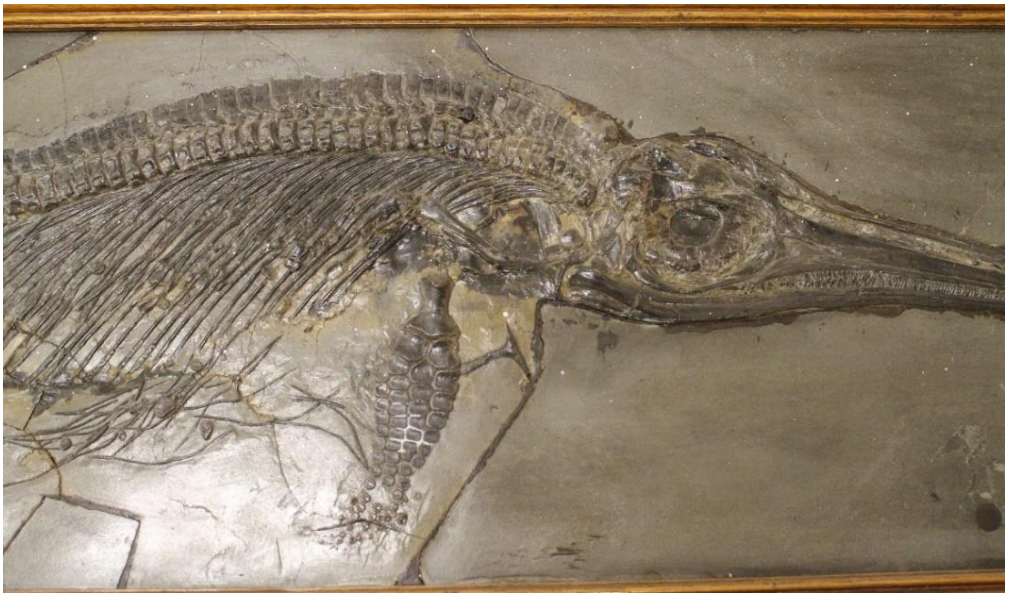

Figure 29: Jurassic ichthyosaur *Stenopterygius quadriscissus* from Holzmaden, Germany (D'Arcy Thompson Zoology Museum)

Mammals include a mastodon tooth, mammoth tooth, a tooth-like fossil labelled *Rhytiua* with another similar specimen noted as 'Not *Rhytiua*? (Stellar's Sea Cow)', several skull and jaw fragments of the oreodon *Merycoidodon*, and a set of rhinoceros, fox, horse, deer, bear (Fig. 30) and hyaena teeth, bear claws and phalanges with other indeterminate bone fragments collected from a bone breccia. Several large jaw fragments and a tooth labelled 'Mammalia Pterissodactyla' are perhaps associated with additional bags of similar material. One jaw fragment is labelled as *Palaeotherium crassum*, an Upper Eocene ancestor of the horse from Vaucluse, France. A further interesting cast is of a Triassic dicynodont skull that was difficult to orientate at first (the label

identifies it as snake due to the large fang-like teeth); the original specimen is linked to Richard Owen.

Invertebrate fossils include examples of echinoderms (heads of the blastoid *Pentremites*, an articulated stem and head of a Liassic crinoid in a black frame, a *Uintacrinus* in chalk and articulated crinoid stems that might be a trace fossil), brachiopods (lingulid brachiopod and a box with *Dinorthis* from the Ordovician of Kentucky, *Spirifera* from the Devonian of Canada and *Platystrophia* from Cincinnati, Ohio, dated 1868), arthropods (the Cambrian trilobite *Elrathia*, cast of the Silurian trilobite *Calymene*, fossils of the crab *Xanthopsis* (also spelt *Zanthopsis*) and a lobster from the Eocene London Clay), cephalopods (various including ammonites, such as a *Hamites* from the Gault Clay at Folkestone), corals (fragment of the coral *Donacosmilea whigatii* with the mention of it being a 'new one' in the label), bryozoans (*Schizoporella* from Port Phillip Head, Victoria, *Proboscinna*, *Microporella* (Tasmania), *Diastopora* (with a note to see monograph), *Alveolania* (foraminifera), a sponge from the Red Crag of Suffolk and a fossil from the Coralline Crag, among others. Six additional boxes have similar content: *Entalophora*, *Lophorlepsis* (from Faringdon and likely to be Sponge Gravel), [*Hebroflora comfera*], [*Menifis angulate*] (Faringdon), [*Cillelp globularia*] (from near Vienna) and *Reticulopora*.

Plants in the collection are limited to a large '*Sigillaria* or *Stigmaria* root' from the Carboniferous and a *Cyclopteris* described in an associated letter (Jason Hilton, National Museums Scotland, 2002) as being nodular and therefore possibly from the Mazon Creek Flora of Illinois. Additional fossils are in the botany building: several *Parka decipiens* from the Devonian of Westhall Terrace (near Tealing, Angus), lycopsids from the Devonian Rhynie Chert, and fragments of the early psilopsid plants *Cooksonia* and *Zoosterophyllum* from the Devonian of Angus; various notes suggest some of these are figured, for example, in Edwards (1972). The Carboniferous is represented by *Calamites*, *Stigmaria*, several *Lepidodendron, Sigillaria* and *Pteropsida.*

A cardboard tray contains casts of a variety of fossils: brittle star, Carboniferous arachnid *Eophrynus* from Coseley, West Midlands, irregular ammonite, a regular echinoid, millipede provided by the Open University, Milton Keynes, *Lepidodendron* or similar and small round tree trunk, an ammonite fossil, Carboniferous brachiopod and crinoid showing articulated stem and head.

Research/collection links
Fossils of marine reptiles and Cenozoic mammals (*Merycoidodon* and *Palaeotherium*) could be investigated further, with the potential for studies of material across several collections, including the Glasgow Museums Resource Centre. The preservation of the three-dimensional ichthyosaur skull is unusual and the context, taphonomy and taxonomy could be studied.

Figure 30: Bear teeth from cave deposits (D’Arcy Thompson Zoology Museum)

Montrose Museum (ANGUSalive)

Collection type: Local authority (ANGUSalive)
Accreditation: 2018

Panmure Place, Montrose, DD10 8HF
Contact: MontroseMuseum@angusalive.scot

Location of collections
The collection and the Museum are both linked to the Montrose Natural History and Antiquarian Society, formed in 1836 through the Montrose Chess Club and led by William Beattie. The original building housing the collection was an Old English School, replaced with a new building on the same site designed by Edinburgh Architect John Henderson. It opened in October 1843, on the birthday of Lord Panmure who provided funds; a rear gallery was added in 1889 with refurbishment in the late 1970s. In 1962 the museum and collection formally passed to Montrose Town Council and subsequently Angus Council, with management since 2015 through ANGUSalive Culture, Sport and Leisure Trust. Fossils are on display and in storage onsite.

Size of collections
800-1,000 fossils.

Onsite records
The Museum collections are documented on an Adlib CMS although information on fossils, currently on index cards, has not yet been entered. The Society has an accession book started after the Second World War.

Collection highlights
1. Lower Devonian fossils, linked to Reverend Hugh Mitchell (1822-1894).
2. Fossils from localities on land owned by Lord Kinnaird (9th Lord, George Kinnaird, 1807-1878).
3. Arctic clay fossils collected by James Cunningham Howden (1830-1897) and Robert Boog Watson (1823-1910).
4. Fossils of the Munich Collection.
5. Fish fossils from the Devonian of Abergavenny, Wales.

Published information
Mitchell, H. (1861). On the Position of the Beds of the Old Red Sandstone developed in the Counties of Forfar and Kincardine, Scotland. *Quarterly Journal of the Geological Society*. 17:145-151.
Trewin, N.H. (2013). *Scottish Fossils*. Edinburgh: Dunedin Academic Press.

Collection overview
Fossils can be divided into specimens of the Mitchell and Munich collections with material from additional or unspecified collectors forming the remainder. The Mitchell collection is almost exclusively from Angus and the Devonian: acanthodian fish labelled as *Ischnacanthus*, *Mesacanthus*, *Euthacanthus* (one specimen a sheet of rock in a wooden frame with an old label describing it as the spines and scales of *Euthacanthus* from Farnell), *Climatius* and *Parexus* from Turin Hill, Eggerton, Kinnell and Tillywhandland, and ostracoderms from West Drum Quarry (*Cephalaspis* cf. *pagei*), Kinnaird quarries (*C.* cf. *pagei,* Fig. 31), Turin Hill (*C.* cf. *powriei*), and Brechin Quarry (*C.* cf. *lyellii*). Arthropods include the eurypterids *Pterygotus* (one a large section of *Pterygotus anglicus* body segments from Carmyllie Quarry on display, on loan from National Museums Scotland) and *Hughmilleria* (Turin Hill, Tealing, Canterland Den, Carmyllie). Crustaceans are represented by *Dictyocaris* from Canterland Den, and arthropod cuticle fragment from the same locality, each with notes ‘L. I. Anderson 1994’ (Lyall Anderson, formerly National Museums

Scotland). Arthropod traces include myriapod trackways from the Ferryden foreshore, and *Diplichnites*, *Cochlichnus* with *Isopodichnus* from Canterland Den.

Lower Devonian plant fossils include *Nematophyton* and *Zoosterophylum* from Merton Quarry. Part of the Mitchell Collection is comprised of Carboniferous fossils, notably *Megalichthys*, *Rhizodus* and palaeoniscid fish, plant fragments and nodules from Burdiehouse and the Edinburgh Coalfield. A specimen showing fragments of the plants *Alethopteris*, *Lepidodendron*, *Pecopteris* and other leaves from Felling on Tyne Colliery, Northumberland, and a *Bothriodendron* from Northumberland are attributed to Alex - rather than Hugh - Mitchell. Two specimens from the Carboniferous of the Edinburgh Coalfield are each described as a 'cast of reptile footprint' on old labels and as sedimentary structures in notes added more recently.

Figure 31: The jawless Lower Devonian fish *Cephalaspis* cf. *pagei* from the Kinnaird Quarries, Angus (Montrose Museum)

The Munich Collection comprises fossils almost entirely from the Mesozoic and Cenozoic. The fossils were received as an exchange with Munich Museum for a specimen of *Pterygotus anglicus* from Carmyllie, Angus, around 1899 (Stace *et al*. 1987); information also suggests the *Pterygotus* specimen was destroyed by a bomb during the Second World War. The collection represents all major taxonomic groups. Bivalves include *Pecten*, *Cardium*, *Trigonia* (one preserved with a *Plesiosaurus* tooth from the Lower Jurassic and probably Stonesfield Slate), Jurassic *Gryphaea*, Cretaceous oysters and *Lopha*, wood encrusted by oysters, and Eocene *Pteriomorphia*. Gastropods are represented by disparate types from the Silurian, Carboniferous (including *Euomphalus*), Cretaceous Greensand, taxa typical of the Eocene Barton Beds, and Oligocene *Natica* and *Pleurotomaria*. Cephalopods are represented by ammonites (Jurassic and Cretaceous, several in 'black limestone'), belemnites and nautiloids of various types. Limited numbers of fossils represent brachiopods (Carboniferous *Brachythyris* and Spirifera), corals (*Heliolites*, *Syringopora*, *Thecosmilia*), echinoids (*Cidaris* spine from the Oolite, Upper Jurassic), graptolites (Ordovician graptolites from Dob's Linn) and trilobites (Devonian *Phacops* from Bohemia). A fossil labelled as a '*Buprestis'* beetle wing case from the Lower Oolite is re-identified as a flat, crushing tooth from a shark in Stonesfield Slate and a dragonfly labelled as '*Petalia'* from the Upper Malm (Jurassic) of Solnhofen, Germany, as *Cymatophlebia longialata.* Further investigation is needed to confirm the

identification of a crustacean with several labels, each varying in their spelling of the generic name in '*Panneus' speciosus*. The collection includes the Cambrian trace fossil *Oldhamia* from Bray Head, County Wicklow, Eocene *Dipthelia* from France, the foraminifera *Nummulites* from Italy and large disc-shaped *Orbicula*, and *Serpula* from the Oxford Clay. An interesting specimen is the *Eozoon canadensis* with an origin of Cote St Pierre, La Petit Nation, Seigniay donated by TS Weston of the Geological Survey of Canada in the 1870s. Vertebrate fossils include the Devonian fish *Pteraspis*, samples of bone breccia, Carboniferous acanthodian (*Gyracanthus*) spines, fish vertebra from Gilmerton, *Megalichthys* (including a complete *Megalichthys* from Burdiehouse presented by Robert Barclay Esq among several other fragments of body) and *Rhizodus* fragments (including a jaw with teeth and scapula), Jurassic *Leptolepis* from the Solnhofen Limestone, teeth of the sharks *megalodon* and *Ptychodus* among others (many in chalk), several indeterminate fish in Cretaceous Chalk from Dover, a Quaternary mammal tooth, and a modern bird skull and sacrum.

Several small collections of focused material are present. The Watson Collection (Reverend Robert Boog (misspelt Boag) Watson (1823-1910), whose publications include a report on molluscs collected during the HMS *Challenger* expeditions from 1872-1876) comprises sub-fossil bones from a bovine animal and two wild boar mandibles, and a fossil of the Devonian fish *Cephalaspis*. The James Cunningham Howden Collection comprises Pleistocene Arctic clay fossils from the 'Railway cutting' among other localities; samples of 'Dryleys Clay' are perhaps not Arctic clay in the strict sense, rather a brick clay from the Dryleys brick and tile works near Montrose. The Arctic clays contain mostly bivalves (*Saxicavella*, *Pecten*, *Artica*, *Mytilus*) and gastropods, with rarer brittle stars (*Ophiolepis*). There is also a collection of bones (skull, beak, trachea, sternum, clavicle and vertebrae in bags and limb and other long bones affixed to pieces of wood) from an eider duck discovered at Puppieston in 1891. Moderately sized samples of Arctic clay show similar mollusc fossils but are noted for the barnacle *Balanus*. The progression of the Ice Age is illustrated by fossils from the Arctic clay 10,000 years ago (Arctic clams *Artica islandica*, nut shells *Nucula tenuis* and others, Arctic starfish *Ophiolepis gracilis*, a rock borer *Saxicavella sulcate*, Arctic scallop *Pecten groenlandicus*, upper jaw and second bone from a common seal (*Phoca vitulina*), and replica bones of the eider duck *Somateria*), sub-estuarine peat from 8,000 years ago (branch from the alder *Alnus*, horsetail *Equisetum*, Scots pine cone *Pirius sylvestris* and a sample of 'fossilised' peat) and post-glacial Carse Clay Formation from 6,000 years ago (a common European oyster *Ostrea edulis*, peppery furrow shell *Scrobicularia plana*, common mussel *Mytilus edulis*, Baltic tellin *Macoma balthica* and common cockle *Cerastoderma edule*).

The remaining material might belong to any or none of the collections mentioned. There are numerous examples of *Parka decipiens* (from Watchkey, Carmyllie and Canterland Den, etc), a possible eurypterid trace from Leesmill Quarry, Ferryden, and trace fossils including an Upper Devonian specimen from Elgin presented by Henry Young in 1859. Fossil fish represent the Lower Devonian (*Pteraspis*), Middle Devonian (*Pterichthyodes* and *Osteolepis* with *Glyptolepis*, *Osteolepis* and *Dipterus* from localities in Caithness, such as Achanarras, Castle Hill and Holburn Head, and *Pterichthyodes* from Cromarty among other localities) and Upper Devonian (Cromarty, Dura Den and Gamrie); these are accompanied by various models. Specimens of *Pteraspis* (*P. crouchi* Lankester), *Cephalaspis* and indeterminate fossils are from the Lower Devonian of Abergavenny, Wales. These are accompanied by Carboniferous fossils: fish (scales of *Megalichthys*, one attributed to Dr Steele, Fife, spines and scales of *Rhizodus, Palaeoniscum* (labelled as *Palaeoniscus*) from Burdiehouse, *Gyracanthus* from Gilmerton and other fossils from the Edinburgh Coalfield), brachiopods (notably productids from Fife) and the plants *Calamites*, *Lepidostrobus* and *Lepidodendron*, including one in light-coloured rock from New Zealand. Fossils from other stratigraphic levels include samples of Silurian Much Wenlock Limestone Formation showing brachiopods among fragmentary coral reef debris, a Jurassic ichthyosaur from Lyme Regis, bivalves (oysters, many of large size), various cephalopods (nautiloids and ammonites representing the Jurassic (*Cardioceras*) and Cretaceous) and a mammoth tooth. Interesting specimens are those labelled as *Bourguettocrinus* from the Chalk of Petersbey, Maastricht, and several small round fossils labelled as seeds from the Great Oolite Series (Jurassic) almost certainly platy shark teeth from the Stonesfield Slate.

Fossils on display illustrate the fossilisation process: modern Mytilus with a second shown under sediment and a broken pebble revealing a bivalve cast, an internal mould of a Jurassic bivalve (described by quarrymen as ‘Osses ‘eds’ due to their horse-head shape), Cretaceous *Micraster* and Carboniferous plant frond. Another case shows Devonian trackways, mudcracks and ‘heat blisters’. A handling table includes a large ammonite whorl fragment, a 20cm section of the Carboniferous *Stigmaria* and fossil fern.

Research/collection links

The material attributed to named collectors often occurs mixed within the storage areas; organisation/separation would help to determine the actual size and contents of each and allow potential research projects to be identified. The Mitchell collection is already of interest with fossils of *Vernicomacanthus*, *Climatius* and *Brachycanthus* recently examined by a PhD student from Imperial College, London. Specimens that could be studied include the fish from the Lower Devonian of Abergavenny, a potentially important locality historically and/or scientifically, and the fossils labelled *Bourguettocrinus* from the Chalk (Maastrichtian, Cretaceous) of Petersbey which should be investigated to confirm their identity (as a crinoid), origin and context.

Museums of the University of St Andrews

Collection type: University
Accreditation: Wardlaw Museum 2019 (Provisional); Bell Pettigrew Museum 2017

Bell Pettigrew Museum, Bute Building, St Mary's Quad, University of St Andrews, KY16 9TS
Wardlaw Museum, 7a The Scores, St Andrews, KY16 9AR
Contact: museumenquiries@st-andrews.ac.uk

Location of collections
The University of St Andrews is Scotland's first university, founded between 1410 and 1413. The first University museum was established in 1838 jointly with the St Andrews Literary and Philosophical Society and its collections were displayed in rooms in the United College. From 1904 the University assumed sole responsibility for the remaining collections, which were moved to the new Bell Pettigrew Museum in 1912. In the 1950s the collections were dispersed among relevant academic schools (or to other museums) with only the Zoology Collections remaining at the Bell Pettigrew Museum. Fossils are displayed in the Bell Pettigrew Museum as part of the Zoology Collections (with additional onsite storage in the Bute building). The Geological Collection also includes material from the Literary & Philosophical collections and gathered by significant Scottish scientists, such as Robert Meldrum Craig (1882-1956). The collection has continued to grow through academic fieldwork and research and is used extensively in university teaching. The Geology Collection does not have its own museum, but specimens can be seen in the Wardlaw Museum and, by appointment, in storage.

Size of collections
46 fossils on display with approximately 6,000 geological specimens in storage.

Onsite records
Online database with information and images: https://www.st-andrews.ac.uk/collections/.

Figure 32: The Carboniferous fish *Amblypterus* from Denhead, Fife
(Museums of the University of St Andrews)

Collection highlights
1. Devonian fish fossils from Dura Den, Fife.
2. Fossils linked to James Bell Pettigrew (1834-1908), Reverend John Anderson (1796-1864), Louis Agassiz (1807-1873), Matthew Forster Heddle (1828-1897), Thomas Henry Huxley (1825-1895), Ramsey Heatley Traquair (1840-1912), Dr Thomas Stewart Traill (1781-1862), Reverend Dr John Fleming (1785-1857), Sir Arthur Smith Woodward (1864-1944) and possibly the journalist George Buist (1805-1860).
3. Scottish Carboniferous crinoids collected by Robert Meldrum Craig (1882-1956)

Published information
Pettigrew, J.B. (1908). *Design in Nature: Illustrated by Spiral and Other Arrangements in the Inorganic and Organic Kingdoms as Exemplified in Matter, Force, Life, Growth, Rhythms, &c., Especially in Crystals, Plants, and Animals* (Vol. 2). London: Longman, Green, and Company.
Anderson, J. (1859). *Dura Den. A monograph of the yellow sandstone, and its remarkable fossil remains... With illustrations*. Edinburgh: Constable.
Catalogue of Rocks and Minerals in the Museum of the Literary and Philosophical Society of St Andrews (1849). Dr. Edward Woodford's Press.

Collection overview
The fossils of the Palaeontological collection, forming part of the Geology collection, consist mainly of invertebrate macrofossils organised into taxonomic groups with the majority from UK locations. The collection includes published and type material of Scottish crinoids collected by Robert Craig Meldrum and slabs of the Upper Devonian Dura Den fish. Examples displayed at the Wardlaw Museum represent the teaching and research activity of the University. Fossils displayed in the Bell Pettigrew Museum illustrate the diversity of ancient life through time. Vertebrates include a plesiosaur vertebra from Lyme Regis, dinosaur tooth labelled as *Spinosaurus* from Morocco, coprolite from the Jurassic Morrison Formation of America, *Mioplosus* and *Knightia* from the Eocene Green River Formation, Wyoming, and a mammoth tooth. Fish are represented by *Bothriolepis*, *Glyptopomus*, *Phaneropleuron* and *Holoptychius* from nearby Dura Den, Fife, accompanied in displays by copies of historical text and illustrations. One historic illustration, labelled '*Pterichthys* Dura Den, drawn to scale by M Forster Heddle', and a more recent label reading '*Bothriolepis crestata* Traquair', looks to be of a specimen observed in the Fife Collections Centre. Other fish fossils on display are the smaller *Mesacanthus* and *Palaeospondylus gunni* from Achanarras, an unidentified fish with a label affixed reading 'Nr. Thurso, Caithness C. R. Stonor', dated 1941, *Phaneropleuron*, *Amblypterus* (Fig. 32) and platysomid fish in darker sandstone (Carboniferous) from Denhead, Fife, and *Pycnadus rhombus* and *Palaeoniscum freieslebeni* (labelled as '*Palaeoniscus*') from the Permian of Mansfeld in the Saxony-Anhalt region of Germany.

Casts of a placoderm, *Ceratodus* teeth from the Triassic of Bristol, and a series of modern and fossil shark teeth affixed to a board are displayed near modern fish. A picture-framed model of a skull has two labels reading 'Stegocephali *Orthosaurus pachycephalus* Barker Dorsal aspect of skull found in coal at Low Mains, Newsham, Eng' and 'This is an actual size model of a specimen in the Hancock Museum, Newcastle Upon Tyne'. The same model is also present, but painted white, in the University of Dundee Museum Collections. Two *Archaeopteryx* (casts of the London and Berlin specimens) and a cast of an *Archaeornithes* skull are in a case with bird skeletons themed on the mechanics of flight. Invertebrates are a Cambrian trilobite from Morocco (possibly a reproduction), Ordovician graptolites, 380 million-year-old orthoconic nautiloids from Morocco in polished slabs of rock, a slab with various bivalves from the Jurassic of Robin Hood's Bay, ammonite *Titanites giganticus* from Portland (Dorset), an ammonite cut to show crystal-filled chambers, the crinoid *Encrinus* from the Inferior Oolite (Jurassic), 120 million-year-old mayfly *Ephemeropsis* nymph from Liaoning (China), 100 million-year-old shrimp *Carpopenaeus* from Lebanon and a Quaternary termite in copal.

In many cases fossils are shown with modern equivalents for comparison. Such fossils are of echinoids (the complete and isolated spines of the Cretaceous echinoid *Cidaris*, Cretaceous *Echinocorys* preserved in flint and Miocene *Clypeaster*, including one from Bordeaux), crinoid fragments in limestone, brachiopods (from the Silurian, Carboniferous and Recent shown against the geological timescale), trilobites (*Ogyopsis*, *Ptychoparia* and *Neolenus* from the Cambrian of Mount Stephen, British Columbia, *Homalonotus* from the Silurian of Dudley and *Ogygiocarella* from the Cambrian of Wales), other arthropods (cast of the Xiphosuran *'Prestwichia'* (*Euproops*) from Manchester and an original from the Carboniferous of Barnsley) and corals (*Halysites*, *Syringopora*, *Favosites*, *Pachypora*, *Alveolites*, *Lithostrotion*, *Dibunophyllum*, *Cyathophyllum*, *Calceola* and *Lonsdalia*). Cephalopods are well-represented by fossils with many fragments of belemnites and the ammonites *Hildoceras* from the Lias at Whitby*, Dactylioceras*, *Ludwigella concava*, *Parkinsonia* from the Inferior Oolite at Burton Bradstock, *Teloceras* from the Inferior Oolite at Sherborne and *Hoplites* from the Gault at Folkestone. Displays of other molluscan groups (bivalves, gastropods) did not include any fossils. Microfossils are represented by large *Nummulites* from the Eocene of the Sahara, Egypt, and Mid Eocene (Lutetian) of Southampton. Plants are primarily Carboniferous with examples of *Glossopteris*, *Pecopteris*, *Calamites*, *Lepidodendron* of various sizes, *Sigillaria*, *Sphenopteris*, *Neuropteris* and *Sphenophyllum*, cycad from the Cretaceous of Australia, a lycopod (Fig.33) and 225 million-year-old wood from Madagascar.

Research/collection links

Fossils from localities across Fife could be the basis for a project on their context, and historical and scientific importance with potential for collaboration with other collections holding similar material, such as those managed by Fife Cultural Trust. A broader project could investigate fossils from localities across Scotland and the UK from the perspective of scientific importance, with potential for collaboration with numerous organisations holding similar material, including the Scottish University collections.

Figure 33: Fragments of a Carboniferous lycopod (Museums of the University of St Andrews)

Fife Collections Centre (Fife Cultural Trust)

Collection type: Local authority (Fife Cultural Trust)

Bankhead Park, Glenrothes, KY7 6GH
Contact: museums.enquiries@onfife.com

Location of collections
Several museums across Fife house collections although most of the stored material from the east, central and west local authority regions was centralised at the Fife Collections Centre in Glenrothes in 2017. The collections are managed by Fife Cultural Trust on behalf of Fife Council.

Size of collections
2,000 fossils.

Onsite records
Collection information is stored on a Ke EMu database; the majority of fossils have a basic entry and work is in progress to add additional details from MDA cards as part of a documentation plan.

Collection highlights
1. Fossils from the Fife area.
2. Fossils linked to Reverend John Anderson (1796-1864), Robert Dunlop (1848-1921), Reverend Dr John Fleming (1785-1857), James Wright (1876-1957), J Wood and D Nevey.
3. Fossils forming part of the Lauder Collection.

Published information
Woodward, A.S. (1915). Preliminary report on the fossil fishes from Dura Den. *Reports of the British Association for Advancement of Science, Australia*. 84:122-3.
Wright, J. (1950-1960). *A monograph on the British Carboniferous Crinoidea*. *Palaeontographical Society. London*. 1:1-190; 2:191-347.
Young, G.C. (2005). An articulated phyllolepid fish (Placodermi) from the Devonian of central Australia: implications for non-marine connections with the Old Red Sandstone continent. *Geological Magazine*. 142:173-186.

Collection overview
Fossils from Fife tend to be from the Carboniferous at Kinghorn, Woodmill, Charlestown, Roscobie, Dunfermline, Wemyss, Buckhaven, Bogie Mains, Inverteil and Seafield among other locations. The fossils include corals (*Lithostrotion*, *Favosites*, *Thysanophyllum*, *Lonsdaleia*, *Koninckophyllum*, *Dibunophyllum*), crinoids (many fragmentary specimens in limestone), gastropods (*Bellerophon*, *Platyostonella*, *Macrocheilus*), bivalves (*Nuculana* and others, and samples of mussel band), brachiopods (*Orthis*, *Productus*, *Athyris*, *Aviculopecten*, '*Lingula*', *Terebratula*), bryozoans (*Fenestella*), ostracods (*Cypricardella*, *Leperditia*), cephalopods (*Nautilus*), fish (*Rhizodus*) and plants (*Lepidodendron*, *Lepidostrobus*, *Pecopteris*, *Stigmaria*, *Calamites*, *Annularia*, *Sphenophyllum*, *Neuropteris*, *Sphenopteris*, one from the Coxtool bed, a large tree trunk and fossils described as bark and tree spores). In addition, there are examples of Carboniferous fossils from the Derbyshire, Yorkshire and Staffordshire coal measures and limestones.

Carboniferous fossils are attributed to specific collectors. The Robert Dunlop Collection is comprised of fossils from Woodmill, Dunfermline: gastropods (*Bellerophon*, *Euomphalus*, *Pleurotomaria*), scaphopod (*Dentalium*), brachiopods (*Productus*, *Chonetes*), cephalopods (*Cyrtoceras*, *Orthoceras*) and bivalves (*Nucula*, *Grammatodon*), and from Charlestown brachiopods ('*Orthis*', *Spirifera*), among other fossils from both localities. The James Wright Collection includes a variety of fossils, many without locality information: Corals (*Zaphrenoides*, *Cyathoxinia*, *Koninckophyllum*, *Dibunophyllum*, *Amplexizaphrentis*, *Rotiphyllum*, *Aulacophyllum*), crinoids (*Hydreionocrinus*,

Ulocrinus, *Eupachycrinus*, *Zeacrinus*, Platycrinus, *Poteriocrinus*, *Cocliacrinus*), gastropods (*Euomphalus*, *Mourkinia*, *Loxonema*, *Bellerophon*), sponges, bryozoans, arthropods (ostracod *Leperditia*, crustacean *Leaia*, phyllocarid *Dithyrocaris* and scorpion *Eoscorpius*) and echinoids (*Lepidesthes*). The Wright collection includes shark and fish fossils, for example, *Bothriolepis*, *Holoptychius*, *Eurynotus*, *Rhizodus* and *Petalodus*. Carboniferous fossils are also attributed to J Wood, D Nevey and Dr John Fleming (single *Aulophyllum* coral).

The Lauder Collection (assumed to be from the former Lauder College, Dunfermline) comprises fossils typical of well-known localities, mostly from outside Scotland and representing stratigraphic levels throughout geological time: Trace fossil *Oldhamia* from County Wicklow, Ordovician graptolite *Dictyonema* and trilobite *Angelina* from north Wales, bryozoan *Fenestella* from Halkyn Mountain (North Wales), Silurian Much Wenlock Limestone Formation (*Orthis*, *Cyathophyllum*, *Favosites*), Carboniferous Limestone from Derbyshire (with the crinoids *Actinocrinus* and *Encrinites*, and brachiopods *Productus* and *Rhynchonella*, etc), Jurassic ammonites *Aegoceras* from Whitby and *Quenstediceras* from Weymouth, *Pleurotomaria* from Dundry (Inferior Oolite), *Exogyra* and *Turritella* from Blackdown, *Ostrea*, *Raphidonema* and *Salenia* from the Faringdon Sponge Gravels (Lower Greensand, Cretaceous), Eocene Barton Beds (*Chama*, *Turritella*, *Volute*, *Murex*, *Typhis*, *Natica*, *Crassiatella*) and from Suffolk (molluscs *Mactra*, *Cardium*, *Lucina*, *Neptunea*, *Nassa*) among others. Fossils from Kent (*Terebratula*, *Belemnitella*, *Cidaris*, *Otodus*), Folkestone (*Acteon*, *Hoplites*, *Holaster*, *Natica*) and Isle of Wight (*Terebratula*) are probably Chalk.

Fossils from Fife are of the Upper Devonian fish *Holoptychius*, *Bothriolepis* and *Glyptopomus* in sandstone from Dura Den; some are figured due to excellent preservation. A specimen of the placoderm *Bothriolepis* shows a serrated leading edge on a front fin (Fig. 34) and seems to be the specimen drawn in mirror-image by Matthew Forster Heddle on display in the Bell Pettigrew Museum. The collection includes a painted cast of a placoderm fish, which matches an image in Young (2005, fig 2) described as the cast in the Australian National University Collection, Canberra, of the holotype of *Phyllolepis woodwardi*. The original was from Dura Den and described by Woodward (1915, fig 4). Another cast was observed in the Cockburn Museum (University of Edinburgh Collections).

