Reports

First Fossil Lamprey: A Record from the Pennsylvanian of Illinois

Abstract. *A fossil record of lampreys has previously been unknown. A new genus demonstrates the presence of this group in the Pennsylvanian. The body outline, parts of the head skeleton, rasping tongue mechanism, gill basket, and other internal organs are preserved. The fossils are very similar in structure to modern forms. The absence of hagfish characters in the fossil supports the view that the common ancestor of lampreys and hagfishes lived prior to the Pennsylvanian.*

An extensive fauna, predominantly of marine aspect and composed primarily of soft-bodied, invertebrate animals is known from the middle Pennsylvanian Francis Creek Shale of northeastern Illinois (*1*). Several kinds of vertebrates including pleuracanth and cladodont sharks, acanthodians, paleoniscoids, coelacanths, and amphibians are preserved in ironstone concretions from this site. We have recognized in this fauna six specimens that represent the first record of a fossil lamprey (Fig. 1). These jawless vertebrates, today widely distributed in temperate marine and fresh water, are surviving examples of the oldest vertebrate line, the Agnatha of the Middle Paleozoic.

The fossil lampreys, all lying in lateral position in the split concretions, include specimens representing at least two growth stages. The eyes, gill basket, liver, and intestinal tract are preserved in the form of dark stains on the fossil plane of the concretions (Fig. 2). The outlines of the elements of the cartilaginous head skeleton in the holotype are more subtly stained. After emphasizing the markings on photographic enlargements (Fig. 3) a pattern arises that can be compared with illustrations (*2*) of the cranial skeleton of metamorphosing and adult *Lampetra planeri*. This enabled us to develop the reconstruction shown in Fig. 4.

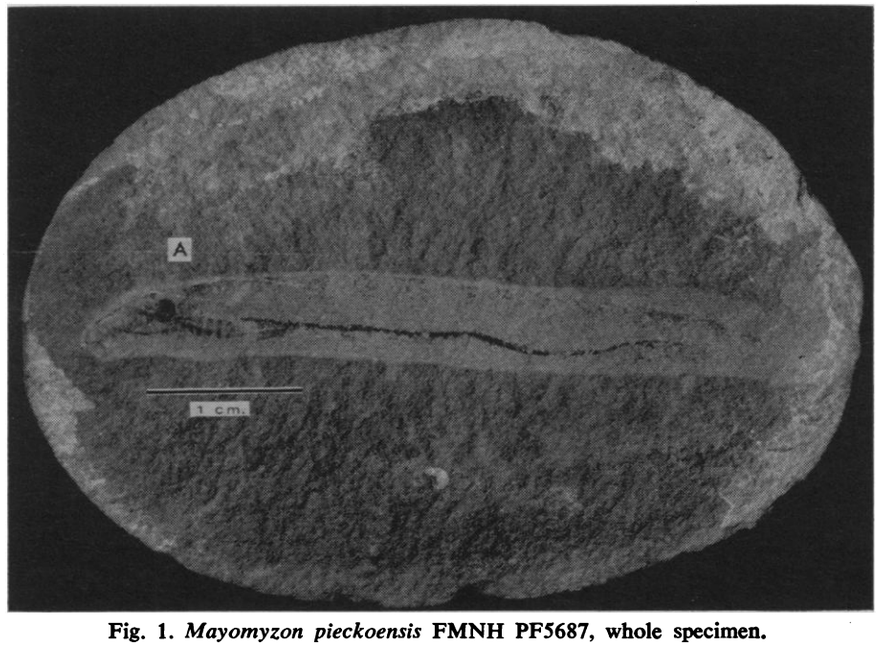

Fig. 1. *Mayomyzon pieckoensis* FMNH PF5687, whole specimen.

