# *At the Water's Edge*

## Weston Loan Programme with Art Fund

The exhibition has been made possible by a grant from the Weston Loan Programme with Art Fund which provides funding and training for regional museums and galleries to secure important strategic loans from major UK collections. The grant has included money for improved environmental monitoring of the Museum, as well as the provision of new display cases and exhibition materials. There is more information about the Garfield Weston Foundation and the Art Fund at the end of this document (p.14).

## Year of Coasts and Waters

The Scottish Government designated 2020 the 'Year of Coasts and Waters' to celebrate our coastal heritage. Due to the disruption caused by the Covid-19 pandemic, this designation has continued into 2021. The temporary exhibition *At the Water's Edge* is part of Elgin Museum's contribution to this special theme; see https://elginmuseum.org.uk/year-of-coasts-and-waters-2020/ for more information. Further details of other events can be found on VisitScotland's webpages: https://www.visitscotland.com/about/themed-years/coasts-waters/

## Geology

Fossilisation occurs when the bones or shells of animals are replaced by minerals in the soil or water in which the material is deposited. Generally, soft parts are not preserved, having been scavenged by predators or destroyed by bacteria before the replacement process begins. This takes place over thousands and millions of years and the bones or shells become part of the rock formed by the burial of the sediment in which the bones or shells were originally deposited.

The rocks in which the *Elginerpeton* fossils were found are from the middle of the Late Devonian period and are ~ 375 million years old (the Frasnian period). At the time Scotland was positioned in a large land mass called Pangea some 20˚ south of the equator. Moray was on the northern flank of a mountain range (the present-day Grampian Mountains) with rivers flowing northwards towards areas of low-lying land. At times, a large ephemeral lake also lay to the north, Lake Orcadie.

The fossiliferous deposits at Scaat Craig (see below) are composed of conglomerate and pebbly sandstones, the eroded remnants of the mountain chain to the south.

The sandstones were laid down by rivers, sometimes fast flowing, leading to the formation of layers of sandstone containing large cobbles of different rock. The sandstones contain small, angular, faceted pebbles (dreikanters) formed by wind erosion in a desert environment.

## Discovery of Scaat Craig

Fossil fish were first found at Scaat Craig, near Fogwatt, 4.5 km south of Elgin, by John Martin in 1826. Over subsequent years 13 species of fish were identified from the site which became a world-famous fossil locality attracting the attention of European palaeontologists. By 1840 the site was largely forgotten as other more complete fish fossils were discovered at Cromarty and other

sites around the Moray Firth. The locality is a Site of Special Scientific Interest (SSSI); more information can be found at: https://sitelink.nature.scot/site/1409

## Discovery and Naming of *Elginerpeton pancheni*

In 1991 Dr Per Ahlberg, a former student of Dr Jenny Clack (a world authority on early tetrapods), published details of fossils from Scaat Craig which he had re-examined in Oxford University Museum of Natural History. An unusual looking snout alerted Per to the fact that the fossils might not be exclusively fish. He subsequently identified parts of limb bones, and skull and jaw fragments which, along with other fossils from Scaat Craig held at National Museums Scotland, the British Museum, and the British Geological Survey, he described in more detail in 1995. The combination of body fossils allowed him to determine that they were from an early tetrapod which he named *Elginerpeton pancheni* ('the crawler from Elgin'); *pancheni* refers to Dr Alec Panchen, then a Reader in Vertebrate Zoology at the University of Newcastle. His findings were published in the prestigious journal *Nature* and generated a lot of interest in this important discovery.

## The significance of *Elginerpeton*

*Elginerpeton* is the earliest known British tetrapod, a class of animals that first possessed limbs. Technically *Elginerpeton* is a tetrapodomorph as it sits on the evolutionary pathway from lobe finned fish to four limbed animals, making it a transitional species.

Although other tetrapod fossils have been found (see Family Tree (p.8) and *Tiktaalik* entry (p.10) below), *Elginerpeton* remains the oldest known tetrapod that can be reconstructed from reasonable body fossils.