Figure 34: Serrated front fin of an Upper Devonian placoderm fish *Bothriolepis* from Dura Den, Fife (Fife Collections Centre)

Other fossils stand out because they originate from further afield. Specimens from the Southern Hemisphere are *Phoulactus*, *Entellophylum* and *Mucophyllum* from the Middle Silurian Barrandella Shale Member of Yass, New South Wales, with a specimen of *Zenophyla* also likely to be from the same unit, *Thomnopora* from Tasmania, *Favosites* from the Middle Silurian Hume Limestone, *Disphyllum* from the *Receptaculites* Limestone, Middle Devonian of New South Wales, and a bryozoan from the Lower Marine Series of Harpers Hill, Hunter River Valley [Australia]. Specimens from the Palaeozoic of North America are *Tryplasma*, *Favosites* and *Quepora* (dated 1961?) from the Upper Ordovician Oakdale Formation of eastern Connecticut, *Tetroclium* from Ulrich, Trenton, Richmond, and *Homospisa* from Hartsville, Indiana. A fossil coral *Lambeophyllum* from Conrad Bridge Creek could be from Australia or North America.

There are specimens of silicified wood from Haifa desert, Egypt, petrified wood from Fort McMurry, Alberta, fossil wood from Arizona, copal from New Zealand, and Eocene leaf impressions from Bournemouth. A fossil of the trilobite *Ogygia* is from the Cambrian of Mount Stephen, British Columbia, however a *Spirifer* and *Encrinites* labelled with the same locality are more likely to be Carboniferous and their origin should be checked if possible. Other specimens to note are a *Clupea* (herring) from the Lagerstätte of Monte Bolca, Verona, Italy, the cast of an *Archaeopteryx* gifted when Glenrothes was twinned with Ingolstadt, the arthropod *Euproops*, *Carcharodon* shark teeth, an ichthyosaur fossil, coral *Phillipsastrea* from the Devonian of Torquay, a mammoth tooth from the River Medway and a petrified bird's nest from Knaresborough, Yorkshire.

Research/collection links
It would be interesting to know how the fossils from the southern Hemisphere and North America came to be in the collections, as well as further details of their origin.

St Andrews Museum (Fife Cultural Trust)

Collection type: Local authority (Fife Cultural Trust)
Accreditation: 2019

Kinburn Park, Doubledykes Road, St Andrews, KY16 9DP
Contact: standrews.museum@onfife.com (OnFifemuseums.enquiries@onfife.com)

Location of collections
St Andrews Museum is located in a nineteenth-century mansion house in the grounds of Kinburn Park. The collection was formerly part of the North East Fife District Museum Service and includes specimens from the Laing Museum in Newburgh. There is a single fossil on display with the remainder onsite in storage and at the Collections Centre in Glenrothes.

Size of collections
400-500 fossils.

Onsite records
Information is entered on a central KE Emu CMS for the Fife Cultural Trust venues. All the fossils onsite are included.

Collection highlights
1. Fossils from the Fife area.
2. Fossils linked to Robert Dunlop (1848-1921).

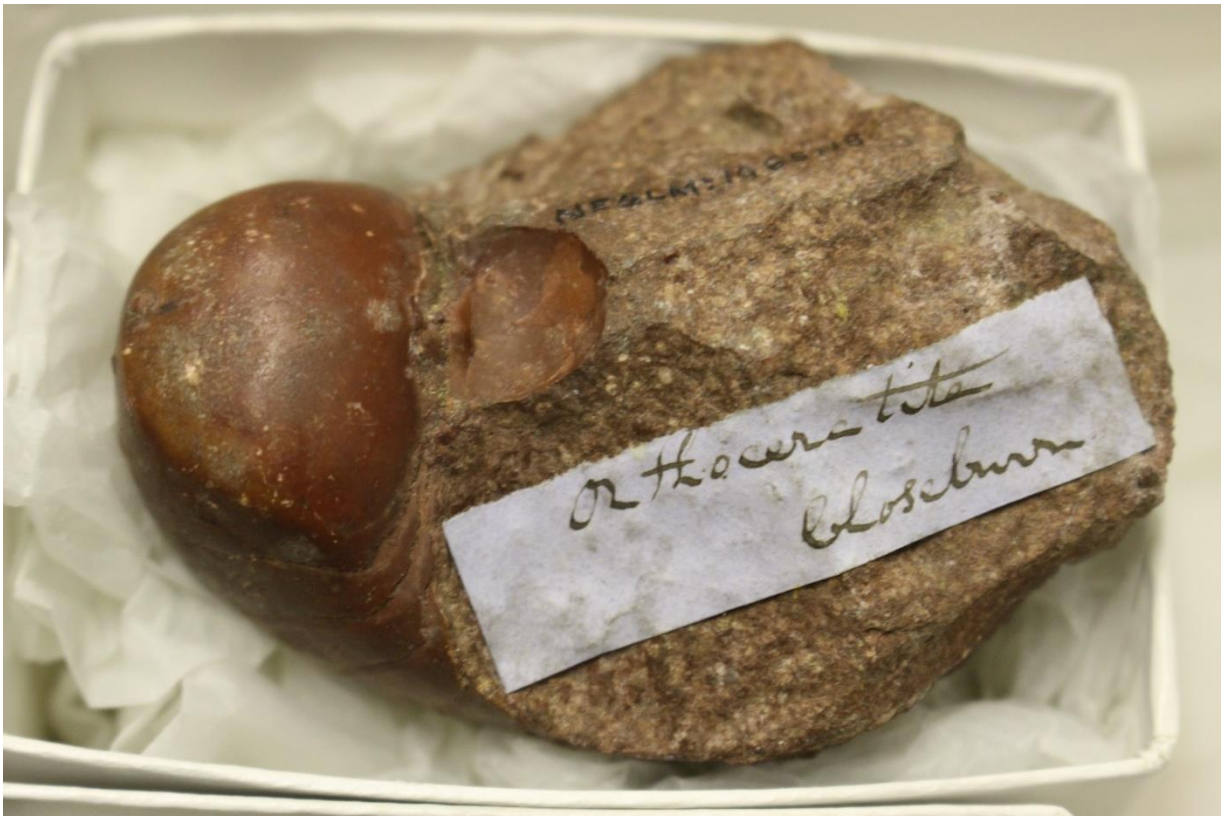

Figure 35: Carboniferous nautiloid *Orthoceratites* from Closeburn, Dumfries and Galloway (St Andrews Museum, ONFife)

Collection overview
The fossils in the collection are from two main stratigraphic levels: the Devonian and Carboniferous, although other levels are represented. Fossils from the Devonian are entirely fish, divided into those from the Middle Devonian, such as *Pterichthyodes* from Caithness, *Osteolepis* and *Glyptolepis*, and those from the Upper Devonian, represented by *Holoptychius*, *Bothriolepis* and *Glyptopomus* from Dura Den, *Pheneropleuron andersoni*, and a *Holoptychius* and indeterminate fish from Scaat Craig near Elgin, among other fragmentary fish remains.

The remaining fossils are almost entirely Carboniferous. A portion of the specimens labelled with origin are from Charlestown Quarry: Corals *Microcyathus*, *Dibunophyllum*, *Lithostrotion* and other rugose forms, spiriferid, productid and orthid brachiopods, crinoids including a set of fossils showing a calyx, arms and stems, bryozoans *Penniretipora* and *Fenestella*, bivalves, gastropods *Bellerophon*, *Palaeostylus* and indeterminate specimens, among others. Specimens also likely to be Carboniferous are of the bivalves *Wilkingia* (some from Duloch), *Lithophaga* (Isle of Man), *Carbonicola* and *Anthracospharium*, brachiopods identified mostly to order level: productids, spiriferids, orthids, rhynchonellid, terebratulida, lingulid and possible '*Lingula*' from Duloch, crinoid fragments, the corals *Aulaphyllum*, *Dibunophyllum*, *Zaphrentis*, *Lithostrotion*, *Lonsdaleia* and *Caninia* (Isle of Man), the gastropods *Euomphalus*, *Palaeostylus*, *Glabrocingulum* and several bellerophontids, cephalopods including an *Orthoceratites* from Closeburn (Fig. 35), orthoceratid from the Isle of Man, goniatites and other ammonoids, and trilobites from Laddedie, Fife, assigned to Phillipsiidae (Order Proetida), one preserved with a productid brachiopod. Carboniferous vertebrates are limited to several *Rhizodus* and a fish from Wemyss, Fife. Plant fossils are of *Cyclopteris*, *Neuropteris*, *Celodendron* (Forest of Dean, Gloucestershire), *Lepidodendron*, *Sigillaria*, a pteridophyte specimen and the thallophyte (group of fungi, lichens and algae, etc) *Metaspora*. There are many additional fossils, not identified or without locality information, that might also originate from the Charlestown Quarry locality and/or be linked to the collector Robert Dunlop (1848-1921).

The remaining fossils are Post-Palaeozoic. The Jurassic is represented by cephalopods (belemnites, orthoconic nautiloid, ceratites, ammonites *Perisphinctes* and *Hildoceras*), coral (*Isastrea* and scleractinian coral preserved with a pectin-like bivalve from Shotover, Oxford), gastropods (*Pleurotomaria* from Wiltshire), echinoids (*Echinocorys*, cidaroid, *Clypeus* and indeterminate echinoids), bivalves (*Ostrea*, *Trigonia*, *Neithea gibbosa*, *Calpitoria* and *Gryphaea* (some from Portree)) and a cast of the sponge *Siphonia*. Vertebrate fossils are of the fish *Pholidophorus beechi* from the Jurassic at Lyme Regis and an ichthyosaur. Other specimens from younger or unknown levels are of the gastropod *Aphorrais*, arthropods (cirripedes and Eocene crabs *Dromilites* and *Zanthopsis*), plants from Shanklin on the Isle of Wight, and *Serpula vermiculeris*. There is a mammal tooth, perhaps from a horse or other herbivore (Recent), and a whale ear bone from Suffolk described as a fossil fish.

Research/collection links
Collaborative projects could investigate the Devonian fish from Fife and/or the diverse Carboniferous fossils.

Kirkcaldy Galleries (Fife Cultural Trust)

Collection type: Local authority (Fife Cultural Trust)
Accreditation: 2019

War Memorial Gardens, Kirkcaldy, Fife, KY1 1YG
Contact: Kirkcaldy.galleries@onfife.com

Location of collections
The Museum opened in 1925 as part of the town's War Memorial with an extension in 1928 providing space for a library. The location has fossils on display but no storage, which is at the Collection Centre at Glenrothes.

Size of collections
5 fossils.

Onsite records
Fossils are on a KE EMu CMS centrally at the Fife Collections Centre.

Collection highlights
1. Fossils from the local area.

Collection overview
Fossils are the rugose coral *Dibunophyllum* from the Seafield Colliery at Kinghorn, productid brachiopod *Gigantoproductus*, the seed fern plant *Mariopteris* and trunk *Sigillaria*, and impression of mussel band bivalves from the Frances Colliery (Fig. 36), all Carboniferous in age.

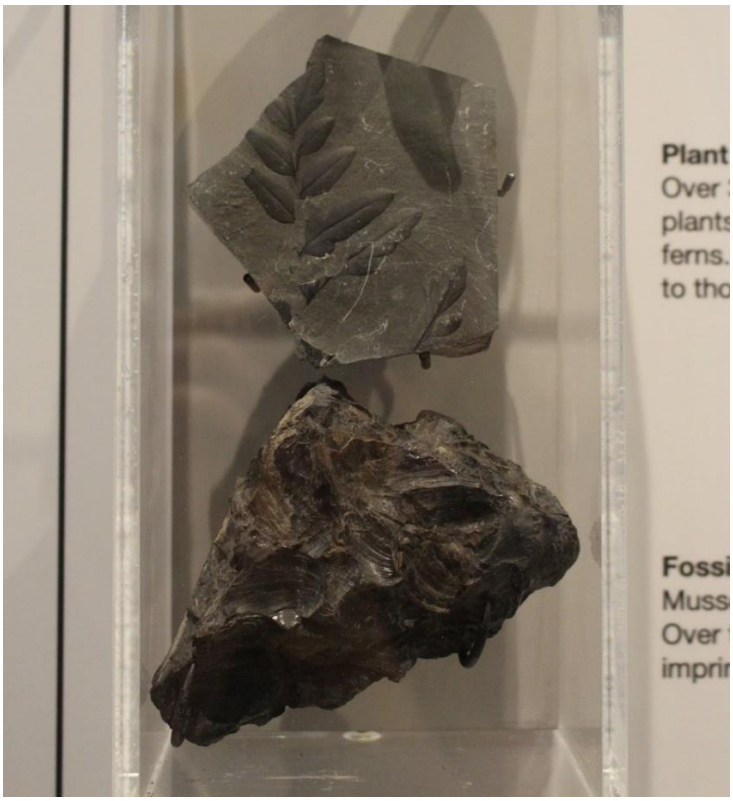

Figure 36: The Carboniferous plant *Mariopteris* (top) and bivalves in a mussel band (below) from Frances Colliery, Fife (Kirkcaldy Galleries, ONFife)

Falkirk Collections Centre (Falkirk Community Trust)

Collection type: Local authority (Falkirk Community Trust)

Museum store
Contact: callendar.house@falkirkcommunitytrust.org

Location of collections
The facility houses the stored collections of Falkirk Council, managed since July 2011 by Falkirk Community Trust. Stored collections are available for display at Callendar House, Kinneil Museum and other venues in the Falkirk area.

Size of collections
100-200 fossils.

Onsite records
Fossils are recorded on a Vernon CMS database with a photograph for each entry. An online collection database is available at: https://collections.falkirk.gov.uk/explore.

Collection highlights
1. Examples of Carboniferous fossils.

Figure 37: Bivalves in a Carboniferous mussel band (Collections of Falkirk Community Trust)

Collection overview
The fossils are almost exclusively from the Carboniferous in the local area, notably the River Avon and Bo'ness shore. Plant fossils consist of both identifiable forms and indeterminate fragments in matrix such as the moderately-sized pieces of *Lepidodendron*, *Calamites*, *Sigillaria*, *Alethopteris* and *Annularia*, several smaller fragments of similar plants and a smaller section of *Stigmaria* with

rootlets; one specimen is a large slab more than a metre across showing a mass of leaflets. Invertebrate fossils are the disarticulated crinoid ossicles and fragments of bryozoans, some occurring together, bivalves in mussel band (Fig. 37) and the coral *Zaphrentis* dated 1920. There are numerous small fragments of productid brachiopods, often difficult to identify as such, and specimens of the brachiopod '*Lingula*', a name under which many fossils have been placed in the interim or absence of a more accurate identification. Several trace fossils are described as worm burrows. Some of the fossils might be from the Hurlet Limestone, a bed used for correlation laterally. Other stratigraphic levels are represented by a few specimens, such as a shelly bioclastic rock possibly from the Cenozoic.

Detail of the Eocene fish *Diplomystus* and *Priscacara* from the Green River Formation, Wyoming.
Yvonne Cooper © Cockburn Museum

Review of Fossil Collections in Scotland

Edinburgh and Lothians

National Museums Scotland

John Ellerman Foundation

Edinburgh and Lothians

Haddington Museum Headquarters (East Lothian Council Museums Service)
Almond Valley Heritage Centre (Almond Valley Heritage Trust)
Cockburn Museum (University of Edinburgh Collections)
Anatomical Museum (University of Edinburgh Collections)
Natural History Collections (University of Edinburgh Collections)

Haddington Museum Headquarters (East Lothian Council Museums Service)

Collection type: Local Authority

41 Dunbar Road, Haddington, East Lothian, EH41 3PJ
Contact: elms@eastlothian.gov.uk

Location of collections
The Libraries and Museums Headquarters houses East Lothian Council's stored collections. Areas to display objects from the collections are available at the John Gray Centre Museum, Haddington.

Size of collections
35-40 fossils.

Onsite records
Information is recorded in a Modes CMS with entry forms for most items.

Collection highlights
1. Material from the Lothian Carboniferous shrimp beds, linked to Euan Clarkson.

Published information
Briggs, D.E.G., N.D.L. Clark, and E.N.K. Clarkson. (1991). The Granton 'shrimp-bed', Edinburgh — a Lower Carboniferous Konservat-Lagerstätte. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 82:65-85.

Collection overview
Fossils are in numbered boxes with other geological specimens. They include corals, brachiopods (*Eomarginifera*, productids and fossils labelled as *Atrypa* but probably a type of orthid brachiopod), bivalves (*Edmondia* and modern oyster), orthoconic nautiloids, gastropods (*Straparollus*), crinoids (usually disarticulated in limestone) and 'macaroni rock' (densely packed with coral, perhaps of the Carboniferous coral *Syringopora* from Barns Ness, Dunbar), most of which are Carboniferous. Several specimens of the shrimp *Tealliocaris* from the Carboniferous Granton Shrimp Beds are accompanied by a model. There are also samples of crinoidal and reef limestone showing fossil debris. Plant fossils include *Lepidodendron*, *Calamites* and *Stigmaria*, and several indeterminate fragments, some of which form part of the Spence Collection. Fossils of the MN Shiel Collection include corals labelled as *Lithostrotion* from Aberlady, ?*Koninckophyllum* and ?*Dibunophyllum* sp., crinoids (many water-worn and all labelled as Lower Carboniferous from Barns Ness 1921), and the brachiopod *Dictyoclostus* (perhaps also from Aberlady or Barns Ness area).

A handling box labelled 'Fossils and dinosaurs' contains large pieces of coral, the Jurassic ammonite *Dactylioceras*, an orthoconic nautiloid, brachiopods, crinoids, trace fossils in micaceous sandstone (the labels suggest *Rhizocorallium* although the identification needs confirming), dinosaur models and wooden cut-outs of dinosaur footprints, and a plaster cast of a complete ichthyosaur (half-size, small-sized adult or juvenile). Labels indicate fossil fish were recently transferred from National Museums Scotland for the handling collection.

Research/collection links
Shrimp fossils mentioning Euan Clarkson highlight a research link with the University of Edinburgh where similar material is located.

Almond Valley Heritage Centre (Almond Valley Trust)

Collection type: Independent
Accreditation: 2016
Recognised Scottish Shale Oil Collection: 2010

Millfield, Livingston, West Lothian, EH54 7AR
Contact: info@almondvalley.co.uk

Location of collections
Originally a watermill and farm, the buildings were saved from demolition in the 1960s and restored as a visitor attraction. Since 1990, the Heritage Centre has been managed by the Almond Valley Heritage Trust. Since 1982, the Livingstone Oil Museum has been the location of a growing heritage collection relating to shale mining and oil production, including the nationally important BP Archive. The Scottish Shale Oil Collection is Recognised by Museums Galleries Scotland as Nationally Significant to Scotland. Fossils are included in the collection and all specimens are on display.

Size of collections
30-40 fossils.

Onsite records
No formal system present.

Collection highlights
1. Vertebrate, invertebrate and plant fossils from the local Lower Carboniferous Oil Shale.

Published information
Smithson, T.R. (1993). *Eldeceeon rolfei*, a new reptiliomorph from the Viséan of East Kirkton, West Lothian, Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 84:377-382.

Figure 38: Carboniferous plant fossils on display (Almond Valley Heritage Centre)

Collection overview

As the Museum is focused on the shale oil industry in the West Lothian area, the fossils are almost entirely from the Carboniferous locally, specifically the Calciferous Sandstone Series. Plant fossils include *Calamites*, *Lepidodendron*, other fronds and indeterminate fragments (Fig.38). There are several large sections of tree trunk, possibly from the local area. Vertebrates are represented by the fish *Eurynotus*, *Mesopoma* and *Rhadinichthys* among others, with many in split nodules comprising part and counterpart pieces. Additional nodules contain coprolites (Fig. 39). There is also a rare fossil of the amphibian *Eldeceeon rolfei*, on long-term loan from National Museums Scotland. Invertebrate fossils include a eurypterid head, crinoid stem fragments, bivalves and corals.

Figure 39: A coprolite part and counterpart in a Carboniferous nodule (Almond Valley Heritage Centre)

Cockburn Museum (University of Edinburgh Collections)

Collection type: University
Accreditation: 2016

Grant Institute, Kings Buildings, West Mains Road, Edinburgh, EH9 3JW
Contact: Cockburn.museum@ed.ac.uk

Location of collections
The collection dates from Victorian times, after most of the original collection was donated to the Royal Scottish Museum (now National Museums Scotland). The Geoscience department moved from its original location in Old College to the Kings Buildings and Grant Institute in 1932. At the new location curation was undertaken on a voluntary basis by Dr Alexander Murray Cockburn (1901-1959), after whom the Museum was named in 1959. Fossils are stored in cupboards and storerooms in the Grant Institute and a second departmental building on campus.

Size of collections
The collection comprises 130,000 geological specimens, an unknown number of which are fossils.

Onsite records
Cataloguing and data enhancement in recent years has focused on the mineral collections with work on the fossils to follow. Documentation is present for fossil specimens that have been moved or loaned.

Collection highlights
1. Research material from the Pentland Hills, Girvan and wider Midland Valley.
2. Extensive collection of fish fossils, including Devonian and Carboniferous material.
3. Fossils linked to Reverend John Anderson (1796-1864), Charles Lyell (1797-1875), James Powrie (1815-1895), John Smith of Dalry (1845-1930), Arthur Smith Woodward (1864-1944) and James Wright (1876-1957).
4. Research collections attributed to Thomas Jehu (1871-1945) and Robert Campbell (1881-1957).

Published information
Aspen P. (2018). AM Cockburn, Curator of the Museum of Geology at Edinburgh University. *The Geological Curator.* 10:531-533
Briggs, D.E.G., N.D.L. Clark, and E.N.K. Clarkson. (1991). The Granton 'shrimp-bed', Edinburgh—a Lower Carboniferous Konservat-Lagerstätte. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh.* 82:65-85.
Bull, E.E. (1996). *Geology and palaeontology of the Telychian (Silurian), reservoir formation of the North Esk inlier, near Edinburgh, Scotland*. Doctoral dissertation, The Open University.
Bull, E.E., and D.K. Loydell. (1995). Uppermost Telychian graptolites from the North Esk Inlier, Pentland Hills, near Edinburgh. *Scottish Journal of Geology*. 31:163-170.
Clarkson, E.N.K., D.A. Harper, A.W. Owen, and C.M. Taylor. (1992). Ordovician faunas in mass-flow deposits, Southern Scotland. *Terra Nova*. 4:245-253.
Clarkson, E.N.K., D.A.T. Harper, and A.N. Höey. (1998). Basal Wenlock biofacies from the Girvan district, SW Scotland. *Scottish Journal of Geology*. 34:61-71.
Davies, L.M. (1943). Tertiary Echinoidea of the Kohat-Potwar Basin. *Quarterly Journal of the Geological Society*. 99:63-79.
Davies, L.M. (1926). Remarks on the known Indian species of *Conoclypeus*, with descriptions of two new species from the Eocene of North-West India. *Recent Zoological Survey of India*. 3:358-368.
Lyell, C. (1990). *Principles of Geology, Volume 1*. Chicago: University of Chicago Press.
Jehu, T.J., and R. Campbell. (1917). The Highland Border rocks of the Aberfoyle District. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 52:175-212.

Powrie, J. (1870). On the earliest known vestiges of vertebrate life; being a description of the fish remains of the Old Red Sandstone rocks of Forfarshire. *Transactions of the Edinburgh Geological Society*. 1:284-301.
Woodward, A.S. (1915). Preliminary report on the fossil fishes from Dura Den. *Reports of the British Association for Advancement of Science, Australia*. 84:122-3.
Woodward, A.S. (1920). Presidential address. *Proceedings of the Linnean Society of London.* 132:25–34.
Wright, J. (1950-1960). A monograph on the British Carboniferous Crinoidea. *Palaeontographical Society, London*. 1:1-190; 2:191-347.
Young, G.C. (2005). An articulated phyllolepid fish (Placodermi) from the Devonian of central Australia: implications for non-marine connections with the Old Red Sandstone continent. *Geological Magazine*. 142:173-186.

Collection overview

The fossils form main, research and teaching collections. The main collection comprises examples of many groups found as fossils for primary reference use. Vertebrate fossils include a large number of fish. The Lower Devonian is represented by cephalaspids from disparate origins across Scotland and the UK and numerous acanthodians from Turin Hill and Forfar (*Ichnacanthus*, *Mesacanthus*). A *Mesacanthus* from Turin Hill is among the specimens presented by James Powrie (1815-1895). *Rhamphodolepis threiplandi* is from the Edderton Fish Bed at Blackpark and a rock with fragmentary fish remains is from the Dartmouth Shale, Cornwall. Middle Devonian fish are from localities, many historic, across north east Scotland: Caithness (Achanarras, Thurso), Orkney (Toah), Nairnshire (Lethen/Lethen Bar), Shetland (Exnaboe), Moray (Tynet burn, Dipple Brae) and Gamrie (Banffshire, now included in Aberdeenshire), with fossils including *Stegotrachelos*, *Palaeospondylus*, *Pterichthyodes*, *Cheirocanthus*, *Mesacanthus* and *Osteolepis*. A fossil is labelled as the small Middle Devonian placoderm *Microbrachius dicki* named by Traquair. Fish from the Upper Devonian are from Dura Den, Fife, with specimens of *Bothriolepis* noted from Scaumenac Bay, New Brunswick, Canada, and Shoalhaven River, Araluen, Australia.

A noted fish specimen comprising several articulated and ornamented plates has two labels, the first reading '*Canobius microcephalus* from the Scottish Calciferous Sandstone Series, Broxburn' and the second '*Phyllolepis* Upper Devonian, near Elgin, Scotland' (Fig.40). The *Phyllolepis* identification is more likely, although not the origin, as the specimen matches exactly a *Phyllolepis woodwardi* in the Australian National University Collection, Canberra, figured in Young (2005, fig 2). The figured specimen is a cast of the holotype originating from Dura Den and described by AS Woodward (1915, fig 4). The consistent colour and edges of the specimen in the Cockburn Museum suggest this is also a cast.

Figure 40: The cast of the Upper Devonian *Phyllolepis* (left) and fragments of Middle Devonian *Millerosteus* from Thurso (right) (Cockburn Museum)

Other labels of interest are dated 1810 and 1813, with fish attributed to Prof Stewart (perhaps Sir Frederick Stewart, Regius Professor from 1956-1986). A fish from Caithness was presented by Mrs Gray 1886, several nodules are associated with the note 'Lethen Bar historically important' and others have been examined relatively recently by Bob Davidson. An interesting fossil is of an *Arandaspis* from the Middle Ordovician Stairway Formation of Mount Watt, Alice Springs, Western Territory of Australia. Silurian fish include fossils of *Lanarkia* and *Loganellia* from Muirkirk (Ayrshire) and Lesmahagow (Lanarkshire), a *Thelodus* from Smithy Burn and *Loganellia* from Shiel Burn, Monks Water, in the Hagshaw Hills, and the fragments of fish teeth, spines and scales preserved in the Ludlow Bone Bed from Ludlow, Shropshire.

The Carboniferous is represented by fossils from the 'Scottish Calciferous Sandstone Series' and Coal Measures. These include *Rhadinichthys* in Oil Shale from Broxburn, West Lothian, *Megalichthys*, *Rhizodus*, *Strepsodus, Plectrolepis (Eurynotus), Crenodus* (including a rib), and *Gyracanthus* spines from Gilmerton, Burdiehouse, Wemyss (Fife), Dalkeith and Burntisland among others; a *Gyracanthus* is from the Rag Mine Ironstone Shale of Fenton. Permian fossils are from the Marl Shale of Durham (*Palaeoniscum* and other palaeoniscids), which is equivalent to the Kupferschiefer Formation of Germany, also represented by examples of *Palaeoniscum*. A fossil of the fish *Palaeoniscum wratislavensis* is from the Kohlenkalk of Bohemia with 'Krantz & co in Berlin' mentioned on the label. These specimens are observed with labels for '*Palaeoniscus*', an incorrect spelling of the generic name. There is also a lungfish, *Gnathorhoriza* sp., from the Permian Wellington Formation in a tributary of Black Bear Creek, Oklahoma. The teeth of the sharks *Acrodus* and *Hybodus* and scales of *Gyrolepis* are preserved in the Triassic Rhaetian Bone Bed from Tübingen. Other fossils are from the Jurassic Solnhofen Limestone of Germany and Liassic of Lyme Regis, and Eocene Green River Formation of Wyoming (*Diplomystes* and *Priacara*) (Fig. 41), London Clay from the Isle of Sheppey and Monte Bolca of Italy (*Lepisosteus*). Further specimens are from Bohemia, Denmark, Australia and Cornwall.

Other vertebrate fossils are a placodont tooth (Triassic), shark teeth (various ages including Portlandian), fossils from the Jurassic Stonesfield Slate of Oxfordshire, a Jurassic ichthyosaur, several vertebrate casts (notably a pterosaur) and Recent mammal bones (mammoth tooth, horse teeth, jaws and other fragments, fox and dolphin). A large wall-mounted ichthyosaur cast has a label reading 'Ichthyosaur (Ichthyosauria or Ichthyopterygia) Lyme Regis, Dorset, England This is a primary cast of an aquatic reptile from the Lower Jurassic to Late Cretaceous period. The original ichthyosaur formed part of the Cockburn Museum Collection until it was auctioned in 1970'.

Invertebrates are represented by crinoid fragments from the Carboniferous, German Muschelkalk and Jurassic of Dorset. A crinoid specimen labelled as *Woodocrinus liddesdalensis* from Penton Linns, Liddesdale, is attributed to James Wright. Echinoderms include starfish and echinoids mainly from the Jurassic (*Clypeus*), Cretaceous, Cenozoic (Kohat Potwar Basin, LM Davies Collection) and Recent; one specimen comprises the plates and spines of *Archaeocidaris urei* from the Abden Limestone of Kinghorn, Fife. Trilobites are represented by most of the main groups: agnostids, paradoxidids, *Olenellus*, *Trinucleus*, Opisthoparia, asaphids, *Ogygia* and phacopids (*Phacops*, *Dalmanites*, *Calymene*) from localities including Girvan (Ladyburn), Shropshire (Shineton, Cheyney Longville), Wales (Llandeilo), County Tyrone (Northern Ireland), Ross-shire (*Olenellus*), Bohemia, Scandinavia, Alabama, British Columbia and Iowa. Additional arthropod groups are also represented by the eurypterid *Pterygotus*, fossils of *Aeger*, *Eryon*, *Penaeus* and *Limulus* from the Solnhofen Limestone, and crustaceans from the Isle of Wight. Bryozoans have a wide geological and geographic range with examples of *Fistulipora* from Roscobie (Fife), *Cryptostomata* from Gilmerton and Castleton, *Rhabdomeson* from Ayrshire and *Fenestella* from the Magnesian limestone of Thuringen, Germany, among others. Brachiopods include linguiliforms (mostly *Lingula*, several in core samples) and representatives of the articulated productids, spiriferids, terebratulids and rhynchonellids from as far back as the Cambrian, although later geological periods are better represented. Silurian brachiopods from England and Wales include *Leptaena* from Dudley and *Atrypa* and *Rhynchonella* from the Much Wenlock Limestone Formation. Devonian brachiopods include *Athyris*, *Leptaena*, '*Orthis*' and *Gypidula* from Gerolstein (Eifel), Pattrath, Cologne, and

Gand near Harz (Germany), and several examples of *Cyrtospirifer verneuili* from Trebarwith Strand, near the Delabole Slate Quarry, Cornwall, where they are known as 'Delabole butterflies'. Carboniferous taxa are especially diverse: *Schizophoria* and *Productus* from Beith, *Productus* from Aulm[ar], *Buxtonia* and *Spirifera* from Potmetal (Kirkcaldy), *Pugnax* from Roscobie (Fife), *Syringothyris* from Barrowdale (Carr Collection) and *Pustula* from Crichton and Whitefield. Other stratigraphic levels are represented: the Permian (Magnesian Limestone from Sunderland), Inferior Oolite (*Aulacothyris*, *Plectothyris*, *Loboidothyris* from Gloucestershire and Somerset among other localities), Greensand, Cretaceous Chalk, including the Red Chalk of Hunstanton, the Eocene London Clay and Pliocene-Pleistocene Red Crag. Several drawers of brachiopods contain 'foreign material', with labels for Germany (Muschelkalk), America and Sweden. The collection includes samples of the Entomostrachan Shale.

Named corals are *Thamnastria*, *Astrea*, *Stylina*, *Asterophyllum*, *Cyclolites*, *Thecosmilia*, *Montlivaltia*, *Heliolites*, *Syringopora*, *Halysites*, *Favosites*, *Thamnopora*, *Alveolites*, *Cyathophyllum*, *Ketophyllum*, *Arachnophyllum*, *Heliopora*, *Diphyllum, Omphyma*, *Heliopora*, *Cyathophyllum*, *Acervularia*, *Ketophyllum*, *Phillisastrea*, *Sphenotrochus*, *Isastrea* (Jurassic) and *Turbinolia* (Gault of Folkestone), with other corals from the Red Crag of Suffolk; these cover typical taxa from throughout the geological timescale, especially the Silurian, Carboniferous and Jurassic. One coral has a label 'Epis. Corallien Wilts, F.H. Burier 1892'. Lower numbers of fossils represent stromatoporoids, stromatolites, foraminifera, diatoms, radiolaria and sponges, notably *Raphidonema* and *Barroisea* from the Cretaceous Faringdon Sponge Gravels with taxa from the Jurassic (Lyme Regis), Cretaceous Greensand and Chalk, and Pliocene among others.