Class Agnatha
Order Cyclostomata
Family Petromyzontidae
Mayomyzon Bardack and Zangerl, new genus

Diagnosis: Body deeper than wide; maximum depth $^1/_8$ to $^1/_9$ in body length. Mouth oblique to body axis, probably without circumoral hood and horny teeth. Eye large, its diameter 3½ in front of head to front of eye. Gill pouches: 7, beginning below otic capsule. This genus is named for S. May who donated this specimen to the Field Museum of Natural History and the root of familial name, myzon.

Mayomyzon pieckoensis Bardack and Zangerl, new species.

Genotype: *Mayomyzon pieckoensis* n. sp.

Holotype: FMNH PF5687 (*3*), a presumed adult specimen.

Referred specimens: FMNH PF5688, FMNH PF5539, HTP 1640, HTP 5015, HTP 980. This species named for Mrs. Helen T. Piecko, who permitted examination of the lamprey specimens in her collection.

Horizon and locality: Pit 11, Peabody Coal Co., Will County, Illinois. Francis Creek Shale, Carbondale Formation (Essex concretion fauna, Johnson and Richardson, 1966, Westphalian, Pennsylvanian.)

Description: Measurements of the six specimens are given in Table 1.

Though similar in profile to metamorphosing stages of living petromyzontids, *Mayomyzon pieckoensis* (Table 1) attains only ¼ to ½ the length of comparable stages of the living forms (*4*). The presence of head cartilages and more diffuse body pigmentation suggests that the holotype is an adult individual; the other specimens presumably are subadult. Three specimens, FMNH PF5539, FMNH PF5688, and HTP 5015 show continuous dorsal, anal, and caudal fins. The latter fin is separated from the first two by shallow notches as in transforming lampreys. The mouth lies oblique to the body axis and is probably a narrow slit, but its shape can only be inferred from the sharp angle between the anterior and ventral surfaces of the body. No circumoral hood, cirri, or horny teeth were observed. The oral cavity is best displayed by HTP 1640, in which head cartilages that surround this cavity in the adult are not yet developed. Younger individuals, besides lacking head cartilages, have smaller gill pouches and a series of discrete, darkly stained areas along the dorsolateral surface of the body. These start behind the otic capsule and end below the dorsal fin. Similar pigmentation patterns appear in young and subadult

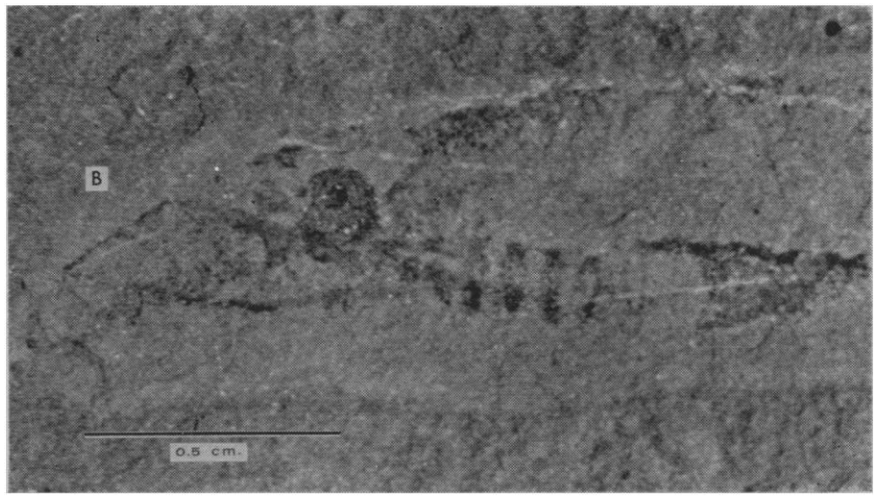

Fig. 2. Enlarged head of *Mayomyzon pieckoensis* FMNH PF5687.