## More information about the fossils on display

The fossils have been loaned from National Museums Scotland (our Weston Loan Programme with Art Fund project partner), the British Geological Survey, and the Oxford University Museum of Natural History and are numbered from left to right and top to bottom of the *Elginerpeton* outline, shown on the panel above the display case.

1. Left premaxmillary fragment OUMNH-PAL-D00796
   *On loan from* Oxford University Museum of Natural History

The structure of the teeth shows that the premaxillary fragments are linked to the mandibular fragments (see 7. below). Taken together, the fragments show that the skull was narrow and triangular in shape.

2. Premaxillary fragment NMS G.1891.92.444
   *On loan courtesy of* National Museums Scotland

The premaxillary fragments also show that the skull of *Elginerpeton* was flat-snouted.

3. Palatal bone GSM 89132
   *On loan courtesy of* the British Geological Survey

The circular depression in the centre of this specimen shows a coronoid fang (one of a pair) that is separate from the tooth row, a primitive tetrapod feature.

This fossil can be seen in more detail on the exhibition website. https://elginmuseum.org.uk/atwe2020/

4. Shoulder girdle GSM 89111
*On loan courtesy of* the British Geological Survey

This is one of four specimens of shoulder girdle from Scaat Craig, and, although severely eroded, it shows part of the cleithrum (the major bone of the pectoral girdle), extending upward from the pectoral fin base and forming the rear margin of the gill cavity.

This fossil can be seen in more detail on the exhibition website.
https://elginmuseum.org.uk/atwe2020/

5. Ilium (pelvic girdle) NMS G.1861.46.52
*On loan courtesy of* National Museums Scotland

This ilium comes from a large individual and shows part of the bone (the postiliac process) thought to have carried muscles that operated the tail.

6. Ilium (pelvic girdle) NMS G.1891.92.458
*On loan courtesy of* National Museums Scotland

This specimen preserves the iliac canal and part of the acetabulum, the articulation point for the femur (see 11. below). This specimen has also come from the Powrie Collection at NMS.

7. Left mandibular fragment NMS G.1967.17.1
*On loan courtesy of* National Museums Scotland

This is one of ~ 20 mandibular fragments from Scaat Craig but this incomplete left mandible is the holotype for *Elginerpeton pancheni*, which is the one specimen used by the author (in this case Per Ahlberg) to determine its scientific nomenclature. It shows numerous small teeth with an internal pulp cavity and irregularly folded orthodentine (polyplocodont teeth).

8. Mandibular fragment GSM 89174
*On loan courtesy of* the British Geological Survey

This fragment is part of a right mandible and comes from the part of the jaw furthest from the snout. The jaw of *Elginerpeton* is slender and up to 40 cm in length with numerous small marginal teeth.

This fossil can be seen in more detail on the exhibition website.
https://elginmuseum.org.uk/atwe2020/

9. Mandibular fragment NMS.G.1861.46.67
*On loan courtesy of* National Museums Scotland

This specimen is identifiable as a tetrapod jaw fragment from its characteristic irregular dermal ornament, comprising both tubercles and short ridges.

10. Tibia OUMNH-PAL-D00793
*On loan from* Oxford University Museum of Natural History

The tibia is generally well preserved and undistorted. It appears to be the full length of the leg bone and would have connected to a tarsas (ankle bone).

11. Femur GSd 4240
*On loan courtesy of* the British Geological Survey

The degree of torsion evident in the bone shows that the hindlimbs were used as paddles and could not have supported the animal's body weight, hence it's designation as the 'crawler' from Elgin.

This fossil can be seen in more detail on the exhibition website.
https://elginmuseum.org.uk/atwe2020/

## What do the fossils tell us about *Elginerpeton*?

The range of body fossils, from different individuals, allows palaeontologists to glean a lot of information about how *Elginerpeton* lived and moved.