Figure 41: The ray-finned fish *Diplomystus* and *Priscacara* from the Eocene Green River Formation, Wyoming (Cockburn Museum). Yvonne Cooper © Cockburn Museum

Mollusc fossils are primarily bivalves with examples from the Silurian, Devonian, Carboniferous (Castleton, *Pterinopecten* from North Staffordshire and *Anthracomya* from Patricroft, Manchester), Permo-Triassic, Jurassic (*Pholadomya*, inoceramids, *Trigonia* from the Oxford Clay at Weymouth and *Astarte* from the Inferior Oolite), Cretaceous (Wealden including *Cyrena* from Netherfield, *Nucula* from the Gault at Folkestone, *Callita*, *Plana* and *Cyprina* from the Upper Greensand at Blackdown, Devon, and *Barbatia* from the Lower Greensand at Atherfield, Isle of Wight). Paleocene

bivalves are from the Thanet Sands, with a wide range from the Eocene Barton Beds of Barton, Hampshire (*Meretrix*, *Ostraea*, *Crassitella*, *Cardium* and *Pecten* among others), Bracklesham Beds on the Isle of Wight, and London Clay of Bognor Regis and Isle of Sheppey. Fossils from the Headon Beds represent the Oligocene and Coralline Crag. Pliocene-Pleistocene Red Crag bivalves *Mya*, *Cardium*, *Tellina*, *Mactra*, *Unio* and *Leda* are from Norwich and Suffolk. Gastropod fossils have a similar range with specimens from the Silurian, Devonian, Carboniferous, Jurassic and Cretaceous. Eocene gastropods are from the Barton Beds (*Cassis*, *Natica*, *Pleurotomaria*, *Murex*, *Ancilla*, *Voluta*, *Cancellaria*, *Conus*, *Mitra*, *Paludinia* (Isle of Wight) and *Cerithium*). Pliocene-Pleistocene gastropods are from the Red Crag (*Nassa* from Orford Castle, *Nassa* and *Voluta* from Sutton in Suffolk and other non-localised *Natica*, *Neptunea*, *Littorina* and *Cerithium*) with *Buccinum* from the Norwich Crag, *Melanopsis* from the Miocene of Baden near Vienna and a *Planorbis* from an Upper Miocene freshwater lake. The gastropod *Hipporites* originates from localities in the UK and Untersberg on the German-Austrian border. Various geological ages are represented by scaphopods (*Dentalium* from the Eocene Barton Beds) and serpulids (*Serpula antiquata* from the Gault of Folkestone) with several casts of the latter. Cephalopods include goniatites and nautiloids from the Carboniferous of Derbyshire (Castleton) and Yorkshire, nautiloids from other stratigraphic levels, Jurassic belemnites, and ammonites from the Jurassic (Liassic, Oolite) and Cretaceous (Greensand, Gault, Chalk) among other levels.

Plants are almost entirely Carboniferous: *Calamites*, *Asterophyllum* and *Annularia* from Burdiehouse, *Lepidodendron*, *Telangium, Alethopteris, Sigillaria*, *Stigmaria*, *Lipidophyllum*, *Neocalamites*, *Neuropteris*, *Lepidostrobus*, cycads and seed cones, with thin sections and cut rock, coal balls from Burnley and opalised wood from various localities and ages.

Fossils from the collection are presented in themed displays, for example, *Early Life on Earth* shows various Ediacaran (*Charnia masoni* and *Charniodiscus concentricus* from the Precambrian (560 million years ago) of Leicestershire, and *Tribrachidium heraldicum*, *Spriggina floundersi*, several *Dickinsonia*, *Cloudina hartmannae* and *Parvancorina* from the Precambrian (555 million years ago) of the Ediacara Hills, Australia). *Permian Mass Extinctions* shows the early Triassic ammonoid *Flemmingites* sp. from Oman and the crinoid *Encrinus gracilis* from the Middle Triassic of Recoaro Terme, Vicentia, Italy.

The research collection comprises material accumulated for staff and student projects with some attributed to specific workers and projects, for example, ‘Clarke WJ Scots Carb Conodonts’, ‘Hallum Swett/Ritchie/Brower’, ‘John Campbell’, ‘Jehu and Craig Highland Border Series’ (Thomas Jehu, Regius Professor 1914-1943), ‘John Smith of Dalry specimens’ and ‘Anderson MORS Caithness fish’ (Reverend John Anderson, 1796-1894). Material highlights studies of Precambrian Ediacara, Cambrian trilobites from Wales (Maesgwynne, Llanfawr Quarry), the Cambro-Ordovician of Durness (north Scotland) and France, a comparison of graptolites from Scotland/UK and Australia, Ordovician olenid trilobites, such as *Ogygiocaris*, from the *Ogygiocaris* Shale of Holz, Oslo and other locations in Scandinavia, Downtonian (Silurian) Cowie Formation from Stonehaven and Sally Brow and Foggy Gill (Cautly Zone, Pusgillian), Crossfell Inlier of Cumbria.

Material from the Southern Uplands of Scotland includes Wandel Burn fossils in mass flow deposits (Clarkson et al 1992), graptolites from Dob’s Linn (Hartfell shales) and other Lower Ordovician localities, Ordovician of the Girvan area (Starfish Beds at Ladyburn, Barr Group), Caradoc Upper Whitehouse Beds and rocks at Penwhapple Bridge), the Silurian of the Girvan area (Rough Neuk Quarry, Craighead Quarry and Newlands Quarry), Llandovery (Silurian) from Old Cambus Quarry, and the Llandovery Gala Group from the Southern Uplands.

Various faunas are from the Silurian of the Midland Valley: The Patrick Burn Formation ‘Shelly Fauna’ from the Lesmahagow Inlier, the Hagshaw Hills and Lesmahagow turbidite fauna, and the North Esk Inlier (and perhaps other inliers) in the Pentlands. Other Silurian fossils are from the Starfish Beds in the Cutter Formation, Henshaw Burn Junction and Deerhope Burn in the Pentlands, with the fossil *Pterotheca* noted. Fossils from the Wether Law Linn and Reservoir formations

(brachiopods *Eoplectodonta*, *Dicoelosia*, *Atrypa*, *Skenidioides*, *Leptaena* and *Orbiculoidea*, trilobites, bivalves and ostracods) may be from the same area (Bull 1996). There are fossils of the Knockgardiner fauna from the Wenlock (Silurian) Straiton Grit Formation of Ayrshire. There is an important collection of material with thin sections from the Rhynie Chert of Aberdeenshire, known for primitive plants among other fossils, attributed to Robert Campbell (1881-1957).

Devonian material includes fossil fish from Scotland (Lower Devonian acanthodians, and Middle Devonian *Glyptolepis* and *Pentlandia*) and rest of the UK (*Pteraspis* from the Lower Devonian of England and Wales). Carboniferous material is labelled as being from the Oil Shale, notably the Granton Shrimp Bed (Fig. 42, known for shrimp fossils such as *Waterstonella* and the first fossil revealing the complete conodont animal known previously only from teeth, with extensive bulk material for future processing) and East Lothian Gullane Shrimp Bed (polished vertical sections showing the laminations with further examples of the shrimp *Tealliocaris*). There are multiple examples of the brachiopod *Eostropheodonta hirnantensis* from the Lower Carboniferous of East Lothian. Fossils include trilobites from the Arnsbergian (Carboniferous) Shunner Fell Limestone/Formation, Yorkshire, attributed to Euan Clarkson with several noted as figured. Material from the Llandovery (Silurian) is from Fauldbog Bay (Kirkcudbrightshire, Dumfries and Galloway) and Kirkton, near Dumfries. Samples of the Coralline Crag from Aldeburgh represent one of very few studies on post-Palaeozoic material. Specimens from beyond the UK are from the Carboniferous of Francis Creek, Illinois, USA. The age and location of several samples is unclear: ‘L. Pal Lakes Sheila Bibby’ with a second label that possibly reads graptolites, ‘Penceris Quarry’, ‘Caradoc Snow Head’ dated 1997 and ‘Silurian [Roquemeillere]’.

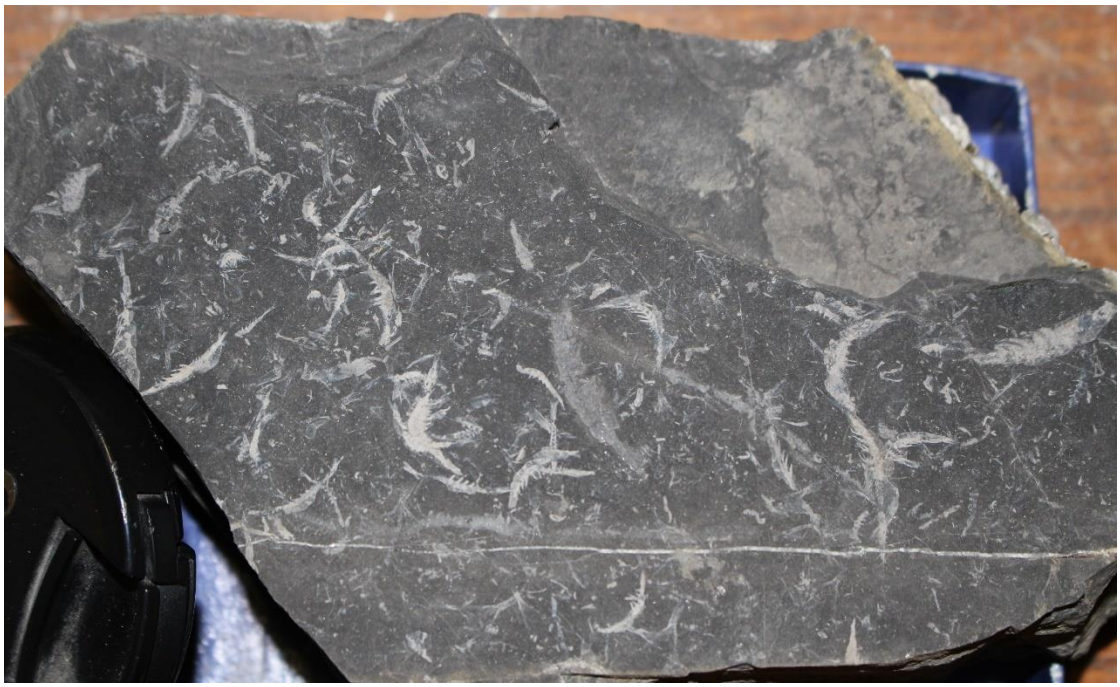

Figure 42: Carboniferous shrimps from the Granton Shrimp Bed, Edinburgh (Cockburn Museum)

Fossils in the teaching collection are recognised by the occurrence of multiple specimens of the same fossil taxa: brachiopods (orthids from the Silurian, spiriferids from the Devonian, productids from the Carboniferous, Jurassic and Cretaceous, rhynchonellids), echinoids, graptolites (mostly *Monograptus*, *Dicranograptus* from the Birkhill shale of Dob’s Linn and *Dichograptus octobranchius* from Campbelltown, Victoria, Australia, among others), trilobites (*Harpes*, *Ogygiocarella*, *Agnostus*, *Paradoxides*, *Calymene*, *Dalmanites* and *Bollandia*, etc), gastropods, bivalves and goniatites (*Glyphoceras* from the Carboniferous Limestone of the Isle of Man). Corals are often cut to show

internal detail with examples of *Thecosmilia*, *Syringopora*, *Lophophyllidium* and *Halysites*, and colonial taxa in limestones from the Silurian and Carboniferous. Casts, notably of the trilobite *Calymene*, echinoids and ammonites, are present. 'Bivalves: teaching sets' comprise *Gryphaea*, *Venericor*, *Cyprina*, oysters, *Pteriomorpha*, *Pecten*, *Solen*, *Mytilus*, some in resin for studies of morphological and anatomical features. Other labels indicate primitive molluscs (scaphopods and chitons), cephalopods (modern nautilus, ammonites and gastropods), bryozoans and sponges. Trace fossils show *Helminthoides* from the Alpine Flysch, *Spirophyton* from the Lower Carboniferous Limestone near Dunbar and *Rhizocorallium*. The trace fossil *Kulindrichnus* is a burrow for living in, as opposed to feeding, lined with shells, known only in modern terebellid worms and cerianthid sea anemones; one example is *K. langii* from Camas Malag. Assemblages or groups of fossils from the same deposits highlight palaeontological aspects, such as benthic palaeocommunities (Ashgill (Ordovician) Boda Reef Limestone of Sweden), biofacies and preservation (Lower Carboniferous Granton Shrimp Bed), and case studies (Ordovician/Silurian of Girvan; Silurian of Ludlow; Ordovician tuff fauna from Cwar-Glas, Dyfed, Llandrindod Wells; Ordovician of the Onny Valley, Shropshire).

Research/collection links

Many specimens are historic and/or related to scientific study and are therefore important. There is still bulk material in the collection waiting to be sorted, processed for fossils and studied, providing the potential for future projects. For example, Euan Clarkson has provided a large collection of trilobites (from Wales and Shunner Fell) and rock from East Kirkton and the Granton Shrimp Bed excavated in mass, although fossil content is not known. Some of the trace fossils seem to be rare, notably the fossil labelled *Kulindrichnus*. A summary project on phyllolepid fish – their distribution, preservation and importance, and current location of specimens – would be interesting and could include the cast of *Phyllolepis* in the Cockburn Museum and second in Fife Cultural Trust collections.

Anatomical Museum (University of Edinburgh Collections)

Collection type: University
Accreditation: 2016

Medical School (Anatomy), Teviot Place, Edinburgh, EH8 9AG
Contact: anatomy.edinburgh@ed.ac.uk

Location of collections
The Anatomical Museum is closely linked to the Edinburgh Medical School founded in 1726 and originally located at Old College. With increasing student numbers, a purpose-built medical school was constructed in Teviot Place, which opened in 1880. The Anatomical Museum within this, situated on three floors, opened in 1884. In the 1950s this space was reduced to the upper floor, the site of the current museum. The core of the collection comprises anatomical preparations and donations for medical studies, some dating back to the 1700s. The small number of fossils are stored in a basement room.

Size of collections
10-20 fossils.

Onsite records
Information is currently in Microsoft Excel and a museum card index system, in the process of being transcribed to a Vernon CMS, used more widely for the University collections. Specimens are also included in the Simpson Inventory, a typed list of the collection made in the 1990s by technician Jean Simpson, and the Saunders Catalogue.

Collection highlights
1. Historic specimens.

Published information
Turner, W. (1912). *The marine mammals in the Anatomical Museum of the University of Edinburgh.* Edinburgh: Macmillan.

Collection overview
Most of the fossils are vertebrate: a tooth described as a *Gorgosaurus* (although the shape looks ceratopsian or hadrosaur), a tooth of the rhino *Diceratherium* (without locality but probably from a gravel or cave deposit), a partial horse jaw with the teeth painted white, and an isolated tooth with enamel. Several fossils are from the Mentone bone caves in France (Fig. 43): two teeth and a bear metacarpal with information handwritten directly onto the fossils in French. Fragments of deer skeleton are also labelled as Mentone with additional information noting their donation by Dr Cumming; further teeth may or may not be from the same locality.

The collection includes several casts and models from Damon and Co (perhaps the firm of Robert Ferris Damon (1845-1921) described as anthropological cast makers), including a cast of a *Stegodon elephantoides* (Clift's elephant) tooth and an associated label referring to a family tree diagram for elephants, perhaps on display at the time. A further mastodon tooth has a label affixed reading 'from Beaufort South Carolina, presented by Dr Batty Duke' with a second label stating it is genuine (other associated specimens are noted as casts) and still being researched (Fig. 44). A final specimen is the lower jaw of a whale that is perhaps juvenile. The label describes it as being found 5 metres down in clay soil during excavations for brick-making near Stirling in 1863. Although it is labelled as a fossil, its age and preservation make it a sub-fossil. The collection also includes over 200 casts (mostly skulls, bones and axes) relating to human evolution, for example, *Homo neanderthalensis*, Chapelle-Aux-Saints, Cro-magnon, *Australopithecus africanus*, *Pithecanthropus*, *Sinanthropus*, *Rhodesiensis*, *A. Africanus Taungs*, and Piltdown man, mostly attributed to F Krantz.

Research/collection links
Studies of the mastodon tooth from Beaufort South Carolina, presented by Dr Batty Duke, are suggested. Although the label states it is a genuine fossil, the form of the black-coloured ridges on the processing surfaces and the coating of sandy, yellow-coloured grains suggest that this may be a cast or reproduction. Examination of the specimen could be followed up with further investigation of the collector and the excavations to determine context and whether other material was recovered from the same locality.

Figure 43: Mammal teeth and bone fragments from the Mentone Bone Caves, France (Anatomical Museum)

Figure 44: Detail of Mastodon tooth from Beaufort, South Carolina (Anatomical Museum)

Natural History Collections (University of Edinburgh Collections)

Collection type: University

Department of Zoology, Ashworth Buildings, University of Edinburgh
Contact: See website for email addresses https://www.ed.ac.uk/visit/museums-galleries/natural

Location of collections
The Ashworth Laboratory building was opened by Prince George, Duke of Kent, on 15 May 1929 with subsequent modifications to provide teaching space, notably the removal of a wall to incorporate the lower part of the museum into the laboratory. Many of the display cases were moved into the upstairs gallery, now known as the Aubrey Manning Gallery (in honour of the Professor of Natural History from 1973-1997) or department corridors; some specimens are no longer onsite. Parts of the current displays are from the 1920s and include limited fossil material.

Size of collections
5-10 fossils.

Onsite records
Documentation has mainly been undertaken through projects: In 1987 the Community Programme Unit within the Department of Zoology was funded by the Manpower Services Commission to update the displays and digitise the existing catalogue. In 1996 and 1997, Zoology students updated the vertebrate displays and expanded the website by adding a history of the museum and collection, and *Virtual Museum* for the displays in the Aubrey Manning Gallery: http://www.nhc.ed.ac.uk/index.php?page=493).

Collection highlights
1. Comparison of modern and fossil specimens of vertebrate groups.

Collection overview
This location was not visited by the JEPC, although the high level of information for the Aubrey Manning Gallery online allowed fossil material to be identified. Fossils are used to illustrate forms of modern groups as they were back in geological time. Vertebrates are represented by the fish *Palaeospondylus gunni*, the fossilised tooth of a large shark, such as *Carcharodon megalodon*, a slab of Upper Devonian sandstone with *Holoptychius* from Dura Den, Fife, and four fossils without visible labels to identify them. Models of fossils are more numerous than actual fossils with reconstructions of *Pteraspis*, *Climatius*, *Pterichthys*, *Osteolepis*, *Elonichthys* and *Eusthenopteron* present with modern fish. There is a cast of a *Pterodactylus* pterosaur from the Jurassic Solnhofen Limestone. Additional fossils are likely to be in the displays of invertebrate material but could not be determined from online resources.

Detail of the Jurassic ammonite *Angulaticeras greenoughi* from Lyme Regis, Dorset. Paisley Museum.
Image copyright of Renfrewshire Leisure Limited

Review of Fossil Collections in Scotland

Glasgow and Strathclyde

National Museums Scotland

John Ellerman Foundation

Glasgow and Strathclyde

Dick Institute (East Ayrshire Leisure)
John Pollock Collection Centre (South Ayrshire Council Museums and Galleries Service)
McKechnie Institute (South Ayrshire Council Museums and Galleries Service)
Isle of Arran Heritage Museum (Isle of Arran Museum Trust)
Low Parks Museum (South Lanarkshire Leisure and Culture)
Biggar and Upper Clydesdale Museum (Biggar Museum Trust)
McLean Museum and Art Gallery (Inverclyde Council)
Paisley Museum (Renfrewshire Leisure)
Zoology Museum (University of Glasgow)
The Hunterian (University of Glasgow)
Glasgow Museums Resource Centre (Glasgow Life)
Kelvingrove Art Gallery and Museum (Glasgow Life)

Dick Institute (East Ayrshire Leisure)

Collection type: Local authority (East Ayrshire Leisure)
Accreditation: 2017

Elmbank Avenue, Kilmarnock, Ayrshire, KA1 3BU
Contact: info@eastayrshireleisure.com

Location of collections
In the late 1800s James Thomson, a local fossil collector, offered the town council his collection on condition that a museum was created to store and display it. Elmbank House, built as the Sheriff Hall in 1792 and later used as the Free Library, was considered too small and demolished, with the new building on the site funded by James Dick (1823-1902) and designed by architect Robert Ingram, both born locally. The Dick Institute opened in 1901 and other collectors began donating their objects; many acquisitions came from the Glenfield Ramblers, notably archaeological specimens linked to member Archibald Fairbairn (1867-1945). The building was badly damaged by fire in 1908 and much of the collection lost. The Institute re-opened in 1911.

Size of collections
2,100 fossils.

Onsite records
Information is in an Access CMS with entries also on a CARDBOX catalogue on DOS. The natural science collection underwent a 'rapid inventory' in the last 10 years; red dots on the front of drawers and individual boxes/bags for each specimen indicate inclusion.

Collection highlights
1. Carboniferous fossils including corals, linked to John Hunter-Selkirk (1835-1898) and James Thomson (1823-1900).
2. Eurypterid fossils from the Silurian of Lesmahagow and other Midland Valley localities.
3. Type and figured material.

Published information
Dunlop, R. (1910). III. The Fossil Amphibia in the Kilmarnock Museum, previous to the Fire of 1909. *Transactions of the Geological Society of Glasgow*. 14:60-64.
Gregory, J.W. (1917). XII. Thomson's Genera of Scottish Carboniferous Corals. *Transactions of the Geological Society of Glasgow*. 16:220-243.
Hunter, J.R. (1865). XXV. Exhibition of Brachiopoda and *Gyrolepis Rankinii* from Braidwood Limestone. *Transactions of the Geological Society of Glasgow*. 2:54.
Lomax, D.R., J.C. Lamsdell, and S.J. Ciurca. (2011). A collection of eurypterids from the Silurian of Lesmahagow collected pre-1900. *Geological Curator*. 9:331-348.
Ross, A.J. (2010). A review of the Carboniferous fossil insects from Scotland. *Scottish Journal of Geology*. 46:157-168.
Ross, A.J. (2017). Insect evolution: the origin of wings. *Current Biology.* 27:113-115.
Trewin, N.H. (2013). *Scottish Fossils*. Edinburgh: Dunedin Academic Press.

Collection overview
The collection includes molluscs (cephalopods, bivalves, gastropods), arthropods (trilobites, crustaceans, arachnids, myriapods, insects), echinoderms (echinoids, brittle stars), corals (many linked to James Thomson), brachiopods, graptolites, bryozoans, chitons, porifera (*Chaetetes*), vertebrates (amphibians, reptiles, fish), microfossils (foraminifera) and plants (Fig. 45). Within each group there is a broad distribution in terms of geographic and stratigraphic origin, although many are from the Carboniferous, reflecting the local geology and interest of local collectors. Carboniferous corals are highly numerous with origins noted as Ayrshire, Fife, Lanarkshire, Lothian, Eifel,

Germany, Canada, Estonia and Sweden; samples from Worcestershire (the Much Wenlock Limestone Formation, specifically from Dudley) are Silurian. A collection of corals, brachiopods, bivalves and nautiloids from the nearby Deans Park Quarry is also present. Carboniferous plants include various leaves, seeds and cones, with fish collected in Ayrshire (Muirkirk, Lugton, the River Avon at Stenhouse near Cumnock and Crosshouse), Edinburgh (Gilmerton, Burdiehouse) and Lanarkshire (Hamilton) among others. *Rhizodus* teeth are from Gilmerton with large *Gyracanthus* spines and shark teeth from Ayrshire and Lanarkshire; some of the shark teeth are from the Cenozoic of America (*Carcharodon*, etc). Noted fossils are the oversize, proportionally complete but fragmentary remains of two *Megalichthys* fish from Crosshouse, and specimens of the early jawless fish *Lasanius problematicus* (Late Silurian) and *Birkenia elegans/*sp. (Middle Silurian) from Muirkirk. A fossil of the Carboniferous insect nymph *Idoptilus peachii* (Woodward, 1887) is a holotype, re-described by Ross (2010) and figured by Trewin (2013) and Ross (2017). Fossils from other stratigraphic levels include eurypterids from Silurian Inliers of the Midland Valley (notably two large examples of *Slimonia*), ostracods from Ayrshire and Lanarkshire, graptolites from Dob's Linn, Dumfries and Galloway, and fragments of Triassic rhynchosaurian vertebrates from Cheshire.

Figure 45: A drawer of invertebrate fossils from various geological periods (Dick Institute)

Post-Mesozoic material tends to be from outside Scotland, for example, echinoids from the south of England or the European continent. Additional gastropods, bivalves and ammonites are labelled Weymouth, Leicester, Northamptonshire, Folkestone, Sheppey, etc, where mostly Mesozoic (Liassic, Oolite) and Cenozoic (London Clay) rocks are found. Two boxes labelled 'Earth Sciences' contain similarly disparate fossils: (1) Carboniferous corals, plants, brachiopods, orthoconic nautiloids, shark teeth, ammonites, Jurassic brachiopod, conularid worm tubes, Cenozoic gastropod *Turritella* and a distorted *Euomphalus* gastropod from the Carboniferous and (2) Carboniferous bivalves, brachiopods, shark teeth, corals and *Bellerophon* gastropods, Jurassic ammonites (*Dactylioceras*) and belemnites, claws labelled as *Velociraptor*, hippo teeth, an echinoid and a large acanthodian spine.

Research/collection links

Fish fossils of *Birkenia* were recently examined by a student at the University of Manchester for research.

John Pollock Collection Centre (South Ayrshire Council Museums and Galleries Service)

Collection type: Local authority

Mainholm Crescent, Ayr, South Ayrshire, KA8 0QD
Contact: rozelle.house@south-ayrshire.gov.uk

Location of collections
The South Ayrshire geological collection was initiated by Alexander Sharpe Alexander (1860-1940), who accumulated objects for a short-lived museum at Bellisle House, south of Ayr, from 1926 to 1933. When this closed the collection was transferred to the Carnegie Library in Ayr alongside other geological collections; what is now the South Ayrshire fossil collection therefore comprises material from various sources. For the past five years the collections have been housed at the John Pollock Collection Centre with additional material relocated from rooms in the County Building basement and Rozelle House; the collection is due to move again to a new facility in Ayr. The Collection Centre is for storage only and while the collections are available for display, there is no established museum in South Ayrshire for exhibitions; Rozelle House and the McKechnie Institute can accommodate small/temporary displays.

Size of collections
1,000-1,500 fossils.

Onsite records
Information for the collection is in an Access CMS with details for the fossils in the process of being added. Prior to this all fossils were given a Dewey number which is still in use for those not yet added to the electronic database. Other records are on a paper card system. The collection was reviewed by John Faithfull from The Hunterian (University of Glasgow) in 2004 with the provision of a report listing geological specimens.

Collection highlights
1. Fossils from the local area, notably Girvan.
2. Fossils linked to Alexander S Alexander (1860-1940).

Published information
Alexander, A.S. (1935). The Alexander Collection, Ayr. Glasgow: John Smith and Son Ltd.
Howells, Y. (1975). Alexander Sharpe Alexander and his collection. *Newsletter of the Geological Curators Group*. 5:231-235.

Collection overview
Fossil material has a notable focus on Ordovician and Silurian rocks in South Ayrshire with a good number from the Girvan area. A box containing Llandovery (Silurian) shelly limestone with *Nidulites*, *Petraia* and *Pinacopora* fossils is from Rough Neuk Quarry, and a gastropod and separate orthid brachiopod in red matrix is from Mulloch Hill. Other specimens are described as fossiliferous limestone from Craighead Quarry, Girvan, one containing fossils of '*Ptilodictyum* and brachiopod' among others. Other specimens are described as Coralline Limestone from the Girvan area, with localities including 'Penkill below castle' and a rock labelled as '*Halysites*, *Favosites* and *Hainopora*' (all corals) from Shalloch shore, dated 1897. Numerous rocks containing complete and fragmentary orthid brachiopod shells, gastropod, trilobites and tentaculitids represent the Silurian of the Girvan area. A trilobite pygidium labelled as *Trinucleus* from Lady Burn, Ayrshire, is Ordovician.

Another large portion of the collection is from the Carboniferous. Plant fossils are *Neuropteris, Lepidodendron, Stigmaria, Sphenopteris, Sigillaria* (including West Calder), *Calamites* (Grangemouth), *Lithodendron* from Corrie Burn, Campsie near Glasgow, and indeterminate

specimens described as fragments and leaves, including one from Stevenston Shore, Ayrshire. Brachiopods include a *Lingula* from Paisley in addition to specimens of the large *Gigantoproductus* (one with reddish colour typical of examples from Arran) and other productids, spiriferids, etc. Fish are represented by *Gyracanthus* spines, many large but in variable condition, with examples of *Rhizodus* teeth, *Megalichthys* teeth, scales and possibly vertebrae, and *Cynopodius* teeth from Burdiehouse. Remains from Blackston, Renfrewshire, have the initials 'K.B.' with other labels in the same writing mentioning Patna, East Ayrshire; these might be from the area around the Blackstoun Mineral Oil and brickworks near Paisley. A fossil from Muirkirk has been identified as *Pinna* although this seems to be a *Rhizodus* tooth or the spine of a similar fish. A partial fish with an articulated fin is preserved with plant branches and is presumably also Carboniferous. Less numerous are the bivalves from a non-marine mussel band, orthoconic nautiloids preserved as internal moulds, and coral (*Zaphrentis*; *Lithostrotion* from Muirkirk). Interesting specimens include three fossils labelled as 'spores in coal. Juniper Green', a locality on the outskirts of Edinburgh. Several large fossils have recently been moved from the basement, notably a cross section of tree trunk and long segment of *Stigmaria*.

Other stratigraphic levels are represented by a limited number of fossils. A sample labelled as *Rastrites*, a graptolite, is from the Lower Silurian of Dob's Linn, Dumfries and Galloway. A *Lanarkia spinosa* is from the Silurian of Muirkirk. There are several Devonian fish, almost entirely from localities in Caithness. One fossil is labelled as the 'head of a fully grown *Dipteris valencienessi* found at Achanarras, Caithness in 1946 by Alex G. McLeod M.A., F.S.A. Scot'. Several boxes contain orthoconic nautiloids, *Gryphaea* and other bivalves, and ammonites. A large (40cm) and robust bone is potentially a mammal skull from the Siwalik Hills, India.

Research/collection links

The mammal bone should be investigated further to determine if it is from the Siwalik Hills, an important locality historically and scientifically, which could lead to research in collaboration with museums in Scotland (Falconer Museum) and across the UK (Natural History Museum, London, and Oxford University Museum of Natural History) where there are larger collections. The Ordovician and Silurian localities in the Girvan area are historically and scientifically important, with many studies focusing on various aspects of the fossil assemblages in the past. The stratigraphic units exposed at each locality perhaps need to be clarified.

McKechnie Institute (South Ayrshire Council Museums and Galleries Service)

Collection type: Local authority

Dalrymple Street, Girvan, KA26 9AE
Contact: keir.Murray@south-ayrshire.gov.uk

Location of collections
The McKechnie Institute was built using funds provided by Thomas McKechnie, a local businessman, and designed by McKissack & Rowan of Glasgow. It opened in 1889 and is still used today as a local museum, art gallery and venue for community groups. Fossils are housed in a display case with some storage in use onsite for the limited number of specimens not on display.

Size of collections
30-40 fossils.

Onsite records
Information for the majority of fossils has been entered on an inventory.

Collection highlights
1. Fossils from the Girvan area potentially linked to Alexander McCallum (1802-1845).
2. Fossils on display linked to Hew McCallum (1935-2016).

Figure 46: A fossil echinoid displayed with modern counterparts (McKechnie Institute)

Collection overview
The collection comprises 30-40 fossil specimens from nearby Upper Ordovician strata, either the Caradoc Series (Ordovician) in the Ardwell Bay area to the south of Girvan or the Ashgill Series

(Ordovician) from Lady Burn to the north. Specimens tend to include fragmentary remains of trilobites, brachiopods, bivalves, orthoconic nautiloids and graptolites. The remaining fossils were collected by Hew McCallum (1935-2016): Several ammonites (Jurassic), coral (probably Carboniferous), echinoid (*Clypeus*, Fig. 46) and plants (fossil wood and *Sigillaria*).