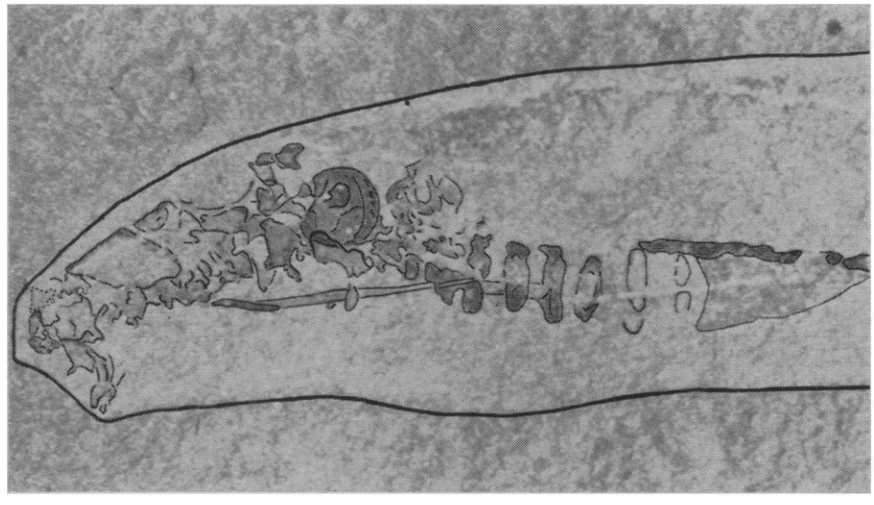

Fig. 3. *Mayomyzon pieckoensis* FMNH PF5687, distribution of cartilage.

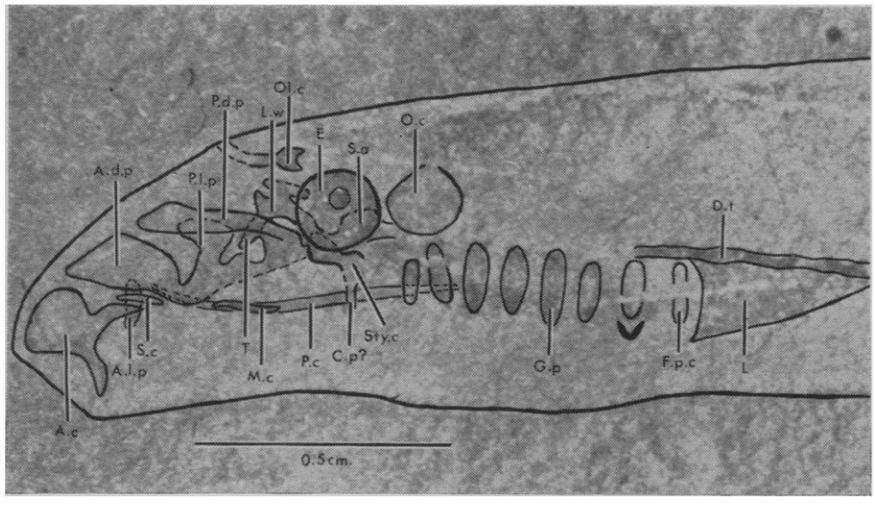

Fig. 4. *Mayomyzon pieckoensis* FMNH 5687, restoration of head skeleton and associated structures. Abbreviations: *A.d.p*, anterior dorsal plate; *A.l.p*, anterior lateral plate; *A.c*, annular cartilage; *D.t*, digestive tract; *F.p.c*, fenestra in pericardial cartilage; *G.p*, gill pouch; *C.p*, cornual plate; *E*, eye; *L.w*, lateral wall of brain capsule; *L*, liver; *M.c*, medioventral cartilage; *Ol.c*, olfactory capsule; *O.c*, otic capsule; *P.c*, piston cartilage; *P.d.p*, posterior dorsal plate; *P.l.p*, posterior lateral plate; *S.c*, stylet cartilage; *Sty.c*, styliform cartilage; *S.a*, subocular arch; *T*, trabecular cartilage.

lampreys today. These pigment patterns are more irregularly distributed and less dense in the holotype.

All principal parts of the head skeleton of extant lampreys are present in the fossil, but these parts differ in relative size or position.

A cup-shaped olfactory capsule (*ol.c*) appears anterodorsal to the eye (*E*). It has not come into contact with the brain capsule as in adult lampreys and lies relatively further from this capsule than in modern metamorphosing lampreys. The nasal canal opens to the dorsal surface.

A broad annular cartilage (*A.c*) surrounds the mouth cavity. The stylet cartilage (*S.c*), embryologically a derivative of the annular cartilage, has already separated from the latter. Anterior dorsal (*A.d.p*), posterior dorsal (*P.d.p*), and posterior lateral plates (*P.l.p*) have the same form as in modern lampreys, but as in immature lampreys each is connected to a cartilaginous element lateral to the oral cavity, which seems to represent an anterior extension of the subocular arch (*S.a*).

Much of the brain capsule is obscured by the eye. The broad flange of this capsule (*L.w*), anterior to the eye, has a shape similar to that seen in transforming lampreys. The trabecular cartilage (*T*) remains as a short process arising from the front of the brain capsule and extends anteroventrad between the arms of the paired posterior dorsal plates. The longitudinal subocular arch is represented by a dark band below the eye. A dark, dumbbell-shaped mass with a stout ventral projection appears anterior to the gill basket and ventral to the eye. This structure may be compared to the styliform cartilage (*Sty.c*) and an incipient cornual plate (*C.p?*). It occupies the proper topographic position anterior to the gill basket but lies ventral to the eye, whereas in *Lampetra* this cartilage is posteroventral to the eye. The more anterior position of the cartilage in the fossil is related, no doubt, to the anterior position of the gill basket.

The piston cartilage (*P.c*) and associated structures of the rasping tongue mechanism are present. The length of the piston in *Mayomyzon* is similar to that of *Lampetra*. A short, medioventral cartilage (*M.c*) lies parallel to the piston below the posterior lateral plate. Its position is indicated by an elongate stain superimposed on the piston. The vertically oriented anterior lateral plate (*A.l.p*) lies medial to the anterior dorsal

Table 1. Measurements of six specimens of *Mayomyzon pieckoensis*. Abbreviations: *, complete fish; s-df, snout to start of dorsal fin; s-ml, snout to middle of eye.

Specimen	Character			
	Body length (cm)	Body depth (cm)	Length s-df (cm)	Length s-ml (cm)
	FMNH PF			
5687	4.8	0.6	3.2	0.6
5688	4.5	0.5	3.0	—
5539	6.1	0.7	3.5	0.6
	HTP			
1640	5.1*	0.6	3.3	0.7
5015	4.1*	0.5	2.5	0.5
980	3.3	0.5	—	—

plate and just in front of the anterior end of the piston.

The seven gill pouches appear as ellipsoids which begin below the otic capsule (*O.c*) and extend with a ventroposterior slope to the pericardial cartilage. In *Lampetra*, the first gill pouch lies posterior to the otic capsule. Each pouch (*G.p*) consists of a dorsal and ventral, dark, cup-shaped stain. The clear central region of each pouch probably represents the opening between pouch and pharyngobranchial duct. The gill basket skeleton is not preserved except for a pair of V-shaped ventral elements below the last gill pouch.

The position of the posterior part of the pericardial cartilage is indicated by the concave outline of the anterior end of the liver (*L*). A pair of vertically arranged fenestrae in the cartilage (*F.p.c*) are in line with the gill pouches, but lack their dark markings. In recent lampreys these fenestrae are more horizontally oriented.

Two organs within the coelomic cavity are seen. A dark triangular mass, twice as long as high, located behind the pericardial cartilage represents the liver. If the entire liver is preserved, it is shorter than in recent lampreys. The digestive tract (*D.t*) is a slender dark band extending from the posterodorsal end of the gill basket to the area below the dorsal fin. The connection between the digestive tract and the pharynx is not apparent. The expanded gill pouches probably forced collapse of the digestive tract in this area. We have found that this part of the tract does not appear in X-rays of recent lampreys.