*Habitat*: *Elginerpeton* was an aquatic animal living in fresh-water river systems. Other tetrapod species are known to have inhabited coastal lakes, estuaries or lagoonal, marshy environments at this time.

*Feeding habits*: At up to 1.5 m in length, the large body size and powerful bite (described as a massive snapping trap) suggest that *Elginerpeton* was a voracious apex predator, feeding on fish and crustaceans. The diversity of fossil fish species found at Scaat Craig indicates that there was a wide choice of prey available, including *Holoptychius* and *Bothriolepis*, specimens of which are displayed in Case 5 (the Upper Devonian) in the Rear Gallery. Other fossils found at Scaat Craig (on loan from Bob Davidson) can be seen in Case 11 upstairs.

## What was driving this evolutionary change?

In 2007, a paper by Prof. Jenny Clack showed that the Late Devonian was a time of environmental change and that this may have driven the evolutionary development of early tetrapods. Atmospheric oxygen levels were thought to be particularly low during this period and river systems were also depleted in oxygen (anoxic). This was partly due to rapid plant diversification which changed the nature of the landscape, stabilising the surface and altering the amount of run-off reaching the rivers. Soils, soluble nutrients and decaying plant matter were washed into the rivers, contributing to their low oxygen content.

By this time, several species of fish had developed lungs to supplement the amount of oxygen received from the gills. The tetrapod stem group were air breathing animals, using their lungs to gulp air at the surface. The development of limbs capable of

supporting the animal's body weight, allowed them to push off the river-bed and thus stay longer at the surface. The early tetrapods were better suited to adapting to these challenging environmental conditions and the diversity of their group increased. *Elginerpeton* only survived as a species for a relatively short period of time; further deterioration in the global environment at the end of the Devonian Period led to a Mass Extinction event and many tetrapod species died out.

## Tetrapod family tree

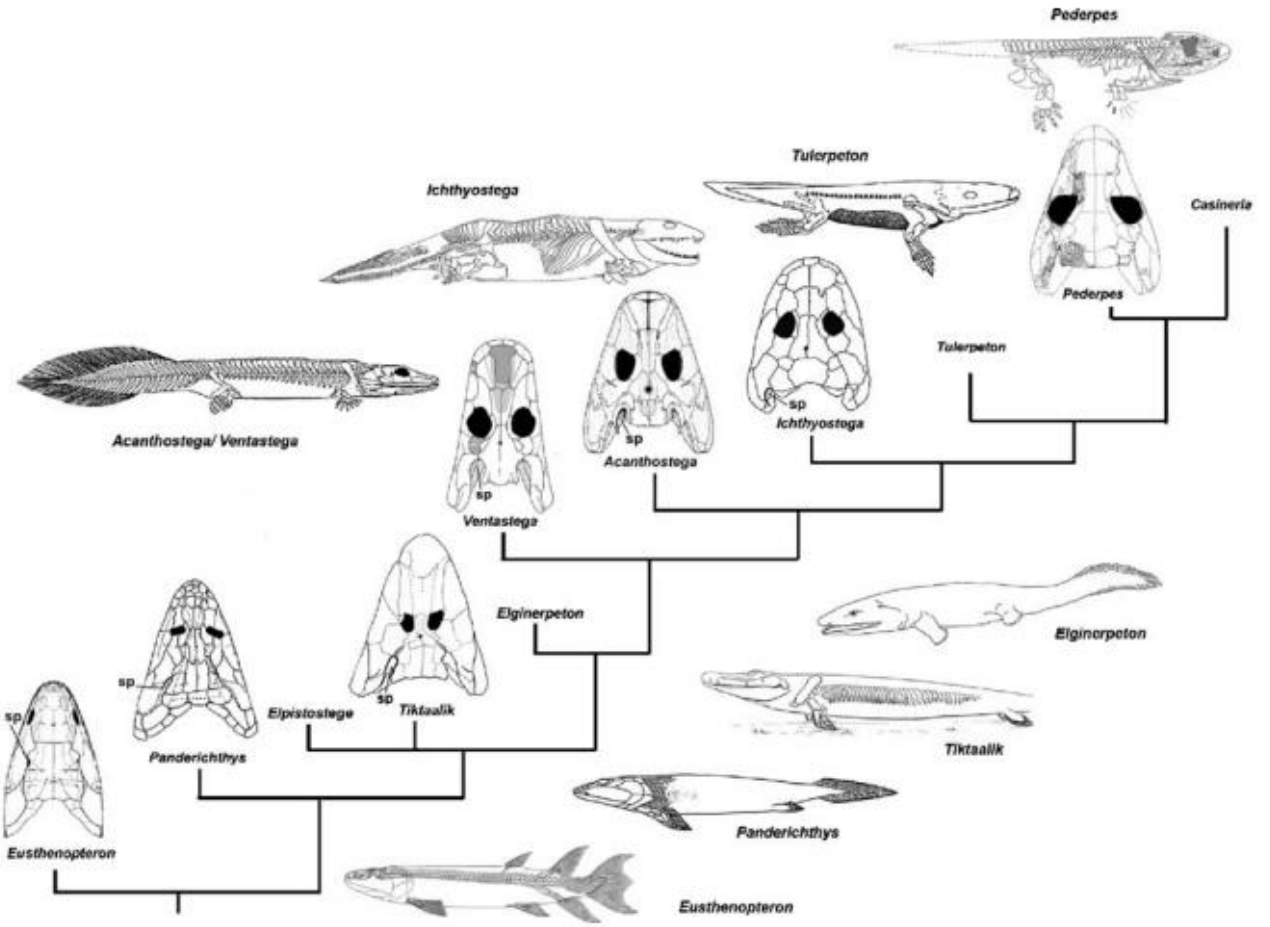



**Fig. 1** Cladogram showing relationships of tetrapodomorphs according to a current consensus. Skulls and skeletal or body reconstructions are shown where these are available. Drawings are not to scale

*From*: Clack, J.A. 2009. The Fish–Tetrapod Transition: New Fossils and Interpretations. *Evolution: Education and Outreach*, **2**, 213–223

## Papers authored by Prof. Per Ahlberg relating to *Elginerpeton*


Ahlberg, P.E. 1991. Tetrapod or near tetrapod fossils from the Upper Devonian of Scotland. *Nature*, **354**, 298-301

Ahlberg, P.E. 1995. *Elginerpeton pancheni* and the earliest tetrapod clade. *Nature*, **373**, 420-525

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

Ahlberg, P.E. 2004. Comment on 'The early evolution of the tetrapod humerus'. *Science*, **305**, 1715c

Ahlberg, P.E. 2019. Follow the footprints and mind the gaps: a new look at the origin of tetrapods. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, **109**, 115-137

Ahlberg, P.E. & A.R. Milner. 1994. The origin and early diversification of tetrapods. *Nature*, **368**, 507-514

# Tiktaalik

*Tiktaalik* is an extinct genus of lobe-finned fish that was identified from fossils found on Ellesmere Island in Nunavut, northern Canada, in 2004. This species is considered more primitive (i.e. older) than *Elginerpeton* (see the Tetrapod Family Tree above) and had front fins with arm-like structural features, including a shoulder, elbow, and wrist. Like *Elginerpeton*, it shows adaptations to oxygen-poor, shallow-water conditions.

The model (on loan from Bob Davidson) is included in the exhibition to help illustrate the transition from fish to fins, which was a fundamental evolutionary development. This allowed life to move on to land and *Tiktaalik* is a strong contender as the common ancestor of all vertebrate terrestrial animals (Grulke, W. 2019. *Beyond Extinction: the Eternal Ocean*. At One Communications. p94).

# Tetrapod Trackways

## Tetropod footprints

One of the puzzles in determining when life began to show the adaptations necessary for moving out of the water and on to land is the occurrence of footprints made by four-limbed creatures some 5 million years before the first body fossils occur. Fossilisation is always a chance process so this in itself is not unexpected but it does mean that what exactly created ~ 380-million-year-old footprints in lagoonal sediments at Zalchemie in Poland is unknown.

## Tarbat Ness

Trackways on the Tarbat Ness peninsular in Caithness were discovered in 1862 by the Rev. Dr James Maxwell Joass (pronounced Joss). Rev. Joass was Minister at Edderton from 1859 to 1866 and, like many clergymen at the time, showed a keen interest in all aspects of local and natural history. In the company of the Minister at Tarbat, Rev. George Campbell, Rev. Joass found several trackways, some of which appeared to show ‘doggie’s footprints’, whereas others had prints arranged in two parallel lines. They considered that the footprints were made by early reptiles, a controversial theory at the time. The reptile footprints in the Elgin sandstones were well known by the 1860s but the relative age of the fish fossils (Devonian) and the trackways (Permian/Triassic) had yet to be determined. The eminent Victorian geologist Sir Roderick Impey Murchison visited the site at Portmahomack and, in discussion with Prof. Thomas Henry Huxley, considered that the trackways were made by crustaceans (arthrodpods). Rev. Campbell donated one of the slabs from Portmahomack to Elgin Museum in 1863 but our trackway (ELGNM: 1863.1) shows the parallel footprints left by a

many-legged arthropod rather than a tetrapod (Rogers, D.A. 1990. Probable tetrapod tracks rediscovered in the Devonian N Scotland. *Journal of the Geological Society, London*, **147**, 746-748). Confirmation that the 'doggie's footprints' were indeed made by an early reptile would no doubt delight both Ministers.

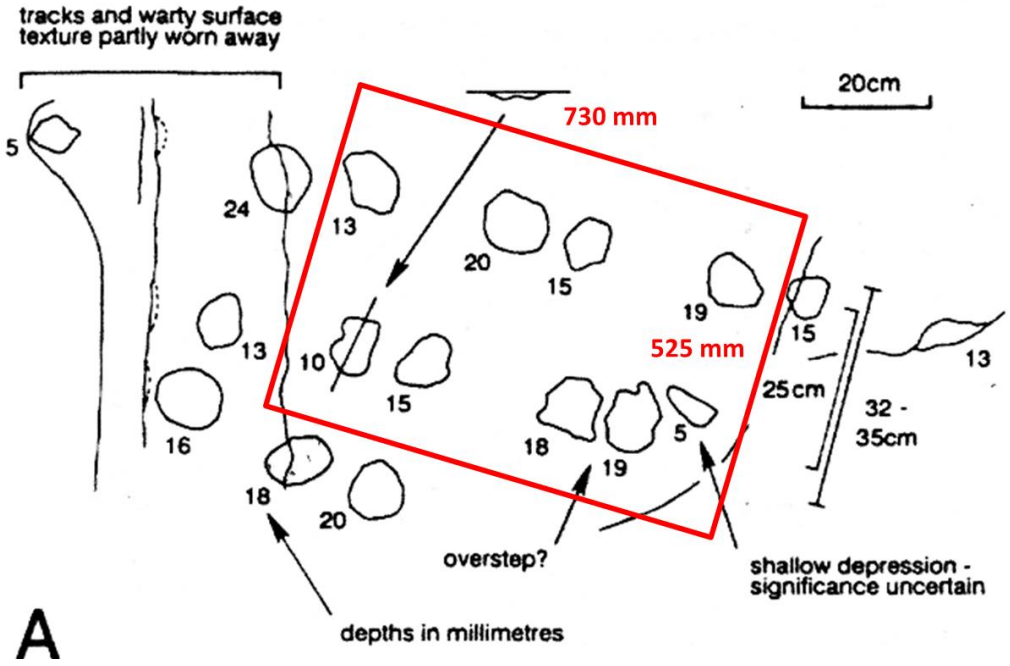

The Rev. Dr James Joass
(Image courtesy of Tain Museum)