Research/collection links

The Girvan fossils represent an exceptionally preserved Ordovician fauna with some rare species, exposed at localities across the Girvan area now designated SSSIs. Fossils from the same localities in other collections have been studied and documented in numerous scientific publications, notably as part of a PhD project by Dr Sarah Stewart at the University of Glasgow (now in the Natural Sciences Department, National Museums Scotland). Publications on fossils from Girvan suggest historic links with the University of Glasgow. Material from the area continues to be of interest with species new to science still being found. There is therefore the possibility for re-examination of material in collections to reveal further new species and assist in revision of others.

Isle of Arran Heritage Museum (Isle of Arran Museum Trust)

Collection type: Independent
Accreditation: 2019

Rosaburn, Brodick, Isle of Arran, KA27 8DP
Contact: info@arranmuseum.co.uk

Location of collections
The late Miss Bess MacMillan MBE, Chairman of the Island Tourist Association, formed the Isle of Arran Museum Association and the Isle of Arran Museum Trust in 1976**.** Founded in 1979, the Museum is located in several former estate buildings dating from the 1700s. Fossils are displayed in the geology room set up by professional geologist Gordon Macleod who also wrote the text for the short introductory video on Arran's geology.

Size of collections
7 fossils.

Onsite records
Not known.

Collection highlights
1. Fossils from the Isle of Arran, including casts of arthropod and vertebrate trackways.

Publications
Briggs, D.E.G., W.D.I. Rolfe, and J. Brannan. (1979). A giant myriapod trail from the Namurian of Arran, Scotland. *Palaeontology*. 22:273-291.
Clark, N.D.L., P. Aspen, and H. Corrance. (2002). *Chirotherium barthii* Kaup 1835 from the Triassic of the Isle of Arran, Scotland. *Scottish Journal of Geology*. 38:83-92.
Clark, N. (2011). The hand-beast of Blackwaterfoot. *Deposits*. 25:6-9.

Figure 47: The Carboniferous brachiopod *Productus* from Corrie (Isle of Arran Heritage Museum)

Collection overview
Fossils all relate to the geology of Arran. Most are Carboniferous in age: Spaghetti rock from Corrie packed with the colonial coral *Lithostrotion*, shale with fossils from Laggan, *Gigantoproductus* brachiopods as isolated fossils or in limestone (one a distinct reddish colour) from Corrie (Fig. 47), and a *Lepidodendron* impression in sandstone from Corrie. Other fossils are worm casts without location or age information and a piece of fossil wood found in tuff from the Jurassic of north east Arran. Trace fossils include a silicon mould of a *Cheirotherium* track found near Blackwaterfoot, cast by researchers at the University of Glasgow, and an isolated, three-toed footprint representing an infilled track in a fine-grained, grey-green rock. Other information in the displays refers to the *Arthropleura* tracks found in Carboniferous rocks at the north end of the island.

Research/collection links
The cast of the reptile trackway was provided by the University of Glasgow following studies of the original.

Low Parks Museum (South Lanarkshire Leisure and Culture)

Collection type: Local authority (South Lanarkshire Leisure and Culture)
Accreditation: 2018

129 Muir Street, Hamilton, ML3 6BJ
Contact: museumresearch@southlanarkshireleisure.co.uk

Location of collections
Low Parks Museum is situated in part of the Duke of Hamilton's former estate. Most of the buildings have been demolished, notably Hamilton Palace, leaving only the Hamilton Mausoleum and the Portland building and Hamilton Palace Riding School which house the Museum. The collections include specimens transferred from Rutherglen and Hamilton in 1996. Fossils are not in use in Low Parks Museum, although specimens from the collection were on display in the Visitor Centre Gallery at Chatelherault Country Park. The collection is housed in two offsite storage rooms several miles from the Museum.

Size of collections
106 fossils.

Onsite records
Information is in a Vernon CMS with a paper catalogue onsite and documentation/entry forms held in the Museum. Notes with the collection suggest fossils were examined and partly inventoried as recently as 2015.

Collection highlights
1. Fossils collected through the local coal mining industry.
2. Fossils from Lesmahagow.

Collection overview
Most of the fossils are from the local Carboniferous, recovered through coal mining. Plants include *Stigmaria*, *Calamites* (a large, curved specimen was recently donated, Fig. 48), *Lepidodendron*, *Lepidostrobus*, a large tree trunk and other fragments, typically preserved as carbon films, moulds and casts, and impressions in black mudstone, although one is a more unusual sample preserved as two-dimensional pyrite fronds in black mudstone. Other fossils include productid brachiopods found as isolated fossils or in limestone, a fish, acanthodian spine, corals, orthoconic (straight) and coiled nautiloids including a polished section, and crinoidal limestone. Bivalves are present as isolated fossils, in an ironstone mussel band (labelled as an important marker horizon in the search for coal), in limestone or a layer known locally as Cambuslang Marble. Specimens from other stratigraphic levels are the piece of fossil wood accompanied by a note reading ‘found in the Sahara Desert in 1945’, and invertebrates, notably the eurypterids *Slimonia* and *Pterygotus* and arthropod *Ceratiocaris* from the Silurian of Lesmahagow.

Research/collection links
The collection has the potential to provide fossils for study although thorough examination of content is necessary to determine this.

Figure 48: Fragmentary remains of the Carboniferous plant *Calamites* (Low Parks Museum)

Figure 49: Carboniferous plants *Sphenopteris* from Forth (left) and *Stigmaria* from Wilsontown (back) and *Dibunophyllum* coral in an erratic from Biggar (right) (Biggar and Upper Clydesdale Museum)

Biggar and Upper Clydesdale Museum (Biggar Museum Trust)

Collection type: Independent
Accreditation: 2019 (Provisional)

156 High Street, Biggar, ML12 6DH
Contact: info@biggarmuseumtrust.co.uk

Location of collections
The Museum is located on the main street following relocation in 2015 from another building in Biggar. Collections are on display with storage upstairs and in a building nearby.

Size of collections
27 fossils on display with an additional undetermined number in storage.

Onsite records
Documentation is in the form of a paper catalogue and an Excel spreadsheet with ongoing work to enter fossils on the latter. Fossil specimens also appear in an entry book for the year they were acquired. All fossils have a reference number prefixed with a letter noting the taxonomic group.

Collection highlights
1. Locally collected fossils.

Collection overview
Fossils are part of a display on local/Scottish geology (Fig. 49). Most are plants from the Carboniferous: *Lepidodendron aculeatum, Stigmaria ficoides* (one with rootlets), *Calamites suckowi* and *Cordaites anglosostri* from localities including Wilsontown, Lanarkshire, *Sphenopteris, Stigmaria ficoides* and fern foliage (Forth, Lanarkshire), and plant cellular structure preserved in ironstone (Medwin, Lanarkshire). There are fossils of the phyllocarid arthropod *Ceratiocaris stygia* from Lesmahagow and a marine bivalve from Wilsontown. The corals *Lithostrotion* junceaum and *Dibunophyllum bipartium* found at Whitecleuch and Crawfordjohn are labelled as erratics – material transported by ice – found in Biggar. Specimens of limestone with brachiopod, coral and other invertebrate fossils are also likely to be Carboniferous. Not from the Carboniferous are specimens of *Gryphaea* (Jurassic) and mudstones with graptolites (probably Ordovician); the onsite catalogue suggests various graptolites (*Climacograptus*, *Dicranograptus*, *Orthograptus*) from Wanlockhead and Dob's Linn. A handling box contains fossils of the plants *Calamites*, *Stigmaria* and *Neuropteris*, *Lithostrotion* and other corals, crinoids from Lugton, Ayrshire, brachiopods and bivalves.

McLean Museum and Art Gallery (Inverclyde Council)

Collection type: Local authority
Accreditation: 2019 (Provisional)

Watt Institution, Kelly Street, Greenock, Inverclyde, PA16 8JX
Contact: wattinstitution@inverclyde.gov.uk

Location of collections
The origins of the collection are linked to the Greenock Philosophical Society whose branch at the Greenock Library was filled with artificial and natural curiosities, leading to designation of the building as a museum in 1816. The collection moved to the Watt Library, named after James Watt (1736-1819), and, as objects continued to accumulate, work began on a museum and lecture hall in 1863. It was funded by local timber merchant James McLean (1802-1877), a member of the Philosophical Society. It was completed in 1876 and Thomas Struthers, a geologist and naturalist from Glasgow, was appointed as the first curator; part of his collection is still onsite. The Museum and library closed in 2016 for a £2 million refurbishment.

Size of collections
800-1,000 fossils.

Onsite records
Information is in a Past Perfect CMS with various paper catalogues, including MDA cards. An online catalogue available at https://mcleanmuseum.pastperfectonline.com/webobject includes some of the fossil specimens.

Collection highlights
1. Fossils from well-known localities worldwide and a notable range of vertebrate fossils.
2. Fossils linked to Thomas Struthers and James Dairon (1811-1891).
3. Post-glacial fossils linked to Thomas L Scott (1849-1929) and Thomas Steel (1858-1925).
4. Labels attributed to fossil dealers Robert Ferris Damon (1845-1929) and LH Pegler MD.
5. Quaternary cave deposits linked to William Pengelly (1812-1894).
6. Fossils from Canada.

Published information
Robertson, D. (1883). I. On the Post-Tertiary Beds of Garvel Park, Greenock. *Transactions of the Geological Society of Glasgow*. 7:1-37.
Scott, T., and J. Steel. (1885). XXXI. Notes on the occurrence of *Leda Arctica* (Gray); *Lyonsia arenosa* (Möller); and other Organic Remains, in the Post-pliocene Clays of Garvel Park, Greenock. *Transactions of the Geological Society of Glasgow*. *7*:279-283.

Collection overview
Fossils are wide-ranging in terms of stratigraphic and geographic origin, with several acquired from dealers. For example, fossils labelled as RF Damon, Weymouth, include an *Omphyma* from the Much Wenlock Limestone Formation, a fish in a split nodule labelled '*Osteolepis* major, Lethen N.B. Old Red Sstone', *Cardinia* from the Lower Lias of Frodingham and a *Harpoceras* ammonite from the Upper Lias of Boll, Germany (Fig. 50). Vertebrate fossils are mostly fish from the Devonian (a *Pterichthyodes* in a nodule, cast of a *Cephalaspis* from Forfarshire in the British Museum, and an *Osteolepis* from Thurso with many other specimens present but not visibly labelled), Carboniferous (*Rhizodus* teeth and other fragments, notably a jaw from Loanhead, Edinburgh, and an acanthodian spine), Permian ('*Palaeoniscus comptus'*, a misspelling of *Palaeoniscum comtus*, from Ferry Hill and *Palaeoniscum freieslebeni*, labelled as '*Palaeoniscus*' from the Kupferschiefer Formation of Rothenburg, Bavaria), Jurassic (*Dapedius*, *Hybodus* and *Heterolepidotus,* and a tooth plate of *Acrodus anningae* from Lyme Regis) and Eocene (shark teeth from the London Clay). Additional

shark teeth are from North America (*Carcharodon*) with specimens more specifically from the River Coosaw (miss-spelt as 'Cossaw'), Beaufort County, South Carolina (where Miocene-Pliocene phosphate deposits were mined), attributed to Captain Black 1886.

Cretaceous fossils of *Beryx lewesiensis* and *B. superbus* from the Chalk at Lewes, and teeth of *Lepidotus mantelli* from the Wealden of Brook Bay, Isle of Wight, have been linked to Gideon Mantell (1790-1852) in the past although this connection is now less certain. The Mantell attribution was written on labels printed 'Mus M & M'. This indicated that they came from the Museum of Mantua & Montferrat, a collection put together by the self-styled 'Prince of Mantua and Montferrat'. His real name was Mr Charles Ottley Groom (1839-1894), described in *The Oxford Dictionary of National Biography* as an 'imposter' with an extensive collection much of which was 'bogus'. The attribution of these specimens to Mantell therefore requires further investigation. A fossil fish described as an impression in limestone from Norfolk could potentially be from the Eocene Green River Formation of Wyoming or similar fish-bearing deposits.

Reptiles are represented by a series of 4-5 vertebrae with possible neural spines/arches from the Jurassic, an *Ichthyosaurus* head from the Jurassic of Lyme Regis, and numerous isolated fish and reptile vertebrae. Mammals are represented by the teeth of a *Hippopotamus bivensis* from the Eocene London Clay of the Isle of Wight, a partial humerus of the giant kangaroo *Diprotodon australis* from Queensland and mammal bones (badger) from Happaway Cave, Devon, presented by E Newton of the Geological Museum, London, with a further note 'Quaternary/Pleistocene ossiferous caves Pengelly Collection'. There are plaster casts of various reptiles including the partial skeleton of a *Mosasaurus tenuidens* with the locality given as Albania, South Africa (Albania referring to a district), a complete Triassic *Lariosaurus* from Perledo, Lombardy, a third skeleton not identifiable due to a damaged label, the skull of the placodont *Cyamodus* showing dentition, a *Scaphognathus* pterosaur from the Solnhofen Limestone, the London specimen of *Archaeopteryx* and the 'largest' *Bothriolepis canadensis* fish held in the British Museum (according to the label).

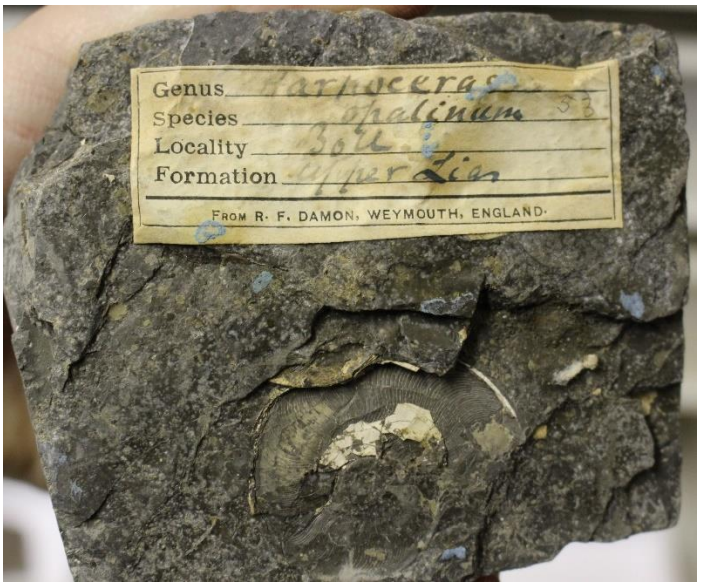

Figure 50: Upper Liassic (Jurassic) ammonite *Harpoceras opalinum* from Boll, Germany, with an RF Damon label (McLean Museum and Art Gallery)

Invertebrate fossils are from every period of the Palaeozoic. The Cambrian is represented by the trilobites *Angellina* from Porthmadoc and an *Asaphus* from Shineton, Shropshire. The Ordovician is represented by brachiopods from Wales and the trilobites *Ogygia* from Builth, an *Asaphus* from County Tyrone, Northern Ireland, labelled as Silurian but probably Ordovician, and a cast of the

trilobite *Asaphus tyrannus* from Llandeilo, Wales; several graptolites are attributed to James Dairon and dated to around 1896. There are additional graptolites from Dob's Linn, Dumfries and Galloway, some of which could be Silurian. Tentaculitids are from the Caradoc of Shropshire. Silurian fossils include the gastropod *Poleumita* and brachiopods from the Pentland Hills (*Strophomena*, *Rhynchonella*, *Leptaena*), *Nidulites* from Mulloch Hill, Girvan, and eurypterids labelled as *Eurypterus* from Gotland and a cast of *Stylonurus*. Fossils from the Welsh Borders (brachiopods *Spirifer*, *Leptaena*, *Atrypa*, '*Orthis*'), Dudley, West Midlands (coral *Favosites,* trilobites *Phacops*, *Proetus* and *Acidaspis*), Buildwas, Shropshire (*Cheirurus*) and without locality information (near fully articulated *Periechocrinus* head) are all likely to be from the Much Wenlock Limestone/Shale.

Interesting specimens are the Middle Silurian bivalves *Ambonychia* and *Hodiolopsis* from Western Ontario, Canada, and a *Stromatopora* and *Amplexus* coral from the Silurian of Elora, Ontario, Canada. Devonian invertebrates include a coral *Aulapora* from Eifel and *Favosites* without information. Carboniferous brachiopods are from Beith, Ayrshire (*Productus*), Fife (*Spirifer*, *Productus*), Little Island (*Aviculopecten*, *Pecten*), Arran (*Gigantoproductus*), Yorkshire (*Spirifer*) and Ireland (*Spirifer*) among other localities. A fossil from Ireland shows a *Cardiomorpha* bivalve and *Fenestella*, another specimen has a label reading 'Fossil mussels from Hemmington coalpit at Newton, Lanarkshire. Found over 200 fathoms under the surface. July 1892'. Trace fossils include Lower Silurian *Crossopodia scotia* from Penwhapple Glen, Girvan, two fragments of *Arenicolites* from the Huronian of St Johns, Newfoundland, and arthropod tracks that could be assigned to *Cruziana*.

Mesozoic invertebrates are almost entirely molluscan; none were observed from the Triassic. Fossils from the Jurassic include relatively numerous specimens of *Gryphaea*, with a set from Morvern, Argyllshire, dated 1943, a set from Broadford, Isle of Skye, and another from the Kimmeridge Clay of Shotover near Headington, Oxford. Bivalves include *Pecten* and *Cardium* from the Upper Oolite Portland Stone Formation of Portland, *Clypeus* from the Inferior Oolite of Birdlip, *Ostrea* from the Great Oolite of Cirencester and a bivalve from the Kimmeridge Clay. Ammonites are relatively numerous with labels for Folkestone, *Hildoceras* from Whitby, *Dactylioceras* from Kittleness, *Stephanoceras* from Sherbourne and specimens that appear to be from the Jurassic of Eathie (Cromarty). Nautiloids include a large partial orthocone and second complete specimen. Non-molluscan fossils include echinoid tests and disarticulated spines from the Coral Rag, Middle Oolite of Oxfordshire and Weymouth, and a specimen labelled as the isopod *Archaeoniscus* from the Upper Oolite of Weymouth, which might be *A. brodiei* from the Purbeck Limestone Group of the Isle of Portland. The Alistair Cowden Geology Collection contains mixed geological material including fossils from the Liassic of Lyme Regis, bivalves from the Upper Jurassic Portland Beds and orthoconic nautiloids in mudstone.

Cretaceous fossils are similarly dominated by molluscs with examples of the bivalve *Exogyra* and cephalopod *Belemnites* from the Speeton Clay of Yorkshire, the unusual bivalve *Gervillia* from the Lower Greensand of Atherfield, Isle of Wight, *Belemnites* from the Upper Greensand, *Hammites* from the Gault of Kent, the bivalve *Inoceramus* from the Gault of Folkestone and *Nucula* from the Chalk of Folkestone. Non-molluscan fossils are the echinoid *Anchytes*, *Terebratula* brachiopods from the Upper Greensand, the echinoids *Micraster*, *Echinoconus* and *Ananchytes* from the Chalk of Kent, the brachiopod *Kingena* from Cheltenham and coral *Holocytes* from the Lower Greensand of the Isle of Wight.

Cenozoic fossils are limited to a few well-known levels. The Eocene is represented by fossils from the London Clay (bivalves *Modiola* from Holloway and *Cytherea* from Fareham, brachiopods *Lingula* from Bognor and *Terebratulina* from Belsize Tunnel, with vertebrates including shark teeth among bivalves from other localities and a hippo jaw fragment from the Isle of Wight), Barton Beds (numerous bivalves, such as *Pectunculus*, and gastropods), Woolwich Beds (*Cyrena* from Charlton) with Paleocene fossils from the Thanet Sands (*Pholadomya*). Several drawers are noted as Pleistocene and/or Quaternary. Among the fossils from the Red Crag locality of Walton on the Naze, Essex, are the gastropods *Natica*, *Trivia*, *Emarginula*, and bivalves *Pectunclus*, *Lucina*, *Cardium*,

Cardita and *Nassa*. The Thomas L Scott collection focuses on material from Quaternary/Pleistocene raised beaches: *Rissoa, Montacuta*, *Lepton* and *Axinus* from Largs, *Mactra* from Innellan, *Lucina* and *Littorina* from Millport, and crustacean remains from Garvel Park, Greenock, a locality described in publications, such as Scott and (James) Steel (1885). Additional drawers of Quaternary/Pleistocene and boulder clay fossils are attributed to Thomas Steel and contain mostly gastropods (*Pleurotoma*, *Buccinum*, *Trophon*, *Fusus*, *Purpura*), algae (*Melobesia*), crustacean fragments and fish remains. A collection of fossils identified by diamond-shaped labels with a blue outline in two compartmentalised boxes is assumed to be from a specific collector. It includes further molluscs (gastropods and bivalves) that appear to be Cenozoic if not Recent, and plants, ammonites, echinoids, crustaceans and belemnites from a range of geological ages. The boxes were found with a list of taxonomic names (mostly bivalve and gastropod) giving origins of Germany, France and Bohemia among other countries, which might be relevant.

Plant fossils are mostly from the coal mining industry in the Central Belt (*Alethopteris*, Sigillaria, *Plecopteris*, *Pecopteris*, *Neuropteris*, *Sphenopteris* including from Burdiehouse, *Stigmaria* from Dunfermline, *Calamites*), Ayrshire (*Lepidodendron* from Dalmellington) and Derbyshire (*Neuropteris*, *Sphenopteris*, *Pecopteris, Lepidodendron*). Among the specimens is one with a label 'Fragments of a *Lycopsidiaceous* (?) plant Fm *Coccosteus* beds at Navity Cromarty' and a second with a label *Alethopteris* from the Carboniferous of Derbyshire mentioning LH Pegler at Gloucester Square, perhaps acquired as part of donation in 1892 (Stace *et al.* 1987). Two fronds have notes mentioning Robert Dykes and an origin of the beach south of Prestwick in 1898 (Fig. 51). A single specimen was noted as Permian: the ostracod *Kirkbyia permiana* from the Lower Zechstein of Saxony, Germany. A rock with a plant frond is etched with 'Barony Pit, Auchinleck, Ayrshire, 300 fathoms 1953, Bob McCallum Park Keeper'. Tertiary plants include a broad leaf fossil labelled 'from the leaf beds of Ardtun, Loch Scriden [sic], Mull. The leaves are embedded in volcanic ash, and the deposit is believed to be the only representative of Miocene strata in Britain'; the deposit is now dated to the Paleocene.

Figure 51: Frond of a Carboniferous fern from Prestwick dated 1898 (McLean Museum and Art Gallery)

Research/collection links

Potentially important scientific material is the collection of mammal bones from Happaway Cave, Devon. The origin of the fossils from Canada would be interesting to research. A drawer of invertebrate fossils affixed to pieces of black card are potentially from Eathie although they are attributed to many collectors with a range of collection dates (Lyle, 1868; Pattinson '89) that could be investigated for context. This collection has the potential for a number of small, focused research projects.

Paisley Museum (Renfrewshire Leisure)

Collection type: Local authority (Renfrewshire Leisure)
Accreditation: 2019 (Provisional)

The Secret Collection, High Street, Paisley, PA1 2BA
Contact: tours@renfrewshireleisure.com

Location of collections
The origins of Paisley Museum lie in the Paisley Philosophical Institute, founded in 1808, whose collection of scientific apparatus, objects, and books needed a permanent home. Fundraising began in 1864, allowing construction of a building to begin in 1869 with the finished Free Public Library and Museum opening in 1871. Several extensions have since been added and the building closed recently for extensive refurbishment, due for completion in 2023. The collections have been relocated to a new storage facility on the main street following demolition of the 1950s store to make way for gallery space.

Size of collections
c4,000 fossils.

Onsite records
Information is currently being transcribed from a card index and catalogues to a Microsoft Excel document which will be transferred to an Adlib CMS. Many specimens have temporary numbers.

Collection highlights
1. Collection of Carboniferous invertebrate, vertebrate and plant fossils.
2. Fossils linked to Hugh Miller (1802-1856), Reverend John Anderson (1796-1864) and Reverend Hugh Mitchell (1822-1894).
3. Several invertebrate and vertebrate fossils from North America.

Published information
Andrews, S.M., and T.S. Westoll. (1970). The postcranial skeleton of Rhipidistian fishes excluding *Eusthenopteron*. *Transactions of the Royal Society of Edinburgh*. 68:207-329.
Jeffrey, J.E. (2001). Pectoral fins of rhizodontids and the evolution of pectoral appendages in the tetrapod stem-group. *Biological Journal of the Linnean Society*. 74:217-236

Collection overview
Although the collection includes casts of the Precambrian Ediacaran *Cyclomedusa* from Leicestershire, the oldest fossils are the burrows in Cambrian Pipe Rock from Wester Ross and the pseudo-fossil *Eozoon canadensis* from Montreal. Trilobites represent the Cambrian, Ordovician and Silurian, with examples of *Ptychagnostus* from Utah, *Olenus* from Pennsylvania, *Conocoryphe* from Bohemia, species from Norway and a rare detrital *Homolonotus* in the Devonian Budleigh Salterton pebble bed from Exmouth. Ordovician and Silurian fossils are mostly graptolites from Glentrool, Girvan, Dob's Linn (Dumfries and Galloway), Pentland Hills and north Wales, with specimens from as far afield as New York State (*Didymograptus* from the Deepkill Shale) and Canada; there are Silurian corals including a *Synaptoyllum* from the Guelph Limestone of Ohio. Silurian specimens from England include a variety of brachiopods, bivalves, gastropods and ostracods from the Much Wenlock Limestone Formation. Scottish fossils include several fragments of eurypterids from Lesmahagow, such as a *Pterygotus* without locality information, a large section of 3-4 articulated segments and another smaller but more complete fossil with the outline of the tergites drawn on in white.

Devonian fossils include early plants (*Hostimella*, *Psilophyton* and *Arthrostigma* from Tarr Burn, Callander), but are predominantly fish: Lower Devonian *Ischnacanthus* and other acanthodians from

Turin Hill; Middle Devonian *Pteraspis* from Cradley, Worcestershire, *Coccosteus* and *Osteolepis* from Edderton, *Mesacanthus* from Tynet Burn, *Pterichthyodes*, *Osteolepis* and *Cheirocanthus* from Cromarty, *Cheirocanthus* from Lethen [Bar]; Upper Devonian *Holoptychius* in sandstone from Dura Den. Several specimens have links to Hugh Miller, Reverend John Anderson or Reverend Hugh Mitchell. An *Osteolepis* from the 'Burn of Tynet' has a label reading 'bought by order of committee'. Another fossil is labelled as *Entonus tuberosa* from Deerhope, a species for which there is little information but may be an ostracod from the Deerhope Formation of the Pentlands.

Figure 52: Carboniferous shrimp *Tealliocaris* from the Gullane Shrimp Bed, East Lothian (from Renfrewshire Council's collection, held by Renfrewshire Leisure Limited)

The largest part of the collection comprises fossils from the Carboniferous. Corals, such as *Lithostrotion,* are from the local region and Scotland generally (Beith, Paisley, Lugton, Bathgate, Kellhead, Arbigland, Fife, Dunbar, Muirkirk, Campsie; a named rock unit is the Petershill Limestone (Brigantian) from the Lower Limestone Formation), England (Avon Gorge, Bristol) and beyond (Ohio, Illinois, Canada). Bivalves include *Carbonicola* and *Cypricardium* from Douglas Water and Lanarkshire, with samples of a mussel band. Cephalopods are represented by orthoconic nautiloids (Carluke) and goniatites. Gastropods are limited to a few species, notably *Bellerophon* of which there are many examples. Brachiopods include various sizes of recognisable productids and other taxa from Barrhead, Beith, Kilmarnock, Dalry, Weston-super-Mare and localities in Derbyshire. There are smaller numbers of conulariids and arthropods (*Tealliocaris* shrimp from the Gullane Shrimp Beds, Fig. 52). Fish include fragments of *Megalichthys* (Airdrie, Lanarkshire, Kilbarchan), *Rhizodus* (Dalry, Nitshill), *Strepsodus* (Gilmerton), *Acrolepis* (Hurlet, East Renfrewshire), *Palaeoniscum* (Blackstone, Kilbarchan), *Sphenocanthus* (Annick Lodge) and *Pleurocanthus* (Annick Lodge). There is a noted collection of *Rhizodus* fragments from Todhills Pit including teeth, isolated or embedded in jaws, with rarer shoulder and other large skeletal elements. Coprolites attributed to fish include a specimen from Kilbarchan (Johnstone, Renfrewshire), Hurlet and Dalry (Ayrshire). A specimen labelled as amphibian from Cardowan, Stepps, Lanarkshire, seems to be a three-toed footprint in dark mudstone.

Carboniferous plant fossils include typical and rare types from around the world: *Pecopteris* (Radstock, Somerset; Whinhill Quarry, Alloa), *Sphenopteris* (Bothwell), *Telangium*, *Asterophyllites* (Foxley, Glasgow; Nova Scotia), *Annularia*, *Alethopteris*, *Calymmatotheca*, *Trigonocarpus*,

Lepidodendron, *Mariopteris*, *Neuropteris* (one might be *Cyclopteris*), *Calamites* (Dunbar, Lanarkshire), *Sigillaria* (Edinburgh, Randwood Colliery, Springhill Colliery), *Stigmaria* (Gateshead), *Urnatopteris*, *Carlopteris*, *Cordaites*, *Seftenbergia*, *Halonia*, *Lepidostrobus*, *Ulodendron*, *Diplotmena* (Whinhill Quarry, Alloa) and other indeterminate fragments; several are oversize. Many plant fossils are attributed to David Beveridge, a former coal worker and janitor at the Museum, whose collection was purchased by the Coats family and donated to the Museum.

Permian fossils are mostly traces: various *Chelichnus* and *Herpetichnus robustus* from Locharbriggs. A *Palaeoniscum* fish from Germany is probably from the Permian Kupferschiefer Formation. Triassic fossils are limited but include samples of the Rhaetic Bone Bed from Aust Cliff, Gloucestershire, a *Cheirotherium* from the Triassic of Storeton, Cheshire, and oversize slabs showing various footprints and a trackway of small, rounded depressions in two rows.

Jurassic fossils originate from Scotland, England and worldwide. Cephalopods include ammonites from Eathie, Tiree (Argyllshire), Robin Hood's Bay, Redcar, Cleveland, Portland, Lyme Regis (Fig. 53) and Blockley (Gloucestershire), a handful of ammonites from the Callovian Clynelish Limestone (Sutherland), *Nautilus* from Brora, and a belemnite from the Jurassic Solnhofen Limestone labelled Krantz of Berlin. A set of ammonites in small boxes is labelled to zone and possibly subzone level. Bivalves are numerous with *Gryphaea*, *Pholadomya* and many other species from Broadford and Brora in Scotland, the south of England including Blockley, and worldwide. Also present are numerous crinoid fragments, examples of the brittle star *Ophioderma* from Lyme Regis, various Jurassic echinoids (*Acroselenia*, *Nucleolites*) and a dragonfly labelled as *Petalia* from the Solnhofen Limestone (now *Cymatophlebia longialata* (Gerner 1839)). Jurassic vertebrates are represented by the fish *Lepidotus* from Thuringia, pterosaur *Scaphognathus* from the Solnhofen Limestone, 'crocodile' *Steneosaurus* and casts of an ichthyosaur limb (the original from Holzmaden in Kelvingrove Art Gallery and Museum).

Oversize specimens include a set of large blocks with part of a rib cage and several near articulated vertebrae assigned to the ichthyosaur *Macroptychius* from the Oxford Clay, a second set of rib and vertebrae fragments, some articulated, assigned to the same taxa but without locality information, and a third comprising crushed ribs from an ichthyosaur collected at Peterborough. There are further large vertebrae without age or locality information, a *Plesiosaurus* fossil from the Kimmeridge Clay of Brora, a marine reptile humerus and an ichthyosaur skull from Peterborough. From further afield is a dinosaur limb bone from Wyoming and a polished dinosaur bone from Colorado. Trace fossils include 'an iguanodontid… poss. Purbeck Stone Quarry', a footprint identified as Jurassic from Swanage and a slab of rock approximately a metre across mounted as a display piece showing two dinosaur footprints. Invertebrates from the Cretaceous comprise terebratulid and rhynchonellid brachiopods, sponges, corals (some from Tampa, Florida), flint echinoids and belemnites from Kent and Lyme Regis, many in chalk. Vertebrates include vertebrae of the marine reptile *Plesiosaurus* and fish, specifically the head of *Saurodon* from the Chalk of Sussex showing high surface detail, a group of small fish from the Cretaceous of Lebanon, and *Tharrhias* in nodules from the Cretaceous Santana Formation. A fossil in chalk is labelled as an infilled worm burrow, perhaps due to its overall long, thin shape, although the fossil seems to be a complete but slightly disarticulated fish; the shape of the specimen follows the outline of the fish. The Cretaceous Ulster White Limestone is represented by fossils from Glenarm and other localities in Northern Ireland.

Cenozoic fossils are mostly from the Eocene. Invertebrates include *Clypeaster* from Egypt, crustaceans (*Xanthopsis* (also spelt *Zanthopsis*) from the Isle of Sheppey; *Thalassina* from eastern Australia), foraminifera (*Nummulites*) and a selection of gastropods (*Pleurotoma*, *Turricula*, *Sconsia*, *Clavilithes*, *Voluta*, *Hippochrenes*, etc) most likely from the Barton Beds or similar. Unusual specimens include larvae from the dragonfly *Libellula* from Piedmont, Italy. Vertebrates are represented by shark teeth (*Lamna*, *Oxyrina*, *Carcharodon*), fish from Monte Bolca, Italy, and Green River Formation (*Knightia*, *Priscacara*), the fish *Smerdis* from France, and the fish *Clupea* and *Leptaucherin* from northern Germany. Cenozoic mammals include teeth and bone fragments of the Miocene *Diceratherium* from Agate Springs, Nebraska, skull and jaw of the Oligocene oreodont

Merycoidodon from North Dakota, and *Mesohippus* from North America. Plant material includes remains from Brora, Sutherland and Eigg, leaves from the Ardtun leaf bed at Bunessan, Mull, and Florissant, Colorado, various species (*Platanus*, *Salix*, *Tilia*, *Acer*) from the Oligocene of Germany, *Metasequoia* from British Columbia and fossil wood from Norwich.

Quaternary fossils include the bivalves (*Cyprina*, *Pecten*) and gastropods (*Trophon*, *Aporrhais*) from the Pleistocene Clyde Beds (Clyde Clay Formation) of Paisley, Largs and Greenock; material can be attributed to Peder Aspen, who collected extensively from the Clyde Beds while working at Paisley Museum. Other fossils are of *Serpula* and barnacles from Linwood (bypass cutting) and Largs; several specimens are labelled as Yorkshire. Vertebrate fossils from Scotland are limited to the jaw of an ox from Seedhill, Paisley, with the majority from outside Scotland: Deer horn from Norfolk, a *Mastodon* tooth from North Carolina, *Equus* jaw and teeth, mammoth teeth from several localities such as Tampa, Florida, an *Elephas* tooth from the Engineer gravels of Alaska, and several bison teeth and a separate jaw from Cripple Creek, Alaska. Fossil wood from Zeltam and Lough Neagh are present.

Miscellaneous fossils are the gastropods from Kansas, a ‘deposit of silica or phosphate containing fossil remains of shells, corals, worm burrows’ from Erskine (East Craigend, Renfrewshire), ostracods, brachiopods (from Houston, Renfrewshire), a fish or reptile head, fossils from Johnstone, Renfrewshire (crinoids and bivalves, etc, perhaps from the Carboniferous), Jurassic fossil oysters and echinoids that could be associated with a label reading ‘roadside – Cotswold Limestone’, a large orthoconic nautiloid that might be from the Carboniferous of Bishop Hill, Kinross, other nautiloids, bivalves and plants (*Endogenites* from Hastings Sand), an indeterminate fossil potentially fucoid (seaweed) and the left shoulder bone of an Irish elk from Paisley. Boxes also contain various brass models of Devonian fish (*Cheirolepis*, *Cephalaspis* and *Bothriolepis*) and Ice Age animals (sabre tooth tiger and mammoth).

Figure 53: Jurassic ammonite *Angulaticeras greenoughi* from Lyme Regis (Paisley Museum). Image copyright of Renfrewshire Leisure Ltd

Research/collection links

Fragments of the Carboniferous fish *Rhizodus* from the Todhills Pit are numerous and could represent a relatively complete individual, providing a focus for a project that could investigate larger elements assigned to *Rhizodus* in other museum collections. Material is certainly held in collections at Glasgow Museums Resource Centre, Cockburn Museum, The Hunterian and University of Aberdeen Museums, with other specimens in smaller collections, such as The Discovery Centre (Mintlaw), Tweeddale Museum, McLean Museum and Art Gallery, and John Pollock Collection Centre. The two specimens from the Beveridge Collection, mentioned by Andrews and Westoll (1970), and Jeffrey (2001), are part of a recent joint Cambridge University/Natural History Museum project which undertook a new study of rhizodont humeri and other material found recently in the Tournaisian of the Borders Region (not yet published).

Additional studies could investigate the identity and origin of several other fossils in the Paisley Museum collection, notably the specimen labelled *Entonus tuberosa* from Deerhope, the set of fossils from Lethen Bar and/or Tynet Burn labelled as eurypterid and Devonian placoderm fish more likely to be a Carboniferous *Megalichthys*. A possible footprint of an amphibian from Cardowan, Lanarkshire, which might be Carboniferous, could provide the basis for a research project on Scottish vertebrate trace fossils. The Mesozoic marine reptile material is also interesting and could be studied, or at the very least documented, as part of an investigation of such material and its context in collections across Scotland. The fossils from the Clyde Beds are important as a record of climatic and habitat changes in late glacial to post-glacial times. It is not clear if the specific fossils from either the Clyde Beds (Firth of Clyde) and Errol Clay (Tayside) in the Paisley collection were part of such studies, which could be investigated. The material collected historically and more recently is still present and available for study.

Zoology Museum (University of Glasgow)

Collection type: University
Recognised Collection: 2007

Graham Kerr Building, University of Glasgow, Glasgow, G12 8QQ
Contact: on website https://www.gla.ac.uk/hunterian/visit/ourvenues/hunterianzoologymuseum/

Location of collections
The project of constructing a building for the Department of Zoology at Glasgow University was undertaken by John Graham Kerr (1869-1957), Regius professor of Zoology 1904-1935. The building was designed by the Glasgow architect Sir John James Burnet and opened in 1923. Displays and stores have been onsite since then and are still used for exhibitions, research and teaching. Material in the Zoology Museum is part of The Hunterian Collections, Recognised under the Museums Galleries Scotland Recognition Scheme as a Nationally Significant Collection. Fossils are included in the displays; further specimens might be in storage, which was not investigated at the time of the visit.

Size of collections
Less than 10 fossils.

Onsite records
Not known. The website has an online collection at: http://collections.gla.ac.uk/#/advancedsearch.

Collection overview
Fossils are limited to a trilobite (labelled *Ogygiopsis klotzi*) and eurypterid for comparison to modern arthropods. There are several fish: Silurian *Lasanius* and *Birkenia* models (Fig. 54), Devonian *Cephalaspis*, *Pteraspis*, *Pterichthyodes*, *Gemuendina* and *Climatius* displayed with modern fish. A *Hesperornis* skull and two casts of *Archaeopteryx* are in a case themed on birds.

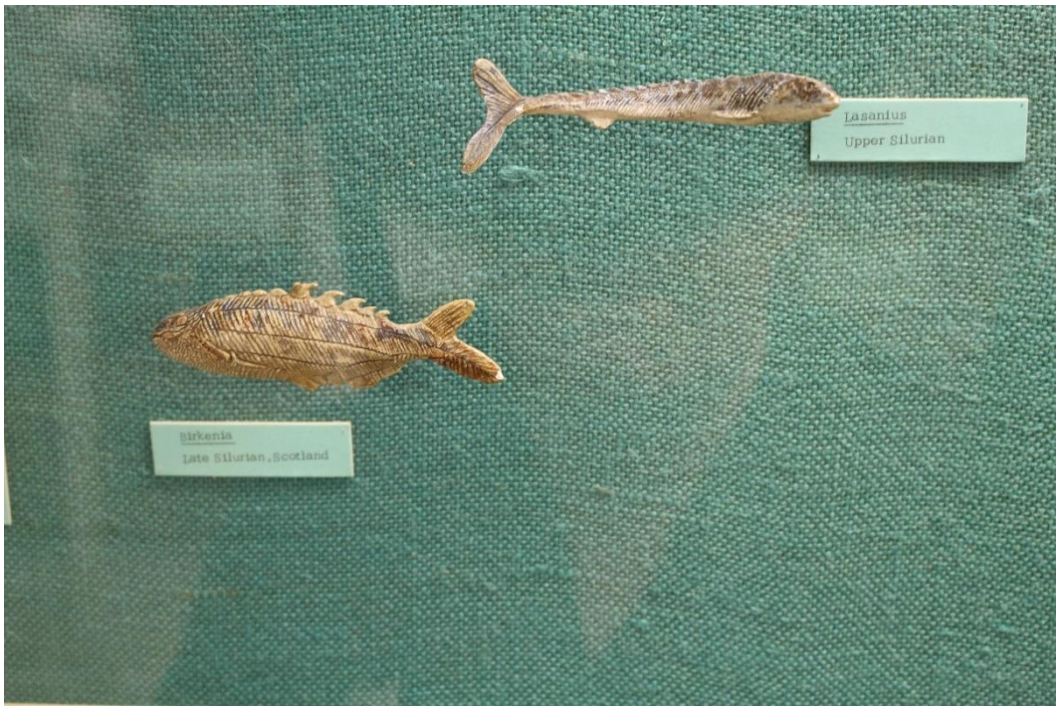

Figure 54: Reconstructions of the jawless Silurian fish *Lasanius* and *Birkenia* from the areas around Lesmahagow and the Hagshaw Hills (Zoology Museum, University of Glasgow)

The Hunterian (University of Glasgow)

Collection type: University
Accreditation: 2017
Recognised Collection: 2007

Gilbert Scott Building, University of Glasgow, Glasgow, G12 8QQ
Contact: hunterian-enquiries@glasgow.ac.uk; hunterian-collections@glasgow.ac.uk

Location of collections
The collection and Museum building are the legacy of Dr William Hunter (1718-1783) who was born locally, attended the University of Glasgow and became a pioneering obstetrician and teacher. Hunter built his first museum, part of an anatomy school, at 16 Great Windmill Street, London. The collection was bequeathed to the University along with funds to create a museum, which opened in the east end of Glasgow in 1807. In 1870 the University moved to its current site and the Museum was relocated to the Gilbert Scott building where it is today. As the collection included everything from paintings to coins and medals, medieval manuscripts, etc, parts have since dispersed to relevant departments. The entire collection of The Hunterian is Recognised under the Museums Galleries Scotland Recognition Scheme as a Nationally Significant Collection. Fossils are onsite in displays with extensive fossil material in offsite storage, which is in the process of being relocated to Kelvin Hall; due to the Covid-19 lockdown it was not possible to investigate the latter.

Size of collections
Approximately 100 fossils on display, with more than 30,000 specimens in storage.

Onsite records
Information for the collection is on a Ke EMu CMS database, with the majority of fossils now added, notably those on display, with ongoing work to include the remainder. Information for the fossils is also documented in various ledgers, MDA card, entry forms, etc. The website lists 5,000 graptolites, 10,000 vertebrates and 10,000 plants; an online collection includes entries for 17,319 fossils at: http://collections.gla.ac.uk/#/advancedsearch.

Collection highlights
1. Fossils illustrating the geological history of Scotland and key points in the evolution of life.
2. Fossils linked to Gideon Mantell (1790-1852) and William Buckland (1704-1856).
3. Fossil collections of Emily Dix (1904-1972), Alfred Nicholson Leeds (1847-1917), Thomas Brown of Lanfine (1774-1853), and James ‘Paraffin’ Young (1811-1883).
4. David Ure (1749-1798) collection of Carboniferous fossils, subject of an extensive publication.
5. Strong collection of c.6,000 trilobite fossils attributed to George Rae (1927-1998).
6. Several thousand type and figured fossils in the collection.

Published information
Clark, N.D.L. (1991). *Palaemysis dunlopi* Peach 1908 (Eocarida, Crustacea) from the Namurian (Carboniferous) of the western Midland Valley. *Scottish Journal of Geology*. 27:1-10.
Clack, J.A., and S.M. Finney. (2005). *Pederpes finneyae*, an articulated tetrapod from the Tournaisian of Western Scotland. *Journal of Systematic Palaeontology*. 2:311-346.
Coates, M.I., and S.E.K. Sequeira. (2001). A new stethacanthid chondrichthyan from the Lower Carboniferous of Bearsden, Scotland. *Journal of Vertebrate Paleontology*. 21:438-459.
Dunlop, J.A., and L.I. Anderson. (2005). A fossil harvestman (Arachnida, Opiliones) from the Mississippian of East Kirkton, Scotland. *The Journal of Arachnology*. 33:482-489.
Mantell, G. (1825). Notice on the *Iguanodon*, a newly discovered fossil reptile, from the sandstone of Tilgate Forest, in Sussex. *Philosophical Transactions of the Royal Society of London*. 115:179-186.

Milner, A.R. and S.E.K. Sequeira. (1993). The temnospondyl amphibians from the Viséan of east Kirkton, West Lothian, Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh.* 84:331-361.
Prokop, J., M. Pecharova, E.A. Jarzembowski, and A.J. Ross. (2018). New palaeodictyopterans from the Late Carboniferous of the UK (Insecta: Palaeodictyopterida). *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*. 107:99-107.
Ure, D. (1793). *The History of Rutherglen and East-Kilbride: Published with a View to Promote the Study of Antiquity and Natural History.* Glasgow: David Niven.

Collection overview

The displays in The Hunterian focus on well-known fossil localities from Scotland, the UK and worldwide where assemblages have been excavated and studied both historically and recently. The oldest specimens are Cambrian Pipe Rock from Ullapool, representing infilled burrows in sand. Fossils from the Ordovician of the Girvan area, 460 million years ago, include the worm tubes of *Serpulites*, orthoconic nautiloids, conularids, starfish (*Drepanaster*, *Stenaster*, *Urasterella*, *Euzosoma* and *Mastigactis*), carpoids (*Dendrocystoides* and *Cothurnocystis*), cystoids (*Pleurocystites* and *Dendrocystoides*), floating sponges *Receptaculites*, brachiopods (*Plaesiomys*, *Dinorthis*, *Schizophorella* and *Leptaena*), echinoids (*Ectinechinus*), crinoids (*Protaxocrinus*) gastropods (*Tropidodiscus*), coral (*Grenwingkia*) and trilobites (*Stenoparia*, *Pseudospharexochus*, *Calymene*, *Erratencrinus*, *Sphaerocoryphe*, *Remopleurides*, *Phillipsinella*, *Decoroproetus*, *Flexicalymene*, *Dindymene*, *Lochodomas*, *Cybeloides*, *Paraproetus*, *Stygina*, *Tretaspis*, *Nankinolithus*, *Toxochasmops* and *Erratencrinurus*). In addition, an 18cm long *Hadromerus keisleyensis*, dated to 435 million years ago from Girvan is highlighted as Scotland's largest trilobite. The collection also includes Ordovician graptolites, such as *Diplograptus*.

Figure 55: Jaw with teeth of the Carboniferous fish *Rhizodus hibberti* from Edinburgh (The Hunterian)

Silurian fossils are from the Lesmahagow and Hagshaw Hills inliers in Ayrshire and Lanarkshire, specifically the localities discovered by James Fallow in the 1840s and subsequently excavated by Dr Robert Slimon (1808-1882), and the Geological Society of Glasgow under the name 'Camp Siluria'. Fossils include the fish *Jamoytius*, the eurypterids *Hughmilleria*, *Pterygotus* (juvenile and adult specimens) and larger *Paracarcinosoma*, a *Pterygotus* claw, the enigmatic shrimp-like

arthropod *Ainiktozoon* (assigned previously to many groups including sea squirts) and the jawless fish *Loganellia*, *Lasanius* and *Birkenia*. A millipede from the Silurian of the island of Kerrera (Argyll and Bute), dated to 425 million years ago, is described as the earliest known land animal, although older terrestrial arthropod fossils have since been found. Devonian fossils are limited to *Cephalaspis* and other fish from Dura Den, Fife.

Carboniferous fossils are from the 330 million-year-old rocks exposed at Bearsden and Bathgate. The Bearsden locality was discovered by Stan Wood (1939-2012) and excavated by The Hunterian in 1982. Fossils include the 'Bearsden shark' *Akmonistion*, the rat-fish *Deltoptychius*, an iniopterygian 'flying shark' (one of a rare few found outside America), smaller shark *Denaea*, the fish *Chirodus* and *Rhizodus*, a coprolite from a large fish, a species of the fish *Mesopoma carriki* known only from Bearsden, the shrimps *Palaemysis* and *Tealliocaris*, with an additional fossil of *Palaemysis* showing preservation of blood vessels and muscles. Fossils from East Kirkton, near Bathgate, are as varied as the hind part and head of the amphibian *Balanerpeton*, two scorpion fossils, the harvestman spider *Brigantibunum listoni*, and carbonate encrusted wood resulting from deposition in hot springs saturated with lime. Additional Carboniferous fossils are of the corals *Aulophyllum* and *Lithostrotion*, brachiopods (*Gigantoproductus, Productus*, *Spirifera* and *Echinoconchus*), coprolites, bivalve *Carbonicola*, crinoid *Parazeacrinus* and bryozoan *Fenestella* (some linked to David Ure), *Tealliocaris* shrimps from Gullane, East Lothian, shark teeth (*Gyracanthus* (Cowdenbeath, Fife), *Gonotodus* (Edinburgh) and other large specimens), *Rhizodus* from Edinburgh (Fig. 55), and the *Arthropleura* track from Laggan, Isle of Arran, with a full-sized model and part of an *Arthropleura* body segment in an ironstone nodule. There is the fossil of the 345 million-year-old amphibian *Pederpes finneyae* (Fig. 56), discovered in the Ballagan Formation at Dumbartonshire in 1973 and named after the finder Peder Aspen and preparator Sarah Finney.

The Permian is represented by the three-dimensional resin cast of a dicynodont skull, produced from an MRI scan of a void in Hopeman Sandstone from the Moray Coast. Fossils from the Mesozoic of Scotland are from the Jurassic of the Isle of Skye: The bivalve *Gryphaea* and ammonites, casts of trackways and footprints (originals in Staffin Dinosaur Museum or still *in situ*), and a dinosaur caudal (tail) vertebra. A footprint found on the Isle of Skye by the curator of vertebrate fossils at The Hunterian, recognised by Guinness (2006) as the smallest footprint in the World, is also on display. This footprint is interesting because it occurs within a second, only moderately larger print.

Early vertebrate fossils are the teeth of the conodont *Jumodontus* from the Lower Ordovician of Perthshire and examples of the complete animals from the Lower Carboniferous of Edinburgh. Early tetrapods are represented by the cast of *Acanthostega* from the Upper Devonian of Greenland, a tail of *Eusthenopteron* from Quebec with a model and cast of the pectoral fin to show the bones, the lower jaw of a baphetid amphibian from the Carboniferous of Larkhall, Lanarkshire, *Eoherpeton* from the Lower Carboniferous of East Kirkton, cast of a *Diplocaulus* skull from the Early Permian of Texas, a fossil showing the rear of the skull, thorax and shoulder girdle of *Discosauriscus* from the Early Permian of the Czech Republic, *Archegosaurus* from the Lower Permian of Germany, lower jaw of *Cyclotosaurus* from the Early Triassic of Germany, and *Thoosuchus* from the Early Triassic of Russia. Fish fossils include *Coturus* and *Ophiopsis* (Upper Jurassic, Eichstatt), *Pachycormus* (Early Jurassic, Holzmaden), *Mene, Myripristis* and *Sparnodus* from the Eocene Monte Bolca, *Diplomystus* (Eocene Green River Formation, Wyoming), *Amia* (Eocene, Darmstadt, Germany), *Dapedius* (Lower Jurassic, no location), *Mallotus* (Quaternery, Ontario), *Diplomystius* (Upper Cretaceous, Mt Lebanon, Lebanon) and *Pholidophorus* (Jurassic, Dorset). A tooth found in 1821 by Mary Mantell in a Sussex Quarry was compared by Gideon Mantell (1790-1852) in a 1925 publication to the tooth of the carnivore *Megalosaurus* that William Buckland (1704-1856) had published on in 1824. Flying vertebrates are represented by the casts of *Archaeopteryx lithographica* (the Berlin specimen showing feather outlines and the Eichstatt specimen found in 1951), a model of *Proavis* in flight (Frank Munro, 1960s), a *Pterodactylus* cast from the Jurassic Solnhofen Limestone, and the bat *Palaeochiropteryx* from the Eocene of Messel, Germany. A dinosaur nest with several eggs from the Upper Cretaceous of China, a large articulated cast of a sauropod dinosaur leg, and a comparison

of a dinosaur limb bone to a section of the 300 million-year-old club moss *Lepidodendron* are present.

Dinosaur fossils are the lower and upper jaws of the Cretaceous *Juxartosaurus* showing the tooth plates and wear, a Cretaceous *Tyrannosaur* jaw with a broken and erupting tooth, a Cretaceous dinosaur 'hand', Cretaceous hadrosaur skin impression cut by a rib and 150 million-year-old (Jurassic) dinosaur dung with plant fragments. A separate display shows the skulls of an *Archaeopteryx* from Germany, *Velociraptor* from Asia, *Diplodocus* from North America and an *Allosaurus* skull from North America. Marine reptiles are represented by a large, wall-mounted Jurassic ichthyosaur and an articulated skeleton of a *Cryptoclidus*. An elephant tooth from Norwich and a mastodon tooth from North America represent mammals. Brittle stars in Arctic clay from Dunbar, East Lothian, are the youngest fossils on display.

Figure 56: The Carboniferous amphibian *Pederpes finnayae* from the Ballagan Formation, Dumbarton (The Hunterian)

Several cases give information on specific collectors and examples of their work, some of which contain fossils. The collection of Emily Dix (1904-1972) comprises Upper Carboniferous (300 million-year-old) plant fossils from France, Germany, Wales and England, used to correlate the respective stratigraphic sections among these regions. Representative specimens on display are of *Acitheca*, *Archaeosigillaria*, *Neuropteris*, *Diplotmema*, *Sphenophyllum*, *Senfteribergia*, *Lepidodendron*, *Asterotheca*, *Callipteridium*, *Alethopteris*, *Annularia*, *Polymorphopteris* and *Odontopteris*. The specimens in The Hunterian are those that survived bombing in London during the Second World War. Many specimens and most of the paperwork and research notes produced by Dix were destroyed; the event led to the remaining material being donated to The Hunterian at the end of the war. Fossils from the collection of George Rae (1927-1998) have a wide range, both geographically and stratigraphically: a Silurian gastropod *Platystoma* from Indiana, Jurassic ammonite *Caloceras* from Somerset, *Diplomystius* and *Knightia* from the Eocene Green River Formation of Wyoming, Ordovician *Ectillaenus* and Devonian *Lioharpes* from the Czech Republic, Ordovician *Asaphus* and *Neoasaphus* from Russia, plants from the Carboniferous of Illinois, the Middle Cambrian trilobite *Acadoparadoxides*, Ordovician trilobite *Onnia* and Devonian trilobites *Ceratarges*, *Morocconites*, *Odontochile* and *Konoprusia* from Morocco, Jurassic belemnite *Megateuthis* from the Isle of Skye and *Microdoceras* from Charmouth, and Cretaceous

Venezoliceras. Material attributed to Rae includes a notable collection of fossils from Girvan, particularly trilobites.

The collection of Alfred Nicholson Leeds (1847-1917) comprises 160 million-year-old vertebrate fossils collected from brick pits around Peterborough to form the largest collection of Jurassic marine reptiles (approximately 600) accumulated by a single family. On display is a front paddle and two dorsal vertebrae of the long-necked plesiosaur *Muraenosaurus*, tail rays and gill rakes from *Leedichthys*, skull and lower jaws of the aquatic crocodile *Metriorhynchus*, skull and isolated tooth from the 'land' crocodile *Steneosaurus* and 4 tooth plates from the chimaerid shark or rat fish *Plichymylus*. The Thomas Brown of Lanfine (1774-1853) collection includes a specimen of limestone showing coral reef debris with a prominent, complete *Encrinurus* calyx (head and arms) and part of the stem from Brunswick, Germany. A second specimen is a *Megalosaurus* tooth and bone fragment from Tilgate, Sussex, with a link to Buckland, and is perhaps the specimen mentioned by Mantell. The James 'Paraffin' Young (1811-1883) collection includes a wooden compartmentalised case of fossils (brachiopod, bivalve, crinoid, coral, gastropod) from the Carluke area, Lanarkshire, with labels providing a genus and species name, locality, and number (there is a total of 98). Most specimens are cut in some way, usually as squares, and polished, the orientation of the cut being given in the information provided by the collector.

Examination of material in storage was not possible due to Covid-19 restrictions; the material on display is assumed to be representative of the fossil specimens in the Hunterian Collection. A summary of the 'Dinosaurs and Fossils' collection is available at https://www.gla.ac.uk/hunterian/collections/collectionssummaries/dinosaursandfossils/. Information from the database and literature highlights various type and figured specimens, including a specimen of the Carboniferous nymph *Idoptilus peachii* figured by Prokop et al (2018).

Research/collection links

Fossils showing the diversity of life in the Girvan area during the Ordovician have been studied through various research projects. Work to find, collect and study vertebrate, invertebrate and trace fossils from the Middle Jurassic of the Isle of Skye is ongoing with the fossils recovered studied in a collaboration of staff and researchers at the University of Glasgow, University of Edinburgh and National Museums Scotland.

Glasgow Museums Resource Centre (Glasgow Life)

Collection type: Local authority (Glasgow Life)
Accreditation: 2017
Recognised Collection: 2009

200 Woodland Road, South Nitshill Industrial Estate, Glasgow, G53 7NN
Contact: museums@glasgowlife.org.uk

Location of collections
The Glasgow Museums Resource Centre (GMRC) is the main store for collections managed by Glasgow Life. The building is divided into large rooms known as 'pods', one of which is reserved for the storage of fossils. There are no displays onsite, although the collections are available for use across Glasgow Life venues (see report for Kelvingrove Art Gallery and Museum below) and for loan to other organisations. Under normal circumstances, the collections are open and accessible 7 days a week with GMRC offering tours, school visits and family activities. The entire collection of Glasgow Museums is Recognised under the Museums Galleries Scotland Recognition Scheme as a Nationally Significant Collection.

Size of collections
c.50,000 fossils.

Onsite records
Information is in Mimsy (Multimimsy), the CMS database used by Glasgow Life, with the majority of fossils entered and work ongoing to add and update others. Additional details are in accession registers, Natural History Department daybooks and object files. An online database is available at: http://collections.glasgowmuseums.com/mwebcgi/mweb?request=home.

Collection highlights
1. Fossil collection 'representative of Scottish palaeontology'.
2. Silurian fossils from Lesmahagow collected by Dr Robert Slimon (1808-1882) and donated in 1909, with other material excavated by Camp Siluria.
3. Extensive collection of Devonian fish from Scotland.
4. Carboniferous fossils from East Kirkton.
5. The John Young (1823-1900) Collection of Carboniferous invertebrates (brachiopods, crinoids, ostracods, corals, bivalves, etc) donated by James Tullis in 1901, the basis for the *Catalogue of Western Scottish Fossils*.
6. Carboniferous corals collected by James Thomson (1823-1900).
7. Plant fossils from the Palaeocene Ardtun leaf beds of Mull.
8. Arctic clay fossils collected by David Robertson (1806-1896) and James Coutts (1810-1886).
9. Fossils are attributed to Dr Robert Gregory Absalom (1902-1975), David Nimmo, James Neilson (1820-1901, the Robert Craig (1822-1901) collection), James Dairon (1811-1891) and David Corse Glen (1824-1892).
10. Approximately 650 type and figured specimens.

Published information
Armstrong, J. (1876). *Catalogue of the western Scottish fossils*. Glasgow: Blackie & Sons.
Black, R.M. (1970). *The elements of palaeontology*. Cambridge University Press.
Brady, G.S., H.W. Crosskey, and D. Robertson. (1874). A Monograph of the Post-tertiary Entomostraca of Scotland. *Monograph of the Palaeontographical Society.* 28:1-232.
Campbell, G. D. (1851). On Tertiary leaf-beds in the Isle of Mull. *Quarterly Journal of the Geological Society of London.* 7:89-103.
Crosskey, H. W., and D. Robertson. (1868). VIII. The post-tertiary fossiliferous beds of Scotland. *Transactions of the Geological Society of Glasgow.* 3:113-129.

Forbes, E. (1851). Note on the Fossil Leaves represented in Plates II. III. and IV. *Quarterly Journal of the Geological Society.* 7:103-103.
Hill, D. (1938). A Monograph on the Carboniferous Rugose Corals of Scotland. *Monographs of the Palaeontographical Society.* 91:1-78.
Hill, D. (1939). A Monograph on the Carboniferous Rugose Corals of Scotland. *Monographs of the Palaeontographical Society.* 92:79-114.
Hill, D. (1940). A Monograph on the Carboniferous Rugose Corals of Scotland. *Monographs of the Palaeontographical Society.* 94:115-204.
Johnson, T. (1937), Notes on the Tertiary flora of Scotland. In *Transactions of the Botanical Society of Edinburgh.* 32:291-340.
Young, J., and J. Armstrong. (1874). XXIV. The Fossils of the Carboniferous Strata of the West of Scotland. *Transactions of the Geological Society of Glasgow.* 4:267-281.

Collection overview
The collection includes material focused on several stratigraphic levels and important localities. Silurian fossils include *Birkenia*, *Lanarkia*, *Logania*, and other agnathans (jawless fish) from the Lesmahagow, and Hagshaw Hills, Inliers. The Devonian is represented by fish: *Cephalaspis* (Ayrshire), *Coccosteus* (Thurso, Achanarras), *Psammosteus*, *Homostius* (Caithness), *Bothriolepis* (Scat Craig, Tynet Burn), *Pterichthyodes* (Caithness), *Osteolepis*, *Glyptolepis*, *Mesacanthus*, *Oracanthus*, *Cheirolepis*, *Dipterus* (Caithness), *Diplacanthus* and *Acanthodes* (Tynet Burn) and *Cheiracanthus* (Cromarty and Caithness); several of these localities are no longer accessible. Upper Devonian Dura Den fossils are also present as large, oversize slabs. Carboniferous fish include *Rhizodus* (Airdrie), *Eurynotus*, *Amblypterus*, *Gyracanthus*, *Nematoptychius*, *Ctenocanthus* (Carluke), *Gonatodus*, *Ctenodus* (Annich Lodge), *Rhabdoderma* and *Elonichthys* (from a blackband ironstone), and many other fragments. Other Scottish vertebrate material includes the scute impressions and bones of the reptile *Stagonolepis robertsoni* in Triassic sandstone. Fish fossils from outwith Scotland are a Jurassic *Dapedius*, isolated teeth in Jurassic Stonesfield Slate (*Hybodus*), several isolated shark teeth from East Anglia and *Carcharodon megalodon* (probably from East Anglia and America), and near complete fossils of *Odotus* (Cretaceous of Dover), *Lepidotes* (Wealden, Isle of Wight) and *Belinostomus* (Santana Formation of Brazil), among others.

A range of vertebrate material from outwith Scotland includes fragments of dinosaur bone, Jurassic plesiosaur femora and marine reptile vertebrae from the Jurassic Oxford Clay, ichthyosaur ribs, a crocodile scute and teeth, whale bones from the Red Crag of Felixstowe and a mammoth tooth, among others. Fragmentary artiodactyl mammal fossils (notably skull and teeth) from the Eocene-Oligocene of North America include *Eporeodon* (specimens from the Oligocene Chamberlain Pass, South Dakota), *Hyracotherium*, *Agriochoerus*, *Systemodon* and *Merycoidodon* (better known as *Oreodon*), among others. There is a complete skeleton of a Moa (*Dinornis*), with several additional limb bones and an articulated foot from New Zealand. There are casts of an *Archaeopteryx* and two ichthyosaurs.

Invertebrate fossils from the Palaeozoic (Cambrian to Permian) tend to be from rocks locally and within Scotland; younger (Mesozoic and especially Cenozoic) fossils are usually from further afield. Invertebrate specimens include examples of sponges, annelids in coal from Ayrshire and foraminifera from numerous stratigraphic levels. The Cambrian is represented by trilobites and trace fossils not examined on this visit. Fossils from the Ordovician include an assemblage from the Ardmillan Series (Caradoc-Ashgill, now Upper Sandbian-Upper Katian) of Girvan, notably trilobites (*Cyclopyge*, raphiophorids) and brachiopods (*Lingullela*, *Leptellina*, *Foliomena*, and *Glyptomena*). Examples of the Ordovician graptolite *Climacograptus* from the Glenkiln Shale (Rein Gill, Abington, Lanarkshire), Ardwell Shale (Girvan), Llandeilo Series (Llandrindod Wells) and the Hartfell Shale (Dob's Linn) were examined although many other taxa are present from these and additional localities. A further Ordovician fossil is *Nidulites* from Drummock, Ayrshire. Silurian fossils are of arthropods from Lesmahagow in Lanarkshire: The eurypterids *Slimonia* and *Carcinosoma* (labelled with the former name, *Eusarcana obesa*) and examples of the phyllocarid *Ceratiocaris* part of a

fauna including early fish (mentioned above), and brachiopods from the Silurian of the Pentland Hills and Much Wenlock Limestone Formation of the Welsh Borderlands (Shropshire and Wales).

A large part of the collection comprises invertebrate fossils from the Carboniferous: Corals (*Dibunophyllum*, *Clisiophyllum*, *Lonsdaleia*, *Carcinophyllum* among many others), crinoids (mostly fragments), bryozoan (*Fenestella*), brachiopods (most notably productids (*Productus*, *Gigantoproductus*) and several other groups), gastropods, goniatites, bivalves (*Aviculopecten*) and ostracods (*Bythocypris*, *Leperditia*, *Cypridinella*, *Healdia* and polycope burrows), many attributed to specific collectors and from localities focused in the southwest of Scotland: Kilmarnock, Dykehead, Blantyre, Beith, Roscobie (Fife), Campsie, Kirktonholm, East Kilbride, Bathgate, Hamilton and Bankhead (Lesmahagow). The corals are often cut to show internal morphology, and there are examples of productid brachiopods showing (rare) long external spines that stabilised them on the seabed during life. Many fossils are attributed to historic workers, such as John Young (1823-1900), James Thomson (1823-1900) and Robert Craig (1822-1901). The corals collected by James Thomson were used as the basis for a monograph of Scottish rugose corals by Dorothy Hill (published 1938-1940).

Figure 57: Eocene gastropod molluscs from England (Barton) and France (Grignon) (Glasgow Museums Resource Centre). Published with permission of Culture and Sport Glasgow (Glasgow Museums)

Mesozoic fossils include bryozoans (Herault, France), ammonites (*Aegoceras*, *Harpoceras* preserved adjacent to an ichthyosaur), brachiopods (terebratulids and rhynchonellids), echinoids (*Clypeus*), crinoids (*Seirocrinus*, *Apiocrinus*) and Jurassic arthropods (*Eryon* from the Inferior Oolite). From the Cenozoic, the Eocene is represented by bivalves and gastropods (*Voluta*, *Mitra*, *Terebra*, *Buccinum* and *Plurotoma*) from the Barton Beds of Barton in Northamptonshire, Turin and France (Fig. 57). A giant gastropod, measuring 50 centimetres, is probably from the Eocene of the Paris Basin. The Pliocene Coralline and Pleistocene Norwich crags are represented by mollusc fossils. There is material labelled as Post-Tertiary, representing Arctic (Pleistocene) glacial marine clays deposited between 13,500 and 12,000 years ago. Labels indicate Gourock and the Firth of Clyde among other localities, where the Clyde Beds (now the Clyde Clay Formation) are exposed.

These contain bivalves, gastropods, brittle stars (*Ophiopholis aculeata*), foraminifera and ostracods, often presented in fully labelled, glass-topped slides.

The taxonomic and geographic diversity of the plant fossils is indicated by drawer labels: Jurassic of Scotland, Miocene of Switzerland, Paleocene of Mull, Pleistocene mainly from Scotland, Silurian plants, Lower Old Red Sandstone from Forfarshire, Lower Old Red Sandstone from Perth and Stirling, and Lower Old Red Sandstone from Callendar, among others. Carboniferous plant fossils are the most numerous and diverse with specimens of *Cordaites*, *Sphenopteris*, *Zeilleria*, *Cordaicarpus* and *Lyginopteris* observed among many others. Fossils from the Paleocene Leaf Beds at Ardtun on Mull are labelled as *Betula cuspridens*, *Hamamelis orbicularis*, *Viburnum coryloides* and *Platanus hebridicus*, *Quercus*, *Gingko* and other deciduous trees; a specimen with fragments of several taxa is figured by Johnson (1937). The leaf bed locality was discovered in 1850 by George Campbell the 8th Duke of Argyll (1823-1900) with fossils donated to numerous museums by his son Lord Archibald Campbell (1846-1912). A drawer of Silurian plants includes *Amphiospongia* (perhaps an unusual hexactinellid sponge) from the Pentland Hills, which has not been observed in other collections to date and is perhaps a rarity. Approximately 1,000 Carboniferous plant fossils from the Scottish coalfields, attributed to Robert Gregory Absalom (1902-1975), were donated in 1946.

Research/collection links

Past research includes work on the Arctic clay fossils attributed to David Robertson, donated in 1902, and James Coutts Collection, donated in 1914, used to show a change in climate and the transition in the Clyde Beds (Clyde Clay Formation) from deep marine to shallow water and rivers. In addition, the molluscs and ostracods infer temperatures in the Clyde area 12,000 years ago that are comparable to cooler climates at higher latitudes today. Fossils from the Ardtun leaf bed are diverse and could be studied to at least document the occurrence of material in this and other collections.

Kelvingrove Art Gallery and Museum (Glasgow Life)

Collection type: Local authority (Glasgow Life)
Accreditation: 2017
Recognised Collection: 2009

Argyle Street, Glasgow, G3 8AG
Contact: museums@glasgowlife.ac.uk

Location of collections
The Museum was purpose-built as the Palace of Fine Arts for the Glasgow International Exhibition in 1901. Following closure for major refurbishment and restoration, the Museum reopened in 2006. The objects at Kelvingrove Art Gallery and Museum are part of the Glasgow Museums Collection which is Recognised under the Museums Galleries Scotland Recognition Scheme as a Nationally Significant Collection. Fossils are onsite in the Museum displays with extensive collections in storage at the Glasgow Museums Resource Centre (see separate report above).

Size of collections
80-100 fossils on display (see GMRC entry above for details of stored collections).

Onsite records
Information is in Mimsy (Multimimsy), the CMS database used by Glasgow Life, with the majority of fossils entered and work ongoing to add and update others. Additional details are in accession registers, Natural History Department daybooks and object files. An online database is available at: http://collections.glasgowmuseums.com/mwebcgi/mweb?request=home

Collection highlights
1. Fossils representing well-known localities across Scotland.
2. Carboniferous amphibian *Balanerpeton* from East Kirkton, found by Stan Wood (1939-2012).
3. Carboniferous plant fossils linked to Dr Robert Gregory Absalom (1902-1975).
4. Fossils attributed to Charles Darwin (1809-1882).
5. Type and figured specimens

Published information
Hibbert, S. (1836). On the freshwater limestone of Burdiehouse in the neighbourhood of Edinburgh, belonging to the Carboniferous group of rocks. With supplementary notes on other freshwater limestones. *Transactions of the Royal Society of Edinburgh.* 13:169-282.
Jeram, A.J., and P.A. Selden. (1993). Eurypterids from the Viséan of East Kirkton, West Lothian, Scotland. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh.* 84:301-308.

Collection overview
Fossils are found in the *Creatures of the Past* gallery in displays focused on several stratigraphic levels. Fossils from the Devonian include the Lower Devonian *Cephalaspis* from Ayrshire, and Middle Devonian *Osteolepis* from Thurso and Orkney, *Gyroptychius* from Quoyloo, *Dipterus* from Caithness, *Palaeospondylus* from Achanarras, and *Cheirolepis*, *Cheirocanthus, Pterichthyodes*, *Coccosteus* and *Homostius* from Caithness, each with a model reconstruction. Two further reconstructions of Coelacanths are suspended from the ceiling. Upper Devonian fossils are of the fish *Holoptychius* in variably sized pieces of sandstone from Dura Den and other Scottish localities. Photographs of the scales of *Holoptychius* and *Osteolepis* placed adjacent to each other allow comparison of the scale ornament.

Carboniferous fossils are mainly plants, such as the giant club moss *Lepidodendron* (trunks, twigs and seed cones from Lanark among other localities), *Lepidostrobus* from Muirkirk and *Stigmaria*.

Horsetails include *Annularia* from Merrystone, *Calamites* from New Cumnock, *Asterophyllites* twig with leaves from Lesmahagow and a *Palaostachya* cone from Foxley, Glasgow. Fern-like plants are *Alethopteris* from Whinhill Pit, Alloa (also labelled as Absalom Collection), *Neuropteris* from Carluke, *Sphenopteris* from Grange Pit, Kilmarnock, and an *Alethopteris* with the seed cone *Trigonocarpus* from Foxley, Glasgow. Fish are represented by *Rhizodus*, *Megalichthys*, a species of *Mesopoma*, *M. carriki*, known only from Bearsden and *Eurynotus* (Broxburn), amphibian *Anthracosaurus* from Lanarkshire, and various coprolites, one macerated to reveal *Acanthodes* fish scales (labelled as 'J. T. Tullis, Young Collection', material collected by Dr John Young (1823-1900) and donated by James Tullis). Invertebrates include a range of corals (*Aulaphyllum*, *Lithostrotian*, *Zaphrentis* and *Lonsdaleia*), crinoids (*Poteriocrinus* showing the arms, cup and stems separately), bryozoa (*Penniretipora* with *Fenestella*), bivalves (*Anthracomya* and other bored shells), brachiopods (*Gigantoproductus*, *Spirifer*, *Antiquatonia*, *Schellwienella*, *Echinoconchus*, *Eomarginifera*, *Rugosochonetes*, *Leptagonia*, '*Lingula'* and *Krotovia*), cephalopods (*Rayonnoceras*, *Tylonautilus*, *Orthoceras*, *Beyrichthioceratoides*), bivalves (*Anculapecten*, *Lithophaga*, *Sanquinolites*, *Polidevcia*), arthropods (*Palaemys dunlopi*, *Paladin cuspidatus*) and gastropods (*Palaeostylus*, *Pleurotomaria*, *Straparollus*). Noted specimens are the large head of the eurypterid *Hibbertopterus* (a figured lectotype) and part of the skeleton of the amphibian *Balanerpeton woodi* from East Kirkton, found by Stan Wood in 1985 (figured).

Figure 58: Triassic *Cheirotherium* footprints from England (Kelvingrove Art Gallery and Museum). Published with permission of Culture and Sport Glasgow (Glasgow Museums)

The Triassic is represented by bones and the impression of bones from the reptile *Stagonolepis robertsoni* collected from Lossiemouth, near Elgin, Moray, and displayed with a life-size reconstruction. The Jurassic is represented by a complete ichthyosaur *Stenopterygius* from the Liassic of Holzmaden, Germany, several dinosaur gastroliths and invertebrate fossils including belemnites, gastropods, ammonites of regular and irregular type and examples of aptychii (the two-part lid used to close the shell with the living animal inside for protection) from the Isle of Skye, Scotland, England and Germany (displayed in a spiral), orthconic nautiloids, sponges, brachiopods, echinoids, corals, a crinoid from Germany, arthropods (lobster) and worm cast. Bivalves include the Jurassic *Gryphaea*, *Trigonia*, *Plagiostoma, Pholadomya* and oysters among other Jurassic and

Cretaceous specimens, such as the echinoid with club spines still attached and preserved in chalk. A bivalve is possibly from a Devensian Arctic clay. Vertebrates are represented by a fish with an old label reading *Caturus* from the Solnhofen Limestone, a second fish that is perhaps Permian, and a turtle. The table also shows a cast of a *Cetiosaurus* limb bone and cast of a *Ceratosaur* tibia, from the Middle Jurassic of the Isle of Skye. On top of the case is an articulated cast of a *Ceratosaur* skeleton from the Jurassic of Wyoming.

Trace fossils originate from several stratigraphic levels: Carboniferous *Eione montiforme* worm traces, Silurian *Crossopodia* snail tracks, Devonian *Helminthites* worm traces, Jurassic *Labricanus* worm casts (possibly from the Solnhofen Limestone), U-shaped *Corophiodes* worm burrows, *Oldhamia* invertebrate tracks, two specimens described as Carboniferous worm burrows and tracks, and more than one Triassic *Cheirotherium* track (labelled as England but probably from Cheshire, Fig. 58) including a cast. Further casts are of a Cretaceous *Protoceratops* nest with eggs and the pterosaurs *Scaphognathus*, *Pterodactylus* and *Rhamphorhynchus*, and an *Archaeopteryx* with a *Pterandon* model suspended from the ceiling.

A box of fossils in a themed display is attributed to Charles Darwin: The bivalve *Spondylus*, a crinoid, echinoid *Cyphosoma*, gastropod *Pleurotomaria*, coral, bivalve *Gryphaea*, belemnite, ammonite, second echinoid, a vertebra from the ichthyosaur *Macropterygius*, bivalve, ammonite and *Ptychodus* shark tooth. In another case related to Darwin is a slab of Much Wenlock Limestone Formation representing coral reef debris and showing fragments of numerous invertebrate fossils.

Research/collection links
Some of the trace fossil species are represented in other collections, notably University of Aberdeen Museums where many specimens are type and figured. A project could investigate whether the fossils displayed at Kelvingrove Art Gallery and Museum are of the ichnospecies studied by workers at Aberdeen with the potential to focus research on those that are ‘new’ or in need of revision.

Detail of Permian footprints *Chelichnus duncani* in sandstone from Dumfries and Galloway. Dumfries Museum and Camera Obscura. © Dumfries and Galloway Council Museums Service

Review of Fossil Collections in Scotland

Scotland South

National Museums Scotland

John Ellerman Foundation

Scotland South

Dumfries Museum and Camera Obscura (Dumfries and Galloway Council)
Sanquhar Tolbooth Museum (Dumfries and Galloway Council)
Stranraer Museum (Dumfries and Galloway Council)
Gem Rock Museum
Newton Stewart Museum
Tweeddale Museum (Live Borders)
Hawick Museum (Live Borders)

Dumfries Museum and Camera Obscura (Dumfries and Galloway Council)

Collection type: Local authority
Accreditation: 2018

The Observatory, Rotchell Road, Dumfries, DG2 7SW
Contact: dumfriesmuseum@dumgal.gov.uk

Location of collections
The original Museum was located in a windmill dating from the late 1700s, preserved in the 1830s by the newly-formed Dumfries and Maxwelltown Astronomical Society for use as an observatory. An extension built in the 1860s added a large gallery and mezzanine level with further gallery and storage space added in the 1980s. Collections are onsite in displays and a main storeroom.

Size of collections
1,000-1,200 fossils.

Onsite records
Information is in an Adlib CMS database transcribed from several previous electronic systems and various paper documents, such as MDA and other index card systems, Gift Books, Accession Registers, free text catalogues, inventories and listings. Fossils are catalogued with other geological material as a series of numbered boxes with a list compiled in the 1980s by James Williams (1944-2009). An online catalogue is available at: https://dgc-web.adlibhosting.com/home but does not yet contain fossil entries.

Collection highlights
1. Permian vertebrate trackways from Locharbriggs and Corncockle quarries linked to Reverend Henry Duncan (1774-1846) and former curator Alfred Truckell (1919-2007).
2. Fossils linked to Dr James Gilchrist (1813-1889) and William George Gibson (1828-1890), founders of the Museum, Dr Thomas Boyle Grierson (1818-1889) of Thornhill and James Watt (possibly the inventor born in Greenock; 1736-1819).

Published information
McKeever, P.J. (1994). The behavioural and biostratigraphical significance and origin of vertebrate trackways from the Permian of Scotland. *Palaios*. 9:477-487.
Several fossils are documented on the Future Museum website: http://futuremuseum.co.uk/

Collection overview
Fossils are almost entirely from the Permian or Carboniferous and from localities within the area of Dumfries and Galloway. The Permian is represented by approximately 20 slabs of sandstone showing vertebrate trackways, labelled as *Chelichnus*, *Saurichnus*, *Prochirotherium* and *Loxodactylus* from Locharbriggs and Corncockle quarries, Dumfries and Galloway; these include type specimens (Fig. 59). The collection also holds the type specimen of *Prochirotherium truckelli* from Corncockle Quarry, named after Alfred Truckell and *Chelichnus locharbriggsensis* from the Locharbriggs Quarry. Carboniferous fossils are numerous and diverse with the displays providing an overview: Brachiopods *Gigantoproductus, Rhynchonella*, *Productus* and spiriferids among others, bivalve *Carbonicola* from a mussel band, several nautiloids (Fig. 60), such as *Actinoceras*, corals *Aulophyllum*, *Lithostrotion* and *Lonsdalia,* shark tooth plate, and plants *Sigillaria*, *Cyclopterus*, *Pecopterus* and *Ulodendron* from localities including Closeburn, Muirburn and Arbigland; a *Terebella*/part of a dentalium (old label) is from Kelhead. A slightly expanded diversity of taxa (crinoids, fish, coprolites, additional corals, brachiopods and bivalves, and gastropods, notably *Bellerophon*) form the collections in storage. Several specimens are oversize: a large colonial coral, plants (*Stigmaria*, *Lepidodendron*, etc), brachiopods (*Productus*) and orthoconic nautiloids. The

Carboniferous from other areas of Scotland is represented by fossils of the fish *Rhizodus* from Gilmerton, near Edinburgh.

Figure 59: Holotype of the Permian *Prochirotherium truckelli* trackway from Corncockle Quarry, Dumfries (image used courtesy of Dumfries Museum)

Fossils from other stratigraphic levels are the ichthyosaur in a wooden frame, perhaps a juvenile but still more than a metre long, and fish in sandstone from the Upper Devonian of Dura Den. A block is noted with a handwritten label reading ‘Grierson early turtle’, the name referring to Thomas Boyle Grierson (1813-1889) whose museum was located in Thornhill and the material from which ended up in Dumfries Museum and Camera Obscura among other locations. Several boxes have mixed rock, mineral and fossil content; fossils of the bivalve *Plagiostoma* (Liassic, Lower Jurassic) and echinoids suggest fossils from the Jurassic are also present.

Research/collection links

The ‘Grierson early turtle’ would be worth investigating to confirm if what seems to comprise a series of overlapping plates is the fused shell of a turtle or another form of reptile. The ichthyosaur fossil, likely to be from the Lower Jurassic of England or Germany, could also be studied.

Figure 60: A Carboniferous nautiloid from Closeburn (image used courtesy of Dumfries Museum)

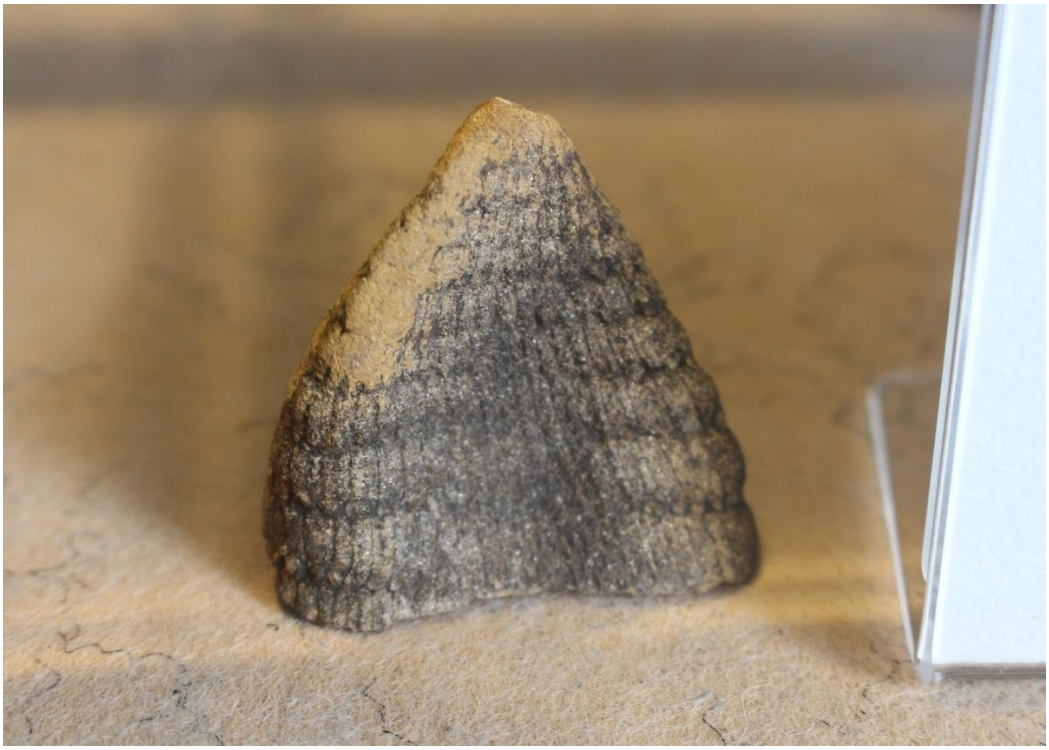

Figure 61: A Carboniferous fossil labelled as the solitary coral *Palaeosmilia*, perhaps the growing tip of the plant *Calamites*, in Sanquahar Tolbooth Museum (image used courtesy of Dumfries Museum)

Sanquhar Tolbooth Museum (Dumfries and Galloway Council)

Collection type: Local authority
Accreditation: 2018

High Street, Sanquhar, Dumfries, DG4 6BN
Contact: dumfriesmuseum@dumgal.gov.uk

Location of collections
The Museum is in a former tolbooth built in 1731 with uses since as a jail and town council chambers. The collection is onsite in displays across two first floor rooms and a small storage area.

Size of collections
Seven fossils on display, no more than two in storage.

Onsite records
Fossils are included in documentation at Dumfries Museum and Camera Obscura.

Collection highlights
1. Fossils potentially linked to Dr Thomas Boyle Grierson (1818-1889) of Thornhill.
2. Fossils collected through the local coal mining industry.

Published information
Several fossils are documented on the Future Museum website: http://futuremuseum.co.uk/

Collection overview
Fossils are all Carboniferous and from the local area: Plants (*Neuropteris*, large *Stigmaria* from Libry Moor, Kirkconnel, *Calamites* and slab of *Lepidodendron*), bivalve *Carbonicola*, a fossil labelled as the coral *Palaeosmilia* that might be better interpreted as the growing tip of the Carboniferous plant *Calamites* (Fig. 61), and a specimen with what is identified as an amphibian vertebra. One of the larger fossils seems to have been cut by machinery, suggesting collection through the local coal mining industry. The fossils are accompanied by interpretive text and a further sheet showing a geological map of the area. A fossil plant (stem or trunk) and gastropod (probably also Carboniferous) are in storage.

Stranraer Museum (Dumfries and Galloway Council)

Collection type: Local authority
Accreditation: 2018

55 George Street, Stranraer, Dumfries and Galloway, DG9 7JP
Contact: stranraermuseum@dumgal.gov.uk

Location of collections
The Museum building is on the main street in the former town hall built in 1776. No fossils are on display; all specimens are in an offsite store located a few minutes from the Museum.

Size of collections
55-60 fossils.

Onsite records
Catalogue on Adlib CMS.

Collection highlights
1. Fossils from Dumfries and Galloway.

Collection overview
The oldest fossils represent the Ordovician, with a box containing eight samples of the graptolites *Dicellograptus* from the Ordovician Hartfell Shale, and *Monograptus*, *Climacograptus* and *Rastrites* from the Silurian Birkhill Shale at Dob's Linn, Dumfries and Galloway. Labels indicate these might have been used in a previous display. Additional graptolite samples include one labelled as part of the Anderson Collection with other similarly labelled fossils; these are attributed to RSG Anderson (1867-1939) who was linked to Wigtown District Museum. Carboniferous plants include variably sized *Lepidodendron* and *Stigmaria*, smaller coalified pieces and multiple fragments in a sandy matrix. Invertebrates include a gastropod, corals (some might be Silurian), large productid brachiopod and crinoidal Limestone. Other fossils are the several ammonites (probably Jurassic, more specifically Liassic), bivalves (Mesozoic), sandstone with shell fragments, a sample of mudstone with bivalves, flint with a plant and worm casts in mudstone.

Gem Rock Museum

Collection type: Independent

Chain Road, Creetown, Dumfries and Galloway, DG8 7HJ
Contact: enquiries@gemrock.net

Location of collections
The current Museum, which opened in 1981, is the third museum on the same site. The collection was started 80 years ago by the father of the current owner, with many specimens collected in the field and others purchased, donated and exchanged. Collections are located in various rooms onsite, acting as both display and storage; all specimens are in public view.

Size of collections
Approximately 150 fossils.

Onsite records
All specimens are listed in an Excel spreadsheet by image; specimens are not numbered.

Collection highlights
1. Fossils represent important and well-known localities from around the world.

Collection overview
Fossils were chosen for display and therefore cover many taxonomic groups, stratigraphic levels and geographic localities worldwide (Fig. 62). Fish are from the Devonian Sandwick Fish Bed and other sites across north east Scotland, Brazil (Cretaceous Santana Formation), and a large slab covered with *Knightia* from the Green River Formation of Wyoming, USA. Shark teeth and a coprolite attributed to a shark are also present. Reptiles include a mosasaur tooth, *Spinosaur* tooth and dinosaur egg labelled as 90 million years old from Yunnan, China. Mammals are represented by various fragments: a bison leg bone, cave bear tooth, two mammoth teeth (from a gravel pit in Bawsey, donated 1972, and another from Aniak, Alaska), a long limb bone from a mammoth, walrus jaw and a cave bear skeleton (called Olga). A creodont skull has an age of 30 million years ago (Oligocene). A bone fragment is identified as a hominid thigh (femur) from the Olduvai Gorge in Tanzania c.1970, close to the area investigated by the palaeoanthropologists Louis Leakey (1903-1972) and his wife Mary Leakey (1913-1996), who discovered many early hominin remains and are noted for work on human evolution in Africa. It might be a specimen left from one of the previous museums but could have been collected by Joe Craig (in Africa) or George Hinchliffe (detail provided verbally).

Invertebrate fossils include trilobites from Utah (Cambrian *Elrathia*) and Morocco, ammonites (*Hamites* and *Dactylioceras* from the Liassic (Lower Jurassic) of Whitby and the Isle of Skye, and Germany), polished Devonian orthoconic nautiloids, belemnites, ammolite (opalescent mollusc shell), brachiopods of various ages, bivalves (Jurassic *Gryphaea* and *Inoceramus* from Cheltenham), Thalassinae (crustacean from Gunn Point, Australia), coral, echinoid (*Ensope calcus*), beetle in tar from Pennsylvania, and a specimen labelled as a mayfly but probably a March fly, although age details are needed to confirm this. Sedimentary rocks contain the bivalves *Turritella* and *Pecten*, a sample of Crag with shell fragments, crinoidal limestone and densely packed corallites in Frosterley Marble from Durham.

Plants, although limited to a few taxa, are represented by multiple *Lepidodendron* and *Stigmaria* and leaves, almost certainly from the Eocene Green River Formation among other origins. Several large trunk cross-sections and logs might be from Arizona. A polished slab is a stromatolite – a sedimentary structure formed by cyanobacterial growth in shallow water - from the Middle Devonian of Orkney (Fig. 63). A label describes the fossil record of stromatolites and similar structures.

Figure 62: A display showing a variety of fossils (Gem Rock Museum)

Figure 63: Polished Devonian stromatolites from Orkney known as ‘Horse-tooth stone’ (Gem Rock Museum)

Newton Stewart Museum

Collection type: Independent

York Road, Newton Stewart, Dumfries and Galloway, DG8 6HH
Contact: themuseumns@gmail.com

Location of collections
A former church building divided into 25 themed sections that form both the displays and storage of the collection.

Size of collections
20-30 fossils.

Onsite records
Information for the collections, including fossils, is in a Modes database.

Collection highlights
1. Fossils potentially linked to Herbert Maxwell (1845-1937), politician, antiquarian and naturalist.

Collection overview
Fossils are from various stratigraphic levels: Silurian bryozoan *Fenestella* and crinoid, the Carboniferous brachiopods *Productus*, *Eomarginifera* in limestone from Great Ormes Head, *Overtonia* and *Plectodonata*, crinoid stem from the Carboniferous of Fife, the Triassic bivalve *Chlamys*, two examples of the Upper Liassic (Lower Jurassic) bivalve *Nuculana*, the ammonites *Echinoceras* (Lower Jurassic) and *Sigaloceras* from the lower Callovian (Middle Jurassic), the Cretaceous gastropod *Natica*, a worn tooth of the shark *Anacorax* and coral *Isastrea* from Helmsdale, Sutherland. The fossil labelled as both an Ordovician graptolite and from the 'Upper Devonian … Devon' is probably the fragments of a Devonian plant. A piece of mudstone labelled as 'impression of lenses or footprints' from an unknown locality is probably not a fossil, and a final label reads 'portion of an uncertain bivalve, unknown locality'. There are also four ammonites most likely from the Liassic (Lower Jurassic), four *Gryphaea* from a similar level (labelled as univalves = bivalves), a fragment of a belemnite guard, single shell of the gastropod *Murex* and an elephant tooth.

Tweeddale Museum (Live Borders)

Collection type: Local authority (Live Borders)
Accreditation: 2019 (Provisional)

Chambers Institute, High Street, Peebles, EH45 8AG
Contact: enquiries@liveborders.org.uk

Location of collections
The Museum is located in the Chambers Institute, known previously as Dean's House and as the Queensberry House before 1775. The Institute was remodelled with the bequest of locally-born William Chambers (1800-1883) and opened in 1859 to provide a library, museum and hall for the Peebles community; an extension funded by Andrew Carnegie (1835-1919) opened in 1912. At one point all the rooms housed displays. The collections today are onsite in two main galleries and storage on a balcony level and adjoining rooms.

Size of collections
358 fossils.

Onsite records
The catalogue is a centralised Vernon system with entries from the four museum collections managed by Live Borders (indicated by prefixes). The original entry forms are present (redone in the 1980s) with 'quick check lists' available.

Collection highlights
1. Range of fish fossils from Scotland, UK and worldwide.
2. Collection of Carboniferous invertebrate fossils.
3. Pennsylvanian (Carboniferous) fossils from Kansas and Illinois.

Published information
Turner, R. (1927). *Descriptive catalogue of the Geological Collection in the Chambers Institution, Peebles*. Edinburgh: James Thin.

Collection overview
Vertebrate fossils include the Carboniferous fish *Rhizodus*, *Elonichthys*, *Rhadinichthys* and *Amblypterus*, the Triassic ray-finned fish *Birgeria*, Jurassic coprolite and vertebra(e) labelled as ichthyosaur, palatal teeth of the Jurassic-Cretaceous *Mesodon* (now *Typodus*), fossils described as spines, scales and/or bones of a Cretaceous ganoid or placoid fish, various shark teeth (*Odontaspis*, *Otodus*) and a cast of a fossil fish. A moderate-sized (70cm) fossil in an old wooden frame is labelled as '*Lepidotus semisonatus* from the Jet rock, Upper Lias, Whitby. Presented by Mr John Mc[Man]'; the fish and casing require conservation. Further specimens of the Cretaceous *Lepidotus* include teeth, fragmentary bone bed material, and fragments associated with the bivalve *Filosina*. Other vertebrate fossils are a 'fish bone embedded in rock' that might be reptile on investigation, and samples from the Westbury bone bed (Rhaetian (Triassic) Westbury Formation) and Ludlow Bone bed (Ludlow Series, Silurian).

Most of the fossils are invertebrates, the oldest of which are the annelid burrows in the basal Cambrian Pipe Rock. Graptolites (*Retiolites*, *Climacograptus*, *Monograptus*, *Diplograptus*, *Rastrites*, *Nemagraptus*, *Didymograptus* and *Dicellograptus,* some represented by several species, especially *Monograptus*) are Ordovician and Silurian. The Trilobites *Ogygia*, *Dalmanites* and *Phacops* among others are from the Ordovician, Silurian and Devonian. Corals tend to represent the Palaeozoic with wide-ranging species including *Thamnopora*, *Palaeosmilia*, *Endophyllum*, *Amplexus*, *Alveolites*, *Siphonophylla* and *Clisiophyllum*; *Heliolites*, *Favositella*, *Favosites*, *Acervularia*, *Halysites*, *Chonophyllum* from the Silurian; *Zaphrentis* and *Cystiphyllum* from the Devonian; *Cyathophyllum*,

Aulophyllum and *Lithostrotion* from the Carboniferous. A Devonian coral from outside the UK is labelled *Smithia* (?*Haplothecia*). An unusual specimen is the reworked coral eroded from rocks of the Devonian and redeposited with Triassic sediments. Brachiopods include Ordovician *Dinorthis*, *Heterorthis* and other orthids, Silurian *Conchidium* (=*Pentamerus*), Carboniferous *Productus*, *Schizophoria* and *Spirifera*, Jurassic *Goniorhynchia* and Cretaceous *Orbirhynchia*, with wide-ranging *Athyris* and *Rhynchonella*. Palaeozoic molluscs are limited to the bivalves *Carbonicola*, *Sanguinolites* and *Edmondia* and gastropod *Bellerophon* from the Carboniferous.

Figure 64: Calyx (head) of a crinoid from the Pennsylvanian (Carboniferous) of Illinois, noted as rare (Tweeddale Museum, Live Borders)

For the Mesozoic and Cenozoic, most of the fossils are molluscan. Bivalves (lamellibranchs) include the Triassic *Rhaetavicula* (Westbury Formation), Jurassic *Plagiostoma* (Liassic), *Gervillia,* and Cretaceous *Epicyprina, Filosina*, *Thetis* (Greensand) and *Spondylus* (Chalk), with *Avictopecten*, *Myalina*, *Cardium* and *Homomya*, and long-ranging taxa *Modiolus*, *Modiola*, *Protocardia, Ostrea, Liostrea, Pholadomya, Pecten, Pinna* and *Chlamys* present. Bivalve shell beds are from the Greensand (Cretaceous). Gastropods include the Palaeozoic *Euomphalus, Murchisonia* and *Naticopsis*, Liassic *Pleurotomaria*, Portlandian *Aptyxiella* (Portland screw), Gault *Jurassiphorus*, Cenozoic *Solarium* and long-ranging *Loxonema* (Palaeozoic-Triassic) and *Viviparus* (Mesozoic-Cenozoic). Ammonites are from the Lower Liassic (*Psiloceras, Oxynoticeras*), Middle Liassic (*Oxynoticeras*, *Paltopleuroceras*), Upper Liassic (*Harpoceras, Phylloceras, Dactylioceras*, *Hildoceras*), Greensand (*Parahoplites*), Gault (*Euhoplites*), Chalk (*Schloenbachia*, *Calycoceras*), with *Aspidoceras*, *Amoeboceras*, *Arnioceras*, *Asteroceras*, *Peronoceras*, *Amaltheus*, *Hildaites*, *Pseudolioceras*, *Eleganticeras*, *Porpoceras*, *Calaceras*, *Schloenbachia*, *Gagaticeras*, *Turrilites*, *Arietites*, *Seguenziceras* (synonym of *Arieticeras*), *Polygrammoceras* and *Acanthoceras* (from France); localities include Whitby and some specimens are cut to show internal structure. Two well-preserved *Kosmoceras* in matrix are from the Oxford Clay (Jurassic) with the label affixed mentioning the locality of Christian Malford in Wiltshire, well-known as a source of exceptionally

preserved cephalopods with a range of soft tissues. Fragments of belemnites (one cut to show chambers) and examples of the nautiloids *Nautilus* and *Orthoceras* are also present.

Echinoderms are represented by the crinoids *Encrinus* (Palaeozoic-Mesozoic), *Poteriocrinus* (Devonian-Permian) and disarticulated stems from various ages (Carboniferous, Jurassic), and the Cretaceous echinoids *Echinocorys*, *Echinus* and *Micraster*. Other specimens are a slab of pale rock with a note 'Starfish *Urastrella* sp, Pennsylvanian, Kansas City, Kansas' and a crinoid calyx and arms in matrix (Fig. 64) labelled 'Unidentified crinoid, La Salle Fm, Pennsylvanian, Pontiac, Illinois, very rare', both worth investigating. Other fossils without stratigraphic information are crustacean arthropods (*Anthrapalaemon*, *Pseudogalathea* and *Hoploparia*), numerous silicified/opalised fossil wood, *Stromatopora*, fossil sponge and *Serpula* worm tubes. Casts are of an ichthyosaur front paddle, the Precambrian (Ediacaran) frond *Charnia* and a dinosaur skull.

Plants are mainly Carboniferous: *Neuropteris*, *Stigmaria*, *Calamites*, *Sigillaria*, *Lepidodendron*, *Pecopteris* and *Sphenopteris*, a fern from Saltwick near Whitby (Jurassic), and samples of Rhynie Chert containing the silicified remains of a Devonian ecosystem found near Huntly, Aberdeenshire.

Research/collection links

Investigations of the Pennsylvanian (Carboniferous) fossils from Kansas and Illinois are suggested to determine their historic and/or scientific importance. There is also a relatively large amount of fish material, especially from the Jurassic and Cretaceous, and it would be interesting to know how it was acquired as most of the specimens are from southern England or beyond. This could be the subject of a project including other fossil fish from the Live Borders collection, housed at Hawick Museum.

Hawick Museum (Live Borders)

Collection type: Local authority (Live Borders)
Accreditation: 2019 (Provisional)

Wilton Park Lodge, Hawick, Scottish Borders, TD9 7JL
Contact: enquiries@liveborders.org.uk

Location of collections
Hawick Museum is located in an historic 18th century mansion house in Wilton Park. It became home to the town's museum in 1910, making it the oldest museum in the Scottish Borders. The collection is onsite across displays and storerooms on several floors.

Size of collections
300-500 fossils.

Onsite records
The fossils are listed in a Vernon document shared by four Live Border museums. MDA cards are present in metal drawers and there are several accession books, the first of which dates from the 1970s. Rapid file inventories were created in Vernon 15 years ago for each storeroom.

Collection highlights
1. Fish fossils from across Scotland, the UK and worldwide.

Published information
Agassiz, L. (1844–1845). *Monographie de poissons fossiles des Vieux Gres Rouges ou Systeme Dévonien (Old Red Sandstone) des Îles Britanniques et de Russie.* Neuchâtel: Soleure, chez Jent and Gassmann.

Collection overview
Fossils are organised taxonomically for the most part. Vertebrates are represented mainly by fish, including Middle Devonian fish scales of a *Coccosteus* from Nairn and fragmentary fish remains from Cromarty and Moray, Upper Devonian *Holoptychius* from Dura Den (old blue label) and possible specimens from Jedburgh (Scottish Borders), a Carboniferous *Gyracanthus* spine from Burdiehouse, acanthodian spine fragments from other localities and *Chonetodus* from the Carboniferous Limestone of Bristol. The Jurassic is represented by *Acrodus* bone fragments and framed *Chondrosteus* tail from Lyme Regis, a *Dapedius* and a *Leptolepis* from the Liassic of Dumbleton, the Eocene by *Knightia* from the Green River Formation of Wyoming, and the Cretaceous by fish in Chalk. Several shark teeth are also present. The label affixed to one fish reads '*Palaeoniscus comptus'*, a misspelling of *Palaeoniscum comtus*, from the Permian of Ferry Hill, Durham. Further notation on the label ('ag') suggests the specimen is figured by Agassiz (1833). A label reading 'Pappenheim' suggests a fish from the Jurassic Solnhofen Limestone of Germany. Other specimens are a bone breccia, rostrum of a reptile (cut and polished to show the cross section), two bones that are possibly sub-fossil, a small whale vertebra and a specimen labelled as vertebrate that might be plant. There is a cast of an *Archaeopteryx* from the Solnhofen Limestone.

A small box labelled fossil fish contains a selection of interesting specimens: Three *Diplomystus* from the Eocene Green River Formation of Wyoming, shark teeth (*Galeocoda*, *Sphyrna*) from the Miocene Tampa Limestone of Florida, a Perspex case of shark teeth from the Eocene Barton Clay, a *Leptolepis talborgensis* from the Triassic West Pennant Hills of New South Wales, Australia, a fish in Chalk, two fragments that could be *Dipterus* or *Osteolepis* from the Devonian of north east Scotland, and three further fish specimens without labels. A matchbox labelled as 'bone fossil,

Eocene Green River Shale from Dairy Fork, Utah' contains a very small but apparently complete fish skeleton (Fig. 65).

Figure 65: A 1cm long fish from the Eocene Green River Shale, Dairy Fork, Utah (Hawick Museum, Live Borders)

Invertebrate fossils include Ordovician graptolites labelled as Dob's Linn and the Upper Birkhill Shale (in part Silurian) (Fig. 66). A single specimen contains two-dimensionally and three-dimensionally preserved graptolite stipes. Corals are often cut and polished to show morphological features with examples from the Silurian, Carboniferous (*Lithostrotion*) and Cretaceous, etc. Brachiopods are represented by numerous specimens, notably from the Carboniferous (productids, rhynchonellids and spiriferids with localities including Dukes Quarry, Langholm), Ordovician (possibly from Girvan and other localities), Silurian (Much Wenlock Limestone Formation) and Chalk (terebratulids among others). Bivalves are equally diverse, being from the Carboniferous (isolated fossils and several shell beds, including a mussel band), Jurassic (*Trigonia*, *Gryphaea,* inoceramids, shell beds, Oxford Clay from Weymouth, Greensand), Chalk (isolated fossils and shell beds) and Recent. Samples of siltstone with Ordovician bivalves are potentially from Girvan or equivalent stratigraphic level. Gastropods are represented by fossils from the Greensand and a series of small (less than a centimetre) fossils presented with a Carboniferous plant fossil. Sandy-coloured blocks with indeterminate but high-density bivalve and gastropod fossils are better described as sedimentary rocks. Trilobites (*Calymene*), bryozoan (*Fenestella)* and sponges are represented by a very limited number of specimens. Similarly, there is a small number of echinoderms, mainly crinoids from the Carboniferous, echinoids from the Chalk, and 5 asteroids, including two small *Aspideria scutelaria* starfish. Cephalopods include various goniatites, ammonites (*Hildoceras* from Whitby), nautiloids (coiled and orthoconic) and belemnites, some with old labels. Trace fossils are present: A *Nereites*, a possible *Helminthopsis* and block of mudstone with trace fossils that might be Jurassic.

Plants are limited to a few taxa, such as *Calamites*, *Glossopteris, Neuropteris* and types of fern, etc, from the Carboniferous with one labelled Lower Jurassic of Whitby; multiple specimens of each fossil taxon are present.

Fossils on display are not generally local. There is a coral limestone from Torquay, impression of a plant stem in Carboniferous Fell Sandstone Formation from Dumfries and Galloway, a Carboniferous fern, Cretaceous echinoderm from Kent, *Equisetum* from Liddel Water, Jurassic ammonite from Cleveland, echinoid fossils in chalk, the trace fossil *Crossopodia* from Longformacus, Berwickshire, graptolites from Dob's Linn, a trilobite from the Much Wenlock Limestone Formation of Dudley, fossil fish from the Eocene Monte Bolca, a second fish from the Permian of Ferry Hill, County Durham, and an ammonite cut and polished to show crystal-lined internal chambers. Boxes labelled 'handling' contain mixed crinoids, sea urchins (echinoids), Carboniferous plants, corals, ammonites (cut and polished) and belemnites (isolated fragments).

Research/collection links

Specimens worth further investigation are the selection of fish fossils from around the world, notably the *Leptolepis talborgensis* from the Triassic of Australia with label reading 'locality now closed – hard to get to. Rare and collectable'. This could form a project including the relatively large and diverse fossil fish collection held at the Tweeddale Museum. Correspondence between Hawick Museum and the Hancock Museum in Newcastle identifying specimens as the scales of *Holoptychius* might relate to a tray of several sandstone samples with fossil fragments and would be worth following up.

Figure 66: Graptolite fossils from the Ordovician-Silurian section at Dob's Linn, Dumfries and Galloway (Hawick Museum, Live Borders)

Detail of the holotype of the Late Carboniferous insect nymph *Idoptilus peachii* (Woodward 1887) from Greenhill Quarry, Kilmaurs, Ayrshire. Dick Institute, East Ayrshire Leisure. © Bill Crighton

Review of Fossil Collections in Scotland

Conclusions

National Museums Scotland

John Ellerman Foundation

Conclusions

Collection highlights

The review of fossil collections found material originating from Scotland, the UK and worldwide, much of it attributed to noted collectors. These collections have the potential to engage audiences by telling the story of the past and to support future investigation and scientific study.

1. Silurian fossils from the Midland Valley
The area between Lesmahagow (Lanarkshire) and Muirkirk (Ayrshire) in the Midland Valley of Scotland has revealed fossils of unusual animals from the Silurian 440-400 million years ago. These include primitive fish lacking jaws (*Loganellia*, *Thelodus*, *Birkenia*, *Lasanius* and *Jamoytius kerwoodi*), fossils of eurypterid arthropods, a group better known as sea scorpions (*Slimonia,* named after Robert Slimon (1803-1882), *Erretopterus*, *Lanarkopterus* and *Brachyopterella*), some of which possessed large claws for grasping prey, and pod-shrimp crustaceans (*Ceratiocaris* and *Dictyocaris*). Fossils from Lesmahagow were excavated on a large scale, first by Dr Slimon and later by members of the Geological Society of Glasgow under the name *Camp Siluria*. Examples are held in collections at Glasgow Museums Resource Centre, Paisley Museum, Cockburn Museum, Dick Institute, and numerous other organisations across Scotland.

2. The earliest terrestrial ecosystem on Earth
The Lower Devonian, 410 million-year-old Rhynie Chert of Aberdeenshire preserves the earliest known terrestrial ecosystem on Earth. The landscape resembled Yellowstone National Park today with pools of mineral-rich hot water from deep underground, surrounded by small branching plants and inhabited by various arthropods. Now and again the hot water would bubble over the land surface, flooding the ecosystem. As the hot water cooled, the silica in the water solidified, preserving everything: The early land plants (*Rhynia, Horneophyton, Aglaophyton*), crustaceans (*Lepidocaris*), insects (*Rhyniella*) and arachnids (*Palaeocharinus*) among other life. The fine crystals of silica replaced and replicated the soft tissues, preserving structures in excellent detail. The Rhynie Chert and the fossils it contains were studied by Nigel Trewin (1944-2017) and colleagues at the University of Aberdeen, with material carefully excavated from trenches for research. Material is also present in collections at Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, Cockburn Museum and Tweeddale Museum.

3. Lower Devonian fossils from Angus
Localities in Angus (Turin Hill, Tillywhandland, Balruddery Den) are a source of historic Lower Devonian fossils. The main collections are at Perth Museum and Art Gallery and The McManus: Dundee's Art Gallery and Museum, with smaller numbers in Montrose Museum, Cockburn Museum and Paisley Museum. Fossils include eurypterids (*Pterygotus*, *Tarsopterella*), the rare millipede *Kampecaris forfarensis*, primitive land plants such as *Psilophyton* and *Zosterophyllum*, and the unusual *Parka decipiens*, once thought to be frogspawn but now believed to be algae. Fish fossils are especially diverse with numerous types of predatory acanthodians (*Mesacanthus*, *Brachyacanthus*, *Parexus*), the earliest fish with jaws, often called spiny sharks for the spines on the fins, tail and body. These are found alongside the slower, shovel-headed cephalaspid fish (*Cephalaspis* (Fig. 67) and *Pteraspis*). Rare cephalaspids have also been found at Bridge of Allan, notably the holotypes of *Securiaspis caledonica* and *S. watersoni*, known only from the Wolf's Hole Quarry locality (Perth Museum and Art Gallery).

4. Lake Orcadie
Fish from the Middle Devonian of Caithness, Sutherland, Orkney, Shetland and the Moray Firth are world-famous. They include streamlined acanthodians (*Mesacanthus*, *Cheiracanthus*, *Diplacanthus*), similar but less spiny *Cheirolepis*, the broad Dipnoi or lungfish (*Dipterus*) and eel-like, centimetre-long *Palaeospondylus*. The heavily armoured placoderms are divided into arthrodires (*Coccosteus*, *Homostius*) with an unusual articulation of the head and jaw, and antiarchs

(*Pterichthyodes*) noted for an almost complete coverage of the body by armour and flat underside suited to sitting on the seabed (Fig. 68). These fish are evidence for a system of lakes, the biggest known as Lake Orcadie, fed by a network of rivers in an otherwise hot, arid desert climate. Correlation of beds from Orkney, Shetland and Caithness suggests the network was well connected at times, although species restricted to small areas (*Palaeospondylus* at Achanarras, *Stegotrachelus* at Sumburgh Head, Shetland) infer fluctuations in water level and a shift in river channels that prevented long-distance movement. Most collections across Scotland have at least a few examples of these fossils with extensive collections in Nairn Museum, Elgin Museum, Inverness Museum and Art Gallery, Stromness Museum, The Discovery Centre and Glasgow Museums Resource Centre.

Figure 67: The Lower Devonian jawless, armoured fish *Cephalaspis* from Balruddery Den (Perth Museum and Art Gallery) © Courtesy of Perth Museum & Art Gallery, Perth & Kinross Council

5. Transition from water to land

The fossil record in Scotland documents Late Devonian aquatic habitats full of fish with primitive terrestrial forests lacking vertebrate life followed by a relative abundance of Carboniferous (Late Visean) vertebrate animals in aquatic and terrestrial settings. These are separated by an interval of 15 million years during which vertebrates made the water-land transition although no fossils document any stage of this, which led to the interval being known as Romer's Gap. In 2008, the Ballagan Formation at Dumbarton revealed the remains of the 345 million-year-old amphibian *Pederpes finnayae* named after Peder Aspen who discovered it and Sarah Finney who prepared it; the fossil is on display in The Hunterian. The TW:eed project included excavations of the Ballagan Formation in East Lothian (Chirnside, Burnmouth), providing a range of early tetrapods and amphibian fossils, such as *Perittodus*, *Koilops*, *Ossirarus*, *Diploradus* and *Aytonerpeton* in the National Museums Scotland collection. The first fossils after Romer's Gap are also from Scotland. Vertebrates from East Kirkton, West Lothian, include *Balanerpeton*, *Silvanerpeton*, *Eldeceeon* and *Westlothiana* ('Lizzie') preserved with help from volcanic hot springs. As well as illustrating life before, during and after Romer's Gap, the Carboniferous vertebrates from Scotland document the

recovery of life following the Hangenberg Event in the Late Devonian, one of the six biggest extinction events in geological time.

6. Fossils in Permian sandstone

Fossils from the Permian of Scotland, 298-251 million years ago, are preserved in sediments representing a hot, arid desert climate. The Hopeman Sandstone of Moray has revealed extremely rare skeletal remains of the pareiasaur *Elginia* and the dicynodonts *Geikia* and *Gordonia* (Elgin Museum), perhaps buried in the shifting desert sand dunes. More intriguing is 'the fossil that isn't there', found when a block of sandstone was split to reveal a void sufficiently interesting to be sent for imaging. The model eventually produced (on display in Elgin Museum with a second in The Hunterian) shows the void is a three-dimensional cast of a dicynodont skull, the bones of which had long since decayed away. The Hopeman Sandstone is also known for more than 300 different trackways and footprints (Elgin Museum, University of Aberdeen Museums), with over 20 from the Lower Permian at Locharbriggs and Lochmabon, Dumfries, including *Chelichnus*, *Saurichnus*, *Prochirotherium* and *Loxodactylus* (Dumfries Museum and Camera Obscura). These 'trace fossils', evidence of behaviour as opposed to actual 'body fossils', indicate reptiles were walking, running, feeding and burrowing in the dunes in surprising abundance, the sand containing enough moisture for the prints and tracks to survive until they were covered. All these animals, and most of life on the planet, was lost soon after in the biggest extinction in geological time, known as the 'Great Dying', at the end of the Permian.

Figure 68: Reconstruction of the placoderm fish *Pterichthyodes* (Elgin Museum)

7. Evidence of dinosaurs from the Isle of Skye

The Middle Jurassic on the Isle of Skye has provided a rare view of an ecosystem from the time. The Staffin Dinosaur Museum displays examples of original and cast footprints and trackways, alongside spines of hybodid sharks, ammonites, their relatives the belemnites and nautiloids, and bivalves (*Gryphaea)*. Material from the Middle Jurassic is important because occurrences of terrestrial rocks, and therefore fossils, of this age are rare globally yet the Isle of Skye has yielded enough of the ecosystem to confidently recreate the palaeoenvironment. The footprints and trackways were produced in soft sediments as dinosaurs walked across a tidal flat or estuary. At times the sea level was higher with well-preserved fossils of fish, turtles, crocodiles, amphibians,

mammals and even ichthyosaurs. Fossils from Skye and those recently discovered on Eigg to the south, are being studied by researchers at the University of Glasgow, University of Edinburgh and National Museums Scotland to reveal more of the life in this unique window. The University of Glasgow collections and Glasgow Museums Resource Centre hold material from the Isle of Skye and surrounding area with fossils featured in displays in The Hunterian and Kelvingrove Art Gallery and Museum.

8. Rare plant fossils from Mull

When the North Atlantic Ocean was opening, Scotland was subjected to intense volcanic activity. Few fossiliferous rocks are present from this time. A rare occurrence is the Paleocene Ardtun Leaf Beds on Mull, discovered in 1850 by Lord George Douglas Campbell, (1823-1900), the 8th Duke of Argyll, and his son, Lord Archibald Campbell (1846-1912) who donated material to various Scottish museums. Fossils are present in the Falconer Museum, McLean Museum and Art Gallery, Paisley Museum and Glasgow Museums Resource Centre. The beds contain a variety of leaves that somehow survived the heat of lava and ash. Labels for Ardtun Leaf Bed fossils give the age as Miocene (23-5 million years ago) although they are now dated to the Paleocene (66-56 million years ago), making the fossils older than originally thought and proving the importance of scientific study and re-study. An impressive feature on Mull is MacCulloch's tree, a 12-metre-tall tube lined with charred wood at the base of a cliff of columnar basalt, representing the remains of a tree engulfed in lava millions of years ago.

Figure 69: A drawer labelled as Miocene vertebrate fossils from the Siwalik Hills, India (Falconer Museum)

9. Mammals and crocodiles from India and Pakistan

In the 1800s, vertebrate fossils from the Siwalik Hills of India and Pakistan, labelled at the time as Miocene but now thought to be Oligocene-Pleistocene, were excavated by Hugh Falconer (1808-1865) and Proby Cautley (1802-1871). The fossils were shipped back to the UK where large collections were formed at the Natural History Museum, London, and Oxford University Museum of Natural History. In Scotland, the Falconer Museum in Forres, Moray, built with the bequest of

Alexander Falconer with credit also given to his brother Hugh, both born in the town, holds a largely unknown collection of several hundred fragments of Siwalik (mammal, crocodile) vertebrate bones and fossil wood (Fig. 69). Further fossils were found in Nairn Museum (muzzle of the crocodile *Leptorhynchus gangeticus*) and University of Aberdeen Museum Collections (two fragments of jaw). The writing on the label of the Nairn fossil could be from Falconer or Cautley, inferring collection and first examination 200 years ago. All the specimens have the potential for furthering scientific knowledge on what is a diverse vertebrate fauna and fluvial palaeoenvironment.

10. Evidence of climate change

The Devensian (Pleistocene) Errol Clay from the Tay Estuary and Clyde Beds around the Clyde Estuary contain several different species of bivalve. These were collected alongside fossils of the brittle star *Ophiolepis*, barnacles, ostracods (bivalved arthropods), foraminifera and the more unusual and very rare vertebrate remains of the seal *Phoca*, an eider duck, bear and mammoth. Material in Glasgow Museums was collected by David Robertson (1806-1896) and James Coutts (1810-1886), and in Montrose Museum by Robert Boog Watson (1823-1910) and James Cunningham Howden (1830-1897). Watson is also known as the author of a report on molluscs collected during the HMS *Challenger* expeditions from 1872-1876. All the collectors conducted scientific studies, revealing a record of alternations between colder glacial periods with coverings of ice, and warmer interglacial intervals. The fossils found in these clays indicate temperatures across Scotland were much colder in the Devensian 13,000-10,000 years ago. The same conditions are found today at higher latitudes, hence ‘Arctic’, indicating the shifting of the colder climate northward. The Arctic clay fossils continue to be important for studies of climate change, which could make use of collections in The McManus: Dundee’s Art Gallery and Museum, Perth Museum and Art Gallery, Glasgow Museums Resource Centre, Montrose Museum and Bute Museum.

Storage and documentation of fossil collections

Storage

Many of the museums included in this collections review were founded in the 19th century to accommodate collections which have expanded beyond their buildings' original capacity. In these cases, storage tends to be located across several rooms rather than being contained in one designated area, with specimens placed wherever space is available. Increasingly, museums also have offsite facilities which vary widely in terms of size and storage systems. Visits to many organisations involved investigating contents in a museum building containing displays and at least some storage. Some museums do not have any onsite storage, instead locating stored collections offsite at a central storage facility. Two organisations were also using cargo containers for storage, situated at variable distances from the museum building and staff.

Furniture used for storing fossils was constructed from wood or metal in the form of static shelving or cabinets, usually with doors. Renovations of storerooms or transfer to a new purpose-built location usually included upgrades to furniture. Roller racking (wood or metal) was noted in the stores of larger museums and collection centres where space and access allowed. Fossils on open shelving tended to be stored in lidded cardboard boxes, some of which were archive-grade, although a wide variety of miscellaneous boxes were noted in use. Cabinet drawers tended to be open although some fossil material was stored in glass-topped drawers. While this material was well protected, examination of individual specimens and their labels, which were often fixed to or placed underneath specimens, was not possible in the time available and limited the information which could be gathered.

Drawers and boxes were in some cases lined with acid-free tissue paper or a thin layer of plastazote/foam. Specimens were placed either directly in drawers or boxes or in small cardboard trays to create a more stable micro-environment. Specimens given additional padding were found in acid-free tissue paper, bubble wrap, paper towel or foam, the occurrence and amounts of which were dependent on resources available. Some of these materials, particularly bubble wrap, are not recommended for collection use and should be removed. It was common for a single collection to show variation in the method and amount of packing material, for example, some being boxed while others were not, again suggesting limited resources and/or capacity to undertake this work. While fossil specimens in the collections visited were found to be in good condition overall, improvements in storage and collection care are necessary in many cases to ensure the long-term preservation of material.

Environmental conditions

At approximately half the organisations visited, temperature and/or humidity monitors were placed in display areas, cases and storerooms. They included Tinytag data loggers and Hanwell environmental monitors which provide electronic data. It was apparent that the recommended temperature and humidity ranges were not widely known, meaning that interpretation of any data was often limited. In others, staff were aware that the conditions were not ideal but were struggling to improve them. Modern facilities or recently renovated storerooms were more likely to have climate control. In contrast, collections stored in cargo containers are of particular concern as internal temperature can be an extreme of that outside with issues of mould due to damp and condensation. Any packing materials, labels and adhesives used for storage, as well as the paper on which associated information is provided, could suffer in these conditions and be vulnerable to deterioration and disintegration.

Environmental conditions in storerooms and areas used for storage were widely variable between locations and even across rooms at a single location. Attic or upper-level rooms were especially

challenging in terms of maintaining appropriate temperature and humidity ranges, being very warm during spring and summer months and cold in winter, occasionally to the point that they were difficult or uncomfortable to work in. The presence of skylights can increase temperature range (Knell and Taylor 1989) and did seem to influence temperature throughout the day, the rooms being cold overnight and warming up toward midday. Heating was on almost constantly in some display and storage areas. Dehumidifiers were in use to reduce moisture in display cases and areas where condensation was apparent.

Maintaining constant environmental conditions is important. Unsuitable or widely fluctuating temperature and humidity can lead to specimen deterioration and processes which can eventually result in the loss of specimens and associated information. A sign that environmental conditions are not ideal is pyrite decay which affects fossils made of iron-sulphide minerals (Fig. 70). There are various indicators of the process, for example, the sulphuric acid produced has a distinct smell that is evident when opening drawers containing affected specimens and where ventilation is poor. The associated increase in acidity can be measured using a simple pH test strip. The process also causes highly visible damage. Occurrences of pyrite decay in the collections visited varied from patches of discolouration (yellow, white, black), indicating initial to moderate stages of decay, to extreme cases where specimens were reduced to piles of white or yellowish powder (Fig. 70). Specimens that are affected can contaminate others nearby and it is important to separate these to prevent decay from spreading. Signs of decay were apparent in most of the collections investigated with anything from a few specimens to entire drawers affected.

Figure 70: Carboniferous *Stigmaria* in sulphur-rich coal showing surface discolouration (top left); a fossil reduced to powder by pyrite decay (top right); a drawer with a decayed ammonite (bottom left); and a matchbox damaged by a decayed pyrite fossil (bottom right)

Fossils from certain stratigraphic levels are known to be more susceptible to pyrite decay, for example fossils preserved in sulphur-rich Carboniferous coal (Fig. 70), ammonites from the Jurassic Oxford Clay (Fig. 70) and Cretaceous Gault, or molluscs from the Eocene Barton and Bracklesham beds, which was apparent during investigation. This is an area where even basic knowledge of the process can make a difference and staff would benefit from training on recognition of the signs to look out for, how to slow decay and methods to prevent or reduce loss in the first place, especially in fossils shown to be more susceptible.

Resources and guidelines for the care of collections can be found in Appendices 6 and 7.

Documentation of fossils

Documentation for fossils in the collections investigated is present in both paper and electronic form. Paper documentation includes formal MDA cards and other index systems, entry forms, minute and daybooks and accession registers, as well as information on labels fixed to or present with fossil specimens. Electronic documentation is stored in a wide range of Collections Management System (CMS) databases, such as Adlib, Adlib Lite, KE EMu, Mimsy, Vernon, Cardbox, eHive, Calm, Access and Past Perfect, with several specialist databases in use provided by John Faithfull at the University of Glasgow (Inca). Information is also recorded electronically in Microsoft Excel, often used by organisations as a transition between paper records and formal CMS databases. While electronic documentation has the advantage of being searchable and available at more than one access point, information on paper can be readily accessed and updated by any member of staff; information for fossils is present in both forms at most organisations.

Examination of documentation for fossils revealed a spectrum across organisations that have progressed well with inventorying and continue to add entries to accession registers or electronic CMS and those for which the task of transcribing information into a formal system is only partially complete and progressing slowly, if at all. This has been compounded during the Covid-19 pandemic with lockdown restrictions having an impact on access to monitor and work on collections at many organisations. Elsewhere, when IT and technical capabilities have been available, remote working during museum closure has allowed staff to make progress on tackling catalogue and inventory backlogs.

The level of information included in documentation is variable. Entries observed at many organisations were incomplete with some of the name, geographic and/or stratigraphic fields empty. The entries present tended to give a basic level of detail or needed revision, such as updates to taxonomic names and correct spelling of scientific names, localities and geological time intervals. These issues can be attributed to skills gaps and limited specialist knowledge. Where formal documentation was absent or incomplete, information was usually present in another form, such as entry forms, minute or daybooks, etc, that can be transcribed when time and resources permit. Two organisations had no formal records, one a small organisation with a limited collection of fossils for display purposes, the other a large collection of material ranging widely in terms of age and origin and with potential for scientific study. It is apparent that extensive work is required to provide even a basic inventory document, formal or otherwise, at a significant number of the collections investigated.

It is noted that work to compile an electronic inventory has been undertaken at many organisations, although the scale and challenge of the task has sometimes been underestimated. In a number of organisations information on fossils had been entered in a series of documentation drives, separated by a decade or so, which do not cover the entire collection and where each drive was in a different electronic system, leading to the further task of combining entries into a single database. In some cases, work had not progressed because an organisation planned to use or had implemented an alternative system for the primary inventory document. Reasons given for changing to a new system included increased data security, greater flexibility in recording and retrieving information,

identifying a database which could accommodate all the collection types held by the organisation, or simply finding something more suitable to their requirements. Organisations also based their choice on cost, the Adlib Lite CMS being chosen because it is free although it does not include the technical support that comes with the full version. It is worth pointing out that the hierarchical levels used to scientifically describe and name an organism are not easily accommodated in every CMS. A further problem is the lack of consistency in the location of data. For example, the term 'fossil' could be entered as a simple name, taxonomic name or description in place of more specific and relevant details. With the term fossil being input in several different fields within the same database there is the likelihood that not all the fossil specimens in the respective collection will be returned in a search. Ensuring consistency in which field holds which unit of information, as well as standardisation of the terms used in particular fields, would greatly improve onsite and remote collection access.

A number of museums have made information in their CMS available as online databases, enabling remote investigation of collections which has been useful in this investigation. Of the organisations visited, 13 have online collection records in the strictest sense, one of which does not yet include fossils. The Natural History Collections (University of Edinburgh Collections) website includes a virtual tour of the displays: http://www.nhc.ed.ac.uk/ Fossils from Dumfries Museum and Camera Obscura and Sanquhar Tolbooth Museum are on the Future Museum website: http://www.futuremuseum.co.uk/. The information available online is useful and an indication of progress toward providing onsite records and readily accessible resources of the fossil and other natural science collections across Scotland.

While there are organisations where few or none of the above issues exist, support and development opportunities must be made available for staff. The generally low completion of formal documentation or inventories of any sort may be ascribed to the limited number of staff employed within the Scottish museum sector who have the specialist knowledge of palaeontological or geological collections necessary to undertake this work. This was also apparent from the requests received for assistance with identification of fossil specimens. Obvious outputs for the project would be to increase subject knowledge at local level and provide further training in aspects of collection documentation, such as data entry and use of Collections Management Systems, although this would only be beneficial where staff are available to undertake the work in the long term. Some planned project work could not be undertaken due to Covid-19 restrictions although National Museums Scotland was able to offer a webinar, *Introduction to the Documentation of Fossils and Other Natural Science Collections*, on 27 January 2021, which was attended by 40 staff and volunteers from collections across Scotland including organisations represented in the Fossil Review.

Information with fossils

Improvements to the level and detail of documentation should also include information displayed in collections and physically with specimens. Most collections are organised taxonomically (by the formal (generic) name assigned) and/or stratigraphically (by the age of the rock they originated from). It would be helpful in the first instance for cabinets, drawers and boxes to be labelled with at least an overview of contents, corresponding to a reference noted in the main inventory, catalogue or accession register used by the organisation, which would make finding a given specimen easier. Furthermore, it is unlikely visitors will have access to entry forms, MDA cards and electronic CMS onsite themselves. It is helpful to have specimens associated with labels giving basic information (at least taxonomic name, geographic locality and stratigraphic level) and/or a 'box list' of the contents of a particular box or drawer, which also acts as an inventory to track specimen location. For the same reason, it was not possible to note all occurrences of type and figured specimens as very few were labelled as such, and it was difficult to know what specimens staff were 'aware of'. The impetus for a research project may be a casual search through a collection, perhaps as part of a conference excursion, which results in finding a specimen that sparks interest and further

investigation or which fits with previous studies and research focus. Having basic identification and origin information with specimens may also result in visitors being able to provide updates, corrections and additional information to increase the value of the resource.

Public engagement with fossils

Despite the extensive fossil material held in Scottish museum collections, its use at many locations is limited. The most frequent and obvious use of fossils is in displays, usually themed on the geology of the local area or on the history of life. Several museums have fossil handling boxes that can be loaned out to schools and other organisations, but staff acknowledged the lower standard of these in comparison to handling boxes on other subjects or themes. There is certainly the desire to develop fossil handling boxes which could be addressed with online guides suggesting ideas for activities and interpretation and advice on identifying fossils and their modern equivalents.

By comparison, other natural science materials are used in a greater variety of ways. Displays are again the main use with materials illustrating themes such as industry (coal and mineral mining, whaling), exploration of the world, surrounding landscape (glaciation, volcanoes) and dioramas of specific habitats using a combination of taxidermy, entomology and botany specimens. Taxidermy was also widely used on its own for school and community group engagement (Scouts, local interest, art groups), and promotion of events online.

In addition, museums provided a range of other activities that could include the use of fossils or at least mention this material. In many cases, museums draw in visitors with family and educational activities with several websites providing ideas for activities at home, especially with the onset of the Covid-19 lockdown. Activity sheets and bags with blank paper, crayons and quizzes, etc, were offered to children at a handful of museums to encourage them to look more closely at objects as they walked around displays.

Priorities for development of fossil collections

The Fossil Review is an account of the fossil collections at 57 locations across Scotland. It is noted other collections exist, and investigation of these would provide further information on the needs of the sector, although what has been observed to date clearly highlights priority areas for future work and development in terms of fossils. These are:

1. To increase curatorial standards for the care of fossil collections.

2. To increase levels of support and advice available for staff working with fossil collections.

3. To increase use of fossil material in public engagement activities.

4. To address the underlying issue of limited specialist knowledge at organisations with fossil and other natural science collections.

Acknowledgements

The *Review of Fossil Collections in Scotland* was conducted and written by Dr Sue Beardmore, John Ellerman Project Curator, on behalf of National Museums Scotland. The project was managed by Dr Nick Fraser, Keeper of Natural Sciences, Jilly Burns, Head of National and International Partnerships, Dr Andrew Ross, Principal Curator of Palaeobiology, and Dr Hazel Williamson, National Fund for Acquisitions Manager, with assistance from Fiona Thornton, National and International Partnerships Officer. Constructive comments and additional information were provided by Dr Sarah Stewart, Assistant Curator of Palaeobiology, Dr Yves Candela, Curator of Invertebrate Palaeobiology, Dr Stig Walsh, Senior Curator of Vertebrate Palaeobiology, Vicen Carrió, Palaeobiology Conservator and Preparator, Emily Brown, Assistant Curator Natural Sciences, and Peder Aspen, formerly Curator of the Cockburn Museum, University of Edinburgh Collections. The Fossil Review team thank staff and volunteers in collections across Scotland who participated in the review, facilitated visits to examine material and assisted with information on collections and collectors. The project was generously funded by the John Ellerman Foundation.

General bibliography

This bibliography lists sources of general information; see individual collection entries for publications relating to specific collections and fossils.

Andrews, M.S. (1982). *The discovery of fossil fish in Scotland up to 1845*. Edinburgh: National Museums of Scotland.

Batchelor, R. (2013). *Earth and Environmental Sciences at St Andrews – an historical Record*. St Andrews: Shieling Publications.

Bower, F.O. (1925). Robert Kidston. *Proceedings of the Royal Society of Edinburgh*. 44:248-252.

Cameron, I.B. and Stephenson, D. (1985). *British regional geology: The Midland Valley of Scotland.* Edinburgh: HM Stationery Office.

Fothergill, H. (2005). The state and status of geological collections in United Kingdom Museums: 2001. *Geological Curator*. 8(3): 53-136.

Geikie, A. (1905). *The founders of geology*. Edinburgh: Macmillan.

Harper, D.A., and A.W. Owen. (1996). *Fossils of the upper Ordovician. Palaeontological Association Field Guides to Fossils 7.* Dorchester: Dorset Press.

Hey, M.H. (1962). *An index of mineral species & varieties arranged chemically: with an alphabetical index of accepted mineral names and synonyms* (No. 549). London: British Museum (Natural History).

Johnstone, G.S. (1966). *British regional geology: the Grampian Highlands*. Edinburgh: HM Stationery Office.

Johnstone, G.S., and W. Mykura. (1989). *British regional geology: The Northern Highlands of Scotland*. Edinburgh: HM Stationery Office.

Knell, S.J., and M.A. Taylor. (1989). *Geology and the local museum: making the most of your geological Collection*. London: HM Stationery Office.

Lawson, J.D., and Weedon, D.S. (Eds). (1992). *Geological excursions around Glasgow and Girvan*. Glasgow: Geological Society of Glasgow.

MacFadyen, C.J. (1994). *The Silurian fossil-bearing Sites of Special Scientific Interest of the Lesmahagow area*. Site visits March/April 1994. Earth Science Site Documentation Series 88-93. Scottish Natural Heritage. Unpublished.

MacGregor, A.R. (1968). *Fife and Angus geology*. Edinburgh and London: William Blackwood and Sons Ltd.

MacGregor, M., and A.G. MacGregor, (1956). *British Regional Geology: The Midland Valley of Scotland*. Edinburgh: HM Stationery Office.

Macnair, P. and F. Mort. (eds). (1908). *History of the Geological Society of Glasgow, 1858-1908: With Biographical Notices of Prominent Members*. Glasgow: Geological Society of Glasgow.

McAdam, A.D., and E.N.K. Clarkson. (1986). *Lothian geology: an excursion guide*. Edinburgh: Scottish Academic Press.

McAdam, A.D., E.N.K. Clarkson, and P. Stone. (1993). *Scottish Borders geology: an excursion guide*. Edinburgh: Scottish Academic Press.

McIntosh, W.C. (1913). *Brief Sketch of the Natural History Museum of the University of St Andrews*. St Andrews University (re-printed from the *Museums Journal*, 1913).

Miller, C.G. (ed). (2006). Realising standards–Proceedings of the 20th Anniversary Conference. *The Society for the Preservation of Natural History Collections.* New York.

Mykura, W., D. Flinn, and F. May. (1976). *British regional geology: Orkney and Shetland*. Edinburgh: HM Stationery Office.

Mykura, W., and J. Phemister. (1976). *Geology of Western Shetland*. Edinburgh: HM Stationery Office.

Pringle, J. (1948). *British regional geology: the south of Scotland*. Edinburgh: HM Stationery Office.

Richey, J.E. (1961). *British Regional Geology: Scotland, the Tertiary Volcanic Districts*. Edinburgh: HM Stationery Office.

Saxon, J. (1975). *The fossil fishes of the north of Scotland*. Thurso: Caithness Books.

Selden, P. (2019). The latest on the oldest. *Bulletin of the British Myriapod and Isopod Group*. 31:20-25.

Stace, H.E., C.W. Pettitt, and C.D. Waterston. (1987). *Natural Science Collections in Scotland (Botany, Geology, Zoology).* Edinburgh: National Museums of Scotland.

Stone, P. (ed). (1996). *Geology in south-west Scotland: an excursion guide*. Keyworth, Nottingham: British Geological Survey.

Thomson, C.A. and I.P. Wilkinson. (2009). Robert Kidston (1852–1924): biography of a Scottish palaeobotanist. *Scottish Journal of Geology*. 45:161-168.

White, R.D., and W.D. Allmon. (eds.). 2000. *Guidelines for the Management and Curation of Invertebrate Fossil Collections: Including a Data Model and Standards for Computerization; Presented as a National Science Foundation Workshop at the North American Paleontological Conference, Washington, DC, June 7-14, 1996.* The Paleontological Society, Special Publications 10. Yale: The Paleontological Society.

Appendices

(1) Partner organisations by region
(2) Glossary
(3) Type specimens
(4) Named collectors of fossil material
(5) Locations of selected fossil material
(6) Guidelines for the care and storage of fossils
(7) Further information
(8) Impact of Covid-19 pandemic

Appendix 1: Partner organisations by region

North East Scotland (8)
Elgin Museum, Falconer Museum (Forres), Stonehaven Tolbooth Museum, The Discovery Centre (Mintlaw), Arbuthnot Museum (Peterhead), Zoology Museum (University of Aberdeen Museums), Meston Building (University of Aberdeen Museums) and Blairs Museum (Aberdeen).

Highlands and Islands (14)
Inverness Museum and Art Gallery, Nairn Museum, West Highland Museum (Fort William), Brora Heritage Centre, Dunrobin Castle Museum (Golspie), Timespan (Helmsdale), Stromness Museum, Orkney Fossil and Heritage Centre (Burray), Shetland Museum and Archives (Lerwick), Bute Museum (Rothesay), Hugh Miller's Birthplace Cottage and Museum (Cromarty), Treasures of the Earth (Corpach, Fort William), Staffin Dinosaur Museum (Isle of Skye) and Gairloch Museum.

Tayside, Central and Fife (11)
Stirling Smith Art Gallery and Museum, Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum and The McManus Collection Unit (Dundee), Broughty Castle (Broughty Ferry), D'Arcy Thompson Zoology Museum and University Herbarium (University of Dundee Museum Collections), Montrose Museum, Museums of the University of St Andrews, Fife Collections Centre, St Andrews Museum, Kirkcaldy Galleries, Falkirk Collections Centre, (Glenrothes).

Edinburgh and Lothians (5)
Haddington Museum Headquarters, Almond Valley Heritage Centre (Livingston) Cockburn Museum (University of Edinburgh Collections), Anatomical Museum (University of Edinburgh Collections), and Natural Science Collections (University of Edinburgh Collections).

Glasgow and Strathclyde (12)
Dick Institute (Kilmarnock), John Pollock Collection Centre (Ayr), McKechnie Institute (Girvan), Biggar and Upper Clydesdale Museum, Low Parks Museum (Hamilton), Isle of Arran Heritage Museum (Brodick), McLean Museum and Art Gallery (Greenock), Paisley Museum, Glasgow Museums Resource Centre, The Hunterian (University of Glasgow), Zoology Museum (University of Glasgow) and Kelvingrove Art Gallery and Museum (Glasgow).

Scotland South (7)
Dumfries Museum and Camera Obscura, Sanquhar Tolbooth Museum, Stranraer Museum, Gem Rock Museum (Creetown), Newton Stewart Museum, Tweeddale Museum (Peebles) and Hawick Museum.

Appendix 2: Glossary

Chronostratigraphy	Refers to the geological timescale and its divisions in a hierarchical framework of eons, epochs, periods and stages. Well-known names of intervals are the Jurassic and Cretaceous periods. Reference to the specific level within a division is normally as Lower, Middle and Upper, for example, a locality exposing rock of Middle Devonian age.
CMS	Collections Management System; an electronic database used to inventory collections.
Fm	Abbreviation of 'Formation' used as one of the levels in lithostratigraphy to name a unit of rock.
Holotype	The type specimen or individual organism/fossil upon which the name and description of a new species depends.
Indet	Short for indeterminate, referring to a fossil that has not or could not be accurately identified due to its fragmentary nature and lack of features used in identification.
Inlier	Geological term describing an area of rock at the surface of a given age surrounded entirely by younger rocks. For example, the Silurian Lesmahagow and Hagshaw Hills Inliers surrounded by Devonian and Carboniferous rocks.
In situ	A term used to describe a rock collected from an outcrop or exposure, meaning the exact origin and context is known.
Ky	Abbreviation for thousands of years ago, used mainly in the timescale of glaciation.
Lectotype	The specimen or other component of original material subsequently chosen as the type specimen when no holotype was designated at the time of publication.
Lithostratigraphy	The specific names of a unit of rock, placed within a hierarchical framework of groups, formations, members and beds. Confirmation of a lithostratigraphic name can be made through the British Geological Survey Rock Lexicon (Appendix 7).
Ma	Abbreviation referring to geological time, for example, 65 Ma means 65 million years ago.
Mbr	Abbreviation of 'Member', one of the levels in lithostratigraphy used to name a unit of rock.
Neotype	The specimen chosen to replace the holotype when the holotype is lost or destroyed.
non. loc.	Abbreviation indicating no locality information or the origin is unknown.
NRS	Abbreviation for New Red Sandstone, used historically and still in use today to refer to the Permian and Triassic.

ORS	Abbreviation for Old Red Sandstone, used historically and still in use today to refer to the Devonian. The addition of the prefix ‘L’, ‘M’ and ‘U’ refers to Lower, Middle and Upper divisions respectively.
Paratype	Any specimen(s), other than the holotype specimen, cited in the publication naming and describing the taxon.
SSSI	Site of Special Scientific Interest.
Taxon (plural taxa)	Refers to an organism regardless of the taxonomic level the name refers to, for example, the taxon *Tyrannosaurus*, or taxa within Phylum Brachiopoda, etc.
Taxonomy	The hierarchical levels used to describe an organism, the highest being a phylum, followed by order, class, family, genus and species with various levels (sub- and super- occurring between). Endings of names can indicate the level, for example, a name ending in -dae suggests family level. Generic name and species names are written in italics, the generic name capitalised and species name in lower case: *Homo sapiens*, *Tyrannosaurus rex*.
Type specimen	See holotype.
Waste bin taxon	A taxonomic name under which many fossils have been placed in the interim of a more accurate identification. Essentially, these are fossils that do not fit anywhere else because they lack any distinct characters that might allow their placement as a formally described taxon, or the taxon requires revision.

Appendix 3: Type specimens

The list below comprises the type specimens (holotype, lectotype, paratype, syntype, neotype) identified during investigation of fossil collections across Scotland; it is not exhaustive.

Aberdeen and North East

- *Isopodichnus stromnessi* Trewin 1976; holotype (University of Aberdeen Museums)
- *Cornulatichnus edayensis* Carroll and Trewin 1995; paratype (University of Aberdeen Museums)

Highlands and Islands

- *Rhynchodipterus elginensis* Save-Soderbergh 1937; holotype (Elgin Museum)
- *Pterichthyodes milleri* Agassiz; holotype (Elgin Museum)
- *Bothriolepis cristata* Traquair; holotype (Elgin Museum)
- *Glyptopomus elginensis* Traquair; holotype (Elgin Museum)
- *Gordonia duffiana* Newton 1893; holotype (Elgin Museum)
- *Gordonia juddiana* Newton 1893; holotype (Elgin Museum)
- *Ornithosuchus longidens (Dasygnathus)* Huxley 1877; holotype (Elgin Museum)
- *Hyperodapedon gordoni* Huxley 1859; holotype (Elgin Museum)
- *Stagonolepis robertsoni* Agassiz 1844: holotype (Elgin Museum)

Tayside, Central and Fife

- *Securiaspis waterstoni* White 1963; holotype (Perth Museum and Art Gallery)
- *Securiaspis caledonica* White 1963; holotype (Perth Museum and Art Gallery)
- *Erieopterus brewsteri* (Woodward 1864); counterpart of holotype in National Museums Scotland (The McManus: Dundee's Art Gallery and Museum)
- *Phyllolepis woodwardi*: cast of holotype (Fife Collections Centre)
- Scottish Carboniferous crinoids; type fossils (Museums of the University of St Andrews)

Edinburgh and Lothians

- *Phyllolepis woodwardi*: cast of holotype (Cockburn Museum)

Glasgow and Strathclyde

- *Idoptilus peachii* (Woodward 1887); holotype (Dick Institute)
- *Akmonistion zangerli* Coates and Sequeira 2001; holotype (The Hunterian)
- *Pederpes finneyae* Clack 2002; holotype (The Hunterian)
- *Hibbertopterus scouleri* (Hibbert) 1836; lectotype (Kelvingrove Art Gallery and Museum)

Scotland South

- *Prochirotherium truckelli*; holotype (Dumfries Museum and Camera Obscura)
- *Chelichnus locharbriggsensis* McKeever 1994; holotype (Dumfries Museum and Camera Obscura)

Appendix 4: Named collectors of fossil material

Absalom, Robert Gregory (1902-1975)	Glasgow Museums Resource Centre
Alexander Carmichael (1832-1912)	West Highland Museum
Alexander Sharpe Alexander (1860-1840)	John Pollock Collection Centre
Anderson, Reverend John (1796-1864)	Stirling Smith Art Gallery and Museum, The McManus: Dundee's Art Gallery and Museum, Museums of the University of St Andrews, Fife Collections Centre, Cockburn Museum, Paisley Museum.
Beaton, Angus John (1858-1945)	Inverness Museum and Art Gallery
Bell Pettigrew, James (1834-1908)	Museums of the University of St Andrews
Beveridge, David (not known)	Paisley Museum
Blackwood, James (1823-1893)	Dick Institute
Brown of Lanfine, Thomas (1774-1853)	Cockburn Museum, The Hunterian
Campbell, Lord Archibald (1846-1912)	Glasgow Museums Resource Centre
Campbell, Lord George (1823-1900)	Glasgow Museums Resource Centre
Corr, James B (1855-1931)	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum
Coutts, James (1810-1886)	Glasgow Museums Resource Centre
Craig, Robert (1822-1901)	Glasgow Museums Resource Centre
Craig, Robert Meldrum (1882-1956)	Museums of the University of St Andrews
Dairon, James (1811-1891)	McLean Museum and Art Gallery, Glasgow Museums Resource Centre
Dix, Emily (1904-1972)	The Hunterian
Duff, Rear Admiral Archibald (1773-1858)	Elgin Museum
Duff, Patrick (1791-1861)	Elgin Museum
Duncan, Reverend Henry (1774-1846)	Dumfries Museum and Camera Obscura
Dunlop, Robert (1848-1921)	Stirling Smith Art Gallery and Museum Perth Museum and Art Gallery, Fife Collections Centre
Falconer, Hugh (1808-1865)	Falconer Museum, University of Aberdeen Museums, Nairn Museum, John Pollock Collection Centre

Fleming, Dr John (1785-1857)	Museums of the University of St Andrews, Fife Collections Centre, Glasgow Museums Resource Centre
Forsyth, Isaac (1768-1859)	Elgin Museum
Fraser, James (1834-1929)	Inverness Museum and Art Gallery
Gilchrist, James (1813-1889)	Dumfries Museum and Camera Obscura
Gibson, William George (1828-1890)	Dumfries Museum and Camera Obscura
Glen, David Corse (1824-1892)	Glasgow Museums Resource Centre
Gordon, Reverend Dr George (1801-1893)	Elgin Museum, Nairn Museum
Gordon-Cumming, Lady Eliza (c1798-1842)	Elgin Museum
Graham-Smith, George S (1875-1950)	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum
Graham-Smith, William (c1912-2002)	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum
Grierson, Thomas Boyle (1818-1889)	Dumfries Museum and Camera Obscura
Grigor, John (1814-1886)	Nairn Museum
Groom, Charles Otley (1839-1894)	McLean Museum and Art Gallery
Häberlein, Friedrich Karl (1787-1871)	University of Aberdeen Museums
Heddle, Matthew Forster (1828-1897)	Museums of the University of St Andrews, Cockburn Museum
Henderson, David S (-2005)	The McManus: Dundee's Art Gallery and Museum
Henderson, Stuart M K (1907-1972)	Glasgow Museums Resource Centre
Howden, James Cunningham (1830-1897)	Montrose Museum
Hunter-Selkirk, John (1835-1898)	Dick Institute
Jehu, Thomas John (1871-1945)	University of Aberdeen Museums, Cockburn Museum
Jolly, William (-1912)	The Discovery Centre, Inverness Museum and Art Gallery
Kidston, Robert (1852-1924)	Stirling Smith Art Gallery and Museum, Perth Museum and Art Gallery
Kinnaird, 9th Lord George (1807-1878)	The McManus: Dundee's Art Gallery and Museum, Montrose Museum
Kyle, Canon John James (1828-1917)	Blairs Museum

Lawson, John (1799-1852)	Elgin Museum, The Discovery Centre
Leeds, Alfred Nicholson (1847-1917)	The Hunterian
Malcolmson, John Grant (1802-1844)	Elgin Museum
Martin, John (1800-1881)	Elgin Museum
McCallum, Alexander (1802-1845)	McKechnie Institute
MacLeod, Charles (1919-)	Inverness Museum and Art Gallery
McNicoll, Walter (1827-1908)	The McManus: Dundee's Art Gallery and Museum
Miller, Hugh (1802-1856)	Inverness Museum and Art Gallery, Hugh Miller's Birthplace Cottage and Museum, Paisley Museum
Mitchell, Alex (1837-1858)	Montrose Museum
Mitchell, Reverend Hugh (1822-1894)	Perth Museum and Art Gallery, Montrose Museum, Paisley Museum
Nielson, James (1820-1901)	Glasgow Museums Resource Centre
Nicholson, Henry Alleyne (1844-1899)	University of Aberdeen Museums, Stirling Smith Art Gallery and Museum
Nicol, James (1810-1879)	University of Aberdeen Museums
Nimmo, David (not known)	Glasgow Museums Resource Centre
Powrie of Reswaillie, James (1815-1895)	Montrose Museum, Cockburn Museum
Rae, George (1927-1998)	The Hunterian
Reid of Blairgowrie, James (-1921)	Perth Museum and Art Gallery, Glasgow Museums Resource Centre
Robertson, Alexander (1816-1854)	Elgin Museum, The Discovery Centre, Brora Heritage Centre, Stromness Museum
Robertson, David (1806-1896)	Glasgow Museums Resource Centre
Robertson, James (not known)	Stromness Museum
Scott, Thomas L (1849-1929)	McLean Museum and Art Gallery
Simpson, John Baird (1894-1960)	University of Aberdeen Museums
Slimon, Dr Robert (1808-1882)	Glasgow Museums Resource Centre
Smith of Dalry, John (1845-1930)	Cockburn Museum
Smith, William (1830-1907)	Inverness Museum and Art Gallery

Stables, William A (?1810-?1890)	Nairn Museum
Steel, T (1858-1925)	McLean Museum and Art Gallery
Struthers, Thomas (not known)	McLean Museum and Art Gallery
Taylor, William (1849-1921)	Elgin Museum
Thompson, D'Arcy Wentworth (1860-1948)	The McManus: Dundee's Art Gallery and Museum, University of Dundee Museum Collections
Thomson, James (1823-1900)	Dick Institute, Glasgow Museums Resource Centre
Traill, Thomas Stewart (1781-1861)	Museums of the University of St Andrews
Traquair, Ramsey Heatley (1840-1912)	Museums of the University of St Andrews
Trewin, Nigel H (1944-2017)	University of Aberdeen Museums, Hugh Miller's Birthplace Cottage and Museum
Truckell, Alfred (1919-2007)	Dumfries Museum and Camera Obscura
Tullis, James (not known)	Glasgow Museums Resource Centre
Wallace, Thomas Davidson (1841-1926)	Inverness Museum and Art Gallery
Watson, Robert Boog (1823-1910)	Montrose Museum
Watt, James (1736-1819)	Dumfries Museum and Camera Obscura
Wood, Stan (1939-2012)	The Hunterian, Glasgow Museums Resource Centre
Woodward, Arthur Smith (1864-1944)	Museums of the University of St Andrews, Cockburn Museum
Wright, James (1876-1957)	Fife Collections Centre, Cockburn Museum
Young, John (1823-1900)	Glasgow Museums Resource Centre
Young, Thomas 'Paraffin' (1811-1883)	The Hunterian

Appendix 5: Locations of selected fossil material

Silurian	
Lesmahagow/Hagshaw Hills Inliers	University of Aberdeen Museums, Orkney Fossil and Heritage Centre, The McManus: Dundee's Art Gallery and Museum, Cockburn Museum, Dick Institute, Low Parks Museum, Bigger and Upper Clydesdale Museum, Paisley Museum, The Hunterian, Glasgow Museums Resource Centre, Kelvingrove Art Gallery and Museum.
Lower Devonian	
Rhynie Chert, Aberdeenshire	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, University of Dundee Museum Collections, The Discovery Centre, Tweeddale Museum, Cockburn Museum, University of Aberdeen Museums.
Turin Hill, Tillywhandland, Farnell, Carmyllie	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, University of Dundee Museum Collections, Montrose Museum, Cockburn Museum, Paisley Museum.
Balruddery Den, Whitehouse Den,	Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum.
Kinnaird Collections	The McManus: Dundee's Art Gallery and Museum.
Bridge of Allan	Perth Museum and Art Gallery.
Middle Devonian	
Tynet Burn, Moray	Elgin Museum, The Discovery Centre, University of Aberdeen Museums, Blairs Museum, Inverness Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, Cockburn Museum, Paisley Museum, Glasgow Museums Resource Centre.
Lethen Bar	Elgin Museum, The Discovery Centre, Inverness Museum and Art Gallery, Nairn Museum, Hugh Miller's Birthplace Cottage and Museum, Cockburn Museum, McLean Museum and Art Gallery, Paisley Museum.
Hugh Miller material	Inverness Museum and Art Gallery, Stromness Museum, Hugh Miller's Birthplace Cottage and Museum, Paisley Museum.

Upper Devonian	
Dura Den	The Discovery Centre, University of Aberdeen Museums, Dunrobin Castle Museum, Stirling Smith Art Gallery and Museum, Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, Broughty Castle, Montrose Museum, Museums of the University of St Andrews, Fife Collections Centre, St Andrews Museum, Natural History Collections (University of Edinburgh Collections), Paisley Museum, Glasgow Museums Resource Centre, Dumfries Museum and Camera Obscura, Hawick Museum.
Permian	
Corncockle and Locharbriggs Quarries	Paisley Museum, Dumfries Museum and Camera Obscura.
Hopeman Sandstone Fm/Clashach Quarry	Elgin Museum, University of Aberdeen Museums, The Hunterian.
Triassic	
Reptile *Stagonolepis robertsoni*	Elgin Museum, University of Aberdeen Museums, Nairn Museum, University of Dundee Museum Collections, Glasgow Museums Resource Centre, Kelvingrove Art Gallery and Museum.
Miocene	
Siwalik Hills, India and Pakistan	Falconer Museum, University of Aberdeen Museums, Nairn Museum, John Pollock Collection Centre.
Paleocene	
Ardtun Leaf beds, Mull	Falconer Museum, McLean Museum and Art Gallery, Paisley Museum, Glasgow Museums Resource Centre.
Pleistocene	
Devensian Arctic (Errol Clay/Clyde beds) clays	Elgin Museum, Bute Museum, Perth Museum and Art Gallery, The McManus: Dundee's Art Gallery and Museum, Broughty Castle, Montrose Museum, McLean Museum and Art Gallery, Paisley Museum, Glasgow Museums Resource Centre.

Appendix 6: Guidelines for the care and storage of fossils

Online sources

Geological Curators Group:
https://www.geocurator.org/

Collections Trust – MLA document:
https://collectionstrust.org.uk/resource/geological-collections-a-guide-to-standards-in-their-preservation-and-care/

The website includes Spectrum, the regularly updated UK collection management standard used around the world.

Welsh Museums Federation:
http://welshmuseumsfederation.org/

Literature

Brunton, C.H.C., Besterman, T.P. and Cooper, J.A., (1985). *Guidelines for the curation of geological materials*. Geological Society, Miscellaneous paper 17. Available online through the GCG website: https://www.geocurator.org/images/resources/advice/guidelines_curation.pdf

Knell, S.J., and Taylor, M.A. (1989). *Geology and the local museum: making the most of your geological Collection*. London: HM Stationery Office.

Conservation

Society of Vertebrate Palaeontology (SVP):
https://vertpaleo.org/
https://vertpaleo.org/wp-content/uploads/2021/01/Preparators-Resources.pdf

The Institute of Conservation (ICON):
https://icon.org.uk/

International Institute for Conservation of Historic and Artistic Works:
https://www.iiconservation.org

Appendix 7: Further information

Databases

Palaeobiology Database (https://paleobiodb.org/) – online database of fossil taxa, providing information on the taxonomic classification, who named the genus/species, origin of specimens assigned and stratigraphic range. Spellings can be checked by partially entering names in the search box, which will bring up possible options and the group the taxon belongs to.

British Geological Survey (BGS) rock lexicon (https://webapps.bgs.ac.uk/lexicon/) – online database through which the lithostratigraphic names of rock units can be checked. Information provided also gives the status of the unit (whether it is still a name in use), its age, a description and the units of rock above and below where identified. A tip when searching is to enter just the name without the level. For example, a search for the Dundee Formation returned no results, however, entering Dundee returned options including the Dundee Flagstone Formation, the name the unit is now known by, part of the Upper Devonian Arbuthnott Group.

Earthwise (BGS, http://earthwise.bgs.ac.uk/index.php/Main_Page) – website providing details of localities of geological interest. Much of the information is published in the various BGS reports, for example, regional guides and overviews associated with geological maps.

Mindat (https://www.mindat.org/) – database providing information on mineral species, the group they belong to, origin localities in list and map form, and a glossary.

British Geological Survey palaeontology collections database with information on taxa, stratigraphic and geographic ranges and references: https://webapps.bgs.ac.uk/Palaeosaurus/Home.cfm.

Information on echinoids: https://www.nhm.ac.uk/our-science/data/echinoid-directory/.
Information on trilobites: http://trilobites.info/

Useful websites

National Museums Scotland: https://www.nms.ac.uk/
NatureScot (formerly Scottish Natural Heritage): https://www.nature.scot/
Natural Science Collections Association (NatSCA): https://www.natsca.org/
The Federation for Natural Sciences Collections Research (Fenscore): http://fenscore.natsca.org/
The Society for the Preservation of Natural History Collections (SPNCH): https://spnhc.org/

Networks

Museums Galleries Scotland link to Geographic Museum Forums in Scotland:
https://www.museumsgalleriesscotland.org.uk/advice/working-together/geographic-museum-forums/

Books

Natural History Museum. (1996). *British Palaeozoic Fossils*. London: HM Stationery Office.
Natural History Museum. (1997). *British Mesozoic Fossils*. London: HM Stationery Office
Natural History Museum. (1993). *British Caenozoic Fossils*. London: HM Stationery Office

Appendix 8: Impact of Covid-19 pandemic

The onset of the Covid-19 pandemic and subsequent lockdown in March 2020 curtailed many aspects of the fossil review project. Museum closures and travel restrictions meant that no further visits could be made to examine collections. It was not possible, for example, to view the collections in store at The Hunterian or to investigate additional locations which had been identified as possibly containing collections of interest. Furthermore, many staff were either furloughed or unable to access their collections and could not respond to subsequent queries from the project curator. Fortunately, the majority of visits had been undertaken in the first year of the project and, working remotely, the project curator was able to use the remaining time to write the Fossil Review. Three workshops on natural science subjects had been delivered in the first year of the project as part of National Museums Scotland's National Training Programme. A fourth workshop, *Introduction to the Documentation of Fossils and Other Natural Science Collections*, was delivered online on 27 January 2021. Conferences and seminars at which it had been intended to present project findings (SPNHC, Museums Association, Geological Curators Group, etc) were postponed or cancelled. On a more positive note, we were able to use underspend from the project to offer grants to partner museums for improvements to collection care and documentation and to increase public engagement with their fossil collections.