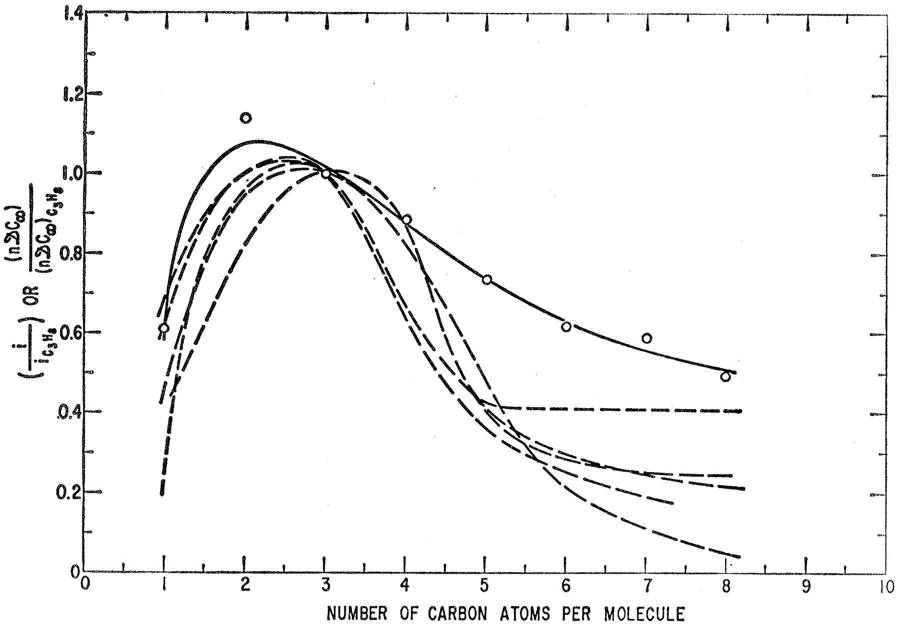

Fig. 2. Relative current densities compared to relative nDC_∞ values for saturated hydrocarbons.

therefore, it probably would have a value characteristic of a chemical or electrochemical reaction, except under the special conditions of $C_0 = 0$, $\theta_{\mathrm{HC}} = 0$.

The diffusion coefficients (*10*) and solubilities (*11*) for normal saturated hydrocarbons in water have been reported for temperatures near 25°C. If consequences of salting-out for the various electrolytes affect the individual members of the homologous series of normal saturated hydrocarbons in the same way, it is reasonable to expect that the ratios of $(D_{\mathrm{HC}}C_{\infty\mathrm{HC}}/D_{\mathrm{C_3H_8}}C_{\infty\mathrm{C_3H_8}})$ will take on the same values from one electrolyte to another and one temperature to another. This is to be expected when the fugacities in the gas phase are made equal for all the members of the series. This, indeed, is the case for nearly all of the fuel cells reported. For octane at 100°C, it is necessary to adjust the solubility values in the manner used by McAuliffe (*11*).

The results for the various fuel cells, expressed as the ratio of current densities at an anode potential of 0.5 volt versus the reversible hydrogen electrode, are shown in Fig. 2, together with the curve for $(nD_{\mathrm{CH}}C_{\infty\mathrm{HC}}/nD_{\mathrm{C_3H_8}}C_{\infty\mathrm{C_3H_8}})$ values. The agreement in the curve shapes is clear. For the lower temperature fuel cells in particular, the deviation from the nDC_∞ curve is greatest for the fuels of higher molecular weight. The reason for this may be that the assumption of fast rates 2, 3, and 4 is not rigorous at these lower temperatures.

The agreement in curve shapes does not show that the product of the solubility and diffusion coefficient limits or determines the overall rate of the anode reaction, but simply indicates that this nDC_∞ product has an important influence upon the relative reaction rates for the conditions $i/i_{\max} > 0.5$ under otherwise essentially identical experimental conditions. At lower overvoltages (and lower current densities) the curves for current density plotted against carbon number do not generally conform to the shape of those in Figs. 1 and 2 (*2*); other processes are of overriding importance (*3*).

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Fossilization of an Ancient (Devonian) Soft-Bodied Worm

Abstract. *A shell-boring polychaete worm was found replaced by the mineral limonite-goethite; this fossil is probably a limonite-goethite pseudomorph after pyrite, suggesting that the soft-bodied worm was originally replaced by pyrite. External structures such as a prostomium, anterior tentacle-like palps, peristomial cirri, parapodia, setae bundles of the parapodia, and dorsal cirri of the parapodia are preserved. This worm resembles living members of the family Spionidae in form and habit. This discovery extends the known range of this family (Cretaceous?, Miocene to Recent) back about 365 million years to the Devonian period.*

In a very fossiliferous layer in the Marcellus Formation (middle Devonian) of central New York, a small, limonitic, rodlike structure resembling a worm within a worm boring in a shell of the bivalve *Cornellites flabellum* (Hall) was discovered (Fig. 1) (*1*). The similarity of this structure to some modern shell-boring polychaetes suggests that this is a mineral replacement of the soft body of a shell-boring worm entombed in its tube-lined boring (*2*). The stratigraphic record has revealed many concretionary objects that superficially resemble organic remains, but this rod has too many structures analogous to those of polychaete worms to be considered merely an object of inorganic origin accidentally resembling a worm.