ELGNM: 1863.1
Parallel trackway created by an arthropod in ~380 Ma sandstone from Portmahomack, Tarbat Ness

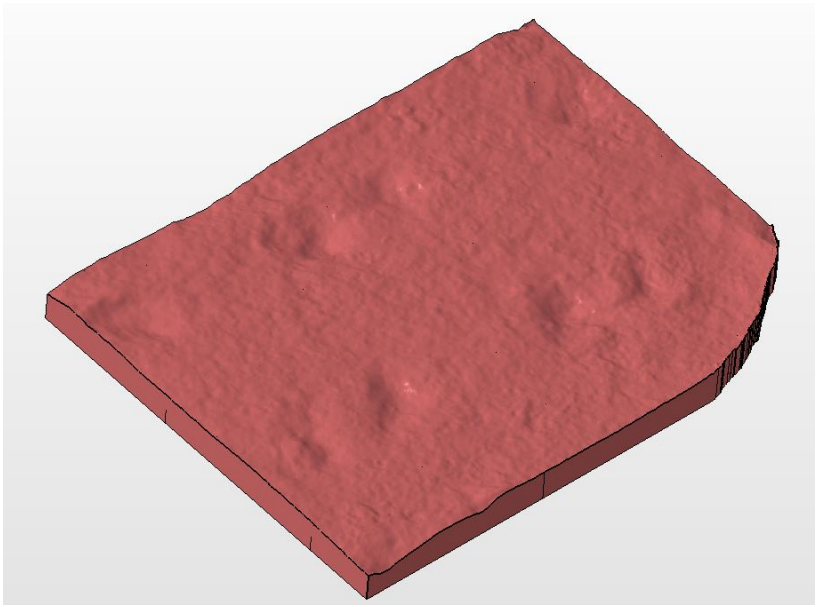
## 3D plastic-printed panel

The panel on display has been created from a digital scan of a silicon cast made by David Rogers in 1990. The original cast measures ~ 170 x 80 cm and is held by the Oxford University Museum of Natural History. The data has been 'extruded' to create a 3d model of the cast and then inverted so that the footprints appear as depressions, as they would have done in the rock, rather than as the upstanding mounds recorded by the cast. The trackway in the panel is shown actual size from a section of

the data and was 3d plastic-printed in 4 pieces by a special company in Mintlaw (Plastiprint3d Ltd.). The pieces were glued together and then spray-painted to look like sandstone.




The complete trackway recorded by David Rogers in 1990, with the section of the panel shown in red.



Screenshot of the digital data generated by Gary Cairns at Plastiprint3d used to create the final panel.

# Garfield Weston Foundation

Established in 1958, the Garfield Weston Foundation is a family-founded, grant-making charity which supports causes across the UK with grants around £70million annually. It has donated over £1billion to charities since it was established.

One of the most respected charitable institutions in the UK, the Weston Family Trustees are descendants of the founder and they take a highly active and hands-on approach. The Foundation's funding comes from an endowment of shares in the family business which includes Twinings, Primark, Kingsmill (all part of Associated British Foods Plc) and Fortnum & Mason, amongst others – a successful model that still endures today; as the businesses have grown so too have the charitable donations.

From small community organisations to large national institutions, the Foundation supports a broad range of charities and activities that make a positive impact in the communities in which they work. More than 1,800 UK charities benefit each year from the Foundation's grants.

# Art Fund

Art Fund is the national fundraising charity for art. It provides millions of pounds every year to help museums to acquire and share works of art across the UK, further the professional development of their curators, and inspire more people to visit and enjoy their public programmes. Art Fund is independently funded, supported by the 159,000 members who buy the National Art Pass, who enjoy free entry to over 240 museums, galleries and historic places, 50% off major exhibitions, and receive Art Quarterly magazine. Art Fund also supports museums through its annual prize, Art Fund Museum of the Year, and through a range of digital platforms.

More information is available at https://www.artfund.org/