Stensiö (*5*) has demonstrated that the lampreys are related to the Paleozoic ostracoderms (Osteostraci and Anaspida), but the question of which particular ostracoderm group is ancestral to them has been much debated by paleontologists. *Mayomyzon pieckoensis* indicates the following possibilities about lamprey evolution: (i) A basically modern lamprey had evolved by mid-Pennsylvanian time. (ii) The close similarity between the Pennsylvanian and recent lampreys implies a pre-Pennsylvanian origin and evolution of the group that may have extended to the middle or even early Paleozoic. If lampreys have always been as conservative in their evolution as *Mayomyzon pieckoensis* would indicate, support is given to Stensiö's view (*6*) that known cephalaspidomorph ostracoderms (Osteostraci, Anaspida, and petromyzontids) represent three lineages independently derived from a common ancestor. (iii) On the other hand, the lamprey ancestry may not have been too remote. Recent study of *Jaymoytius* from the Silurian of Scotland led Ritchie (*7*) to suggest that this vertebrate is derived from an anaspid stock which might have given rise to petromyzontids. *Jaymoytius* has cyclostome characters such as a subterminal, circular mouth and a branchial basket that begins behind the orbit; but *Jaymoytius* retains lateral fin folds, body scales, lacks a piston, and has 15 or more gill slits. The morphology of *Mayomyzon* provides no evidence for or against Ritchie's suggestion. (iv) As can be judged from the mosaic resemblance of *Mayomyzon* to late metamorphosing and adult lampreys, modern lampreys may have evolved neotenically from larval ostracoderms or preostracoderm fishes. (v) Specialized features of the lampreys, such as the hood and the piston (the latter already present in *Mayomyzon*), probably evolved with the development of their specific mode of feeding. (vi) *Mayomyzon* shows no evidence of hagfish characters. Thus lampreys and hagfishes apparently had a separate pre-Pennsylvanian ancestry, supporting Stensiö's opinion that the two types of living cyclostomes are independently derived from two distinct groups. This is in contrast to the view that the cyclostomes represent a single phyletic line (*6*). (vii) The presence of a well-developed piston implies the presence of a rasping tongue. Thus *Mayomyzon* may have been wholly or partially parasitic. We have, however, seen no evidence of suctorial damage to the bodies of vertebrates in the Francis Creek Shale fauna.

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References and Notes

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8. Supported by NSF grant GB 6788 of the first author.

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Light Scattering in Central Arctic Ocean: Some Winter Profiles

Abstract. *Measurements for light scattering in an Arctic water column reveal strong gradients and variability of the order of 15 percent in depths of less than 500 meters. The region of variability appears to persist from day to day and is roughly associated with the typical hydrographic features of the region. No definite nephelocline was observed.*

Use of optical properties of seawater in tracing oceanic currents and differentiation of water mass, and in detecting biological and geological variations

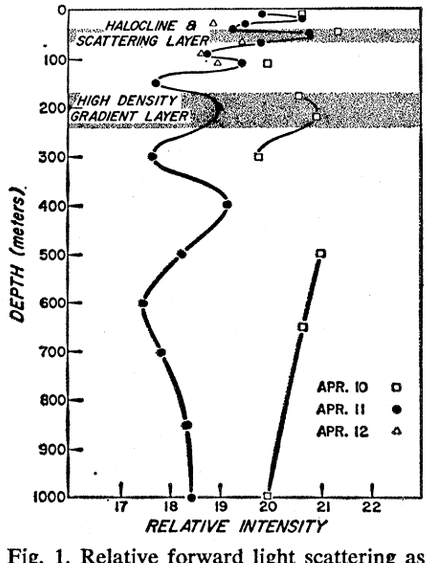

Fig. 1. Relative forward light scattering as a function of depth at the Arctic Ice Island T-3.