This fossilized worm was found in a small hillside quarry 2.2 miles (3½ km) north of Morrisville, New York, where the middle (?) part of the Cardiff shale member of the marine Marcellus Formation is exposed. The fossil was collected from the bedding surface of a silty mudstone at the top of the third terrace in the quarry [about 10 feet (3 m) below the top].

The fossil worm is slightly curved, circular in cross section, 0.43 to 0.67 mm in diameter and 3.30 mm long, and has along each side a nearly straight row of ten closely and regularly spaced nodes (Fig. 1). One end of the rod (worm's body) tapers slightly and terminates abruptly. This is the posterior end. The other end (anterior) has (i) a small platform at the base projecting forward, (ii) four thin filaments (about 0.05 mm thick and 0.50 mm long) projecting downward, and (iii) a much thicker filament (0.17 mm) extending downward and anteriorly (Fig. 1).

The nodes along the sides of the body are about 0.14 mm wide and 0.23 mm long; they project out from the side of the rodlike body only about 0.07 mm. Extending from the base of most of the nodes is a filament 0.10 mm thick and 0.60 mm long. Smaller projections (up to 0.02 mm in diameter and 0.16 mm long when unbroken) occur at the top and near the base of these nodes (Fig. 1).

The rod is composed of limonite-goethite ($HFeO_2$). The tube lining the boring is composed of mud and quartz (SiO_2) grains cemented with limonite and a small amount of calcite ($CaCO_3$). The surfaces of the rod and the agglutinated tube lining the boring have tiny octahedral crystals scattered over them. These crystals are probably limonite-goethite pseudomorphs after pyrite (FeS_2), since they are brown with a submetallic luster like limonite-goethite, rather than yellow with a metallic luster like pyrite. Identical crystals composed of pyrite were found on shells from the same bed in the quarry.

The slightly curved, cylindrical boring parallels the host's shell surfaces and opens perpendicularly toward the shell's ventral margin. It is 1.5 mm in diameter, 8 mm long, and terminates with a rounded inner end (Fig. 1). The rodlike body of the replaced worm is attached to the agglutinated tube that lines this boring.

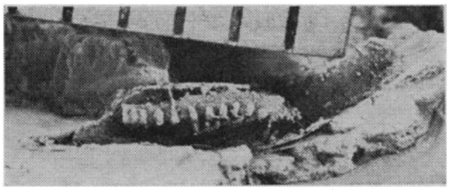

Fig. 1. Side view of replaced worm (coated with ammonium chloride). The worm's ventral and lateral surfaces are exposed in the boring. Divisions on scale are in millimeters. (American Museum of Natural History No. 28471).

Modern polychaetes are segmented worms (phylum Annelida) characterized generally by biramous parapodia which are paired, fleshy, lateral appendages extending from each of the body segments (*3*). The parapodia are usually somewhat laterally compressed, as are the nodes on the specimen under discussion. These nodes greatly resemble parapodia, a fact which would put this replaced worm definitely within the class Polychaeta. The filament extending from the base of many of the nodes possibly represents a dorsal cirrus, a ciliated respiratory structure. If this is the case, then the replaced worm, as revealed in its boring, is unavoidably illustrated upside down (Fig. 1). The needle-like smaller projections at the top and near the base of the outer extremity of the nodes probably represent replaced setae (chaetae) bundles. Although those at the top of the nodes are all broken (or were not completely replaced), they may be the setae of the lower division (neuropodium) of the biramous parapodium. Those near the bottom may be the setae of the upper division (notopodium). The fourth node from the left (Fig. 1) has a large projection which may even represent a ventral cirrus. These nodes, therefore, resemble biramous, setae- and cirri-bearing parapodia (Fig. 2).

The platform at one end (anterior) of the body may be a replaced prostomium. The four thin filaments located just posterior to the platform may be two pairs of cirri projecting from the peristomial region behind the prostomium. The much thicker filament extending from one side of this anterior end of the body may be one of a pair of tentacle-like palps that some worms use in feeding (Fig. 2).

The family Spionidae contains worms which have a pair of anterior tentacle-like palps and long thread-like dorsal cirri extending from most of the parapodia (*4*). These worms are tube-dwelling polychaetes that use their palps to collect suspended matter from the sea water by projecting their palps from the open end of their tubes and actively moving them about in the water. The best studied modern shell- and rock-boring worms are certain species of the spionid genus *Polydora* (*5*).

Boring species of this genus line their borings with an agglutinated tube and frequently position themselves at the margin of the host's shell, as did these Devonian worms. Although *Polydora* borings are U-shaped and often have a *Spreite* (a thin median cavity spread between two limbs of the boring), they otherwise resemble the nearly straight to hooked, unbranched borings of this Devonian worm.

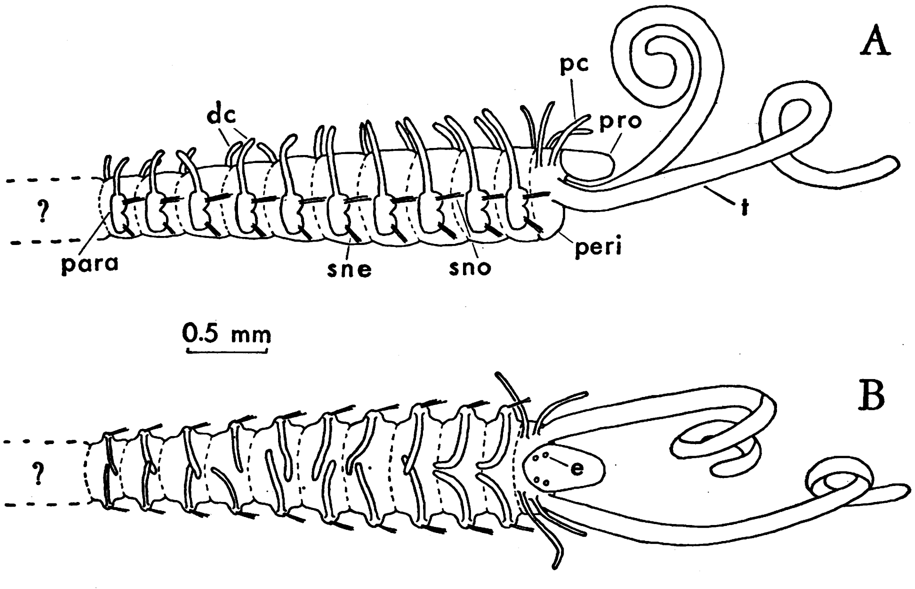

Fig. 2. Restoration of the fossilized Devonian spionid polychaete worm: (A) side view; (B) dorsal view. Ventral cirri may have been present but not enough structures were preserved to warrant their inclusion in the restoration. Explanation of symbols: *para*, parapodium, *sne*, setae of neuropodium; *sno*, setae of notopodium; *dc*, dorsal cirri; *pro*, prostomium; *pc*, peristomial cirrus; *peri*, peristomium; *t*, tentacle-like palp; *e*, eye.

Polydora does not fit snugly into its boring, probably because it must maintain a steady water current over its dorsal cirri for respiratory purposes. Similarly, the replaced Devonian worm occupies only about half of the diameter of its boring. It seems that this was a worm similar to *Polydora* in its habits as well as form, rather than some other kind of polychaete that crawled into a vacant boring.

Since the boring terminates 2 mm behind the rodlike body, this worm may have been only about 5.3 mm long, not considering the possible length of its palps. There are 11 body segments preserved, including the peristomium but not the prostomium as one segment. Perhaps the worm originally had at least twice as many body segments, especially when one considers that the unpreserved posterior segments would have been smaller, closer together, and more numerous. Adults of some species of *Polydora* may also have only about 25 body segments.

The anatomical similarity of the replaced specimen to *Polydora* and other genera of the Spionidae, its discovery in an agglutinated tube lining a worm boring in a bivalve shell, and the improbability of such a structure being produced inorganically suggest very strongly that this is a unique replacement of a nearly whole worm. Fossils are reported from time to time as pyrite or limonite replacements of parts of the original organisms, but, to the best of my knowledge, the fossilization process described above has never before been reported. Furthermore, this discovery extends the known range of the family Spionidae (Cretaceous?, Miocene to Recent) back about 365 million years to the Devonian period.

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Plant Moisture Stress: Evaluation by Pressure Bomb

Abstract. *The recently developed technique for determining the water stress of a plant by measuring the pressure necessary to force water back to the cut surface of a severed twig is adaptable to both field and laboratory experiments. We have designed and operated an efficient portable system weighing less than 18 kilograms. Sampling variation within and among Douglas fir trees varies from less than ± 1 atmosphere under low stress conditions to ± 10 atmospheres under high stress conditions. In the measurement of plants of comparable height and similar exposure, the variation is reduced to a minimum. Values in internal water stress of Douglas fir vary from 3 to more than 40 atmospheres. Both duration and magnitude of stress are important ecologically. Pressure-bomb measurements are used to demonstrate a relation between plant distribution and internal water stress.*

Scholander *et al.* (*1*) demonstrated that a pressure bomb could be used to evaluate the status of water within vascular plants. The simplicity of this technique, compared to other methods of measuring plant water stress, encouraged us to design an instrument that could be used efficiently in both laboratory and field situations. We took measurements with this instrument under a variety of environmental conditions to determine standards for the collection and preparation of samples.

Internal water stress, the key measure for many phases of research related to plant response, is most difficult to predict (*2*) because the status of a plant's moisture is dependent upon soil moisture stress, atmospheric stress, and the plant's ability to control water losses. For clarity we express the water status of plants as internal water stress rather than water potential or diffusion pressure deficit. The units of internal water stress are positive atmospheres rather than negative bars, dynes per square centimeters, ergs per cubic centimeter, or centimeters of water. Stress or water potential is a true scalar potential and "as for any other scalar potential in physics, the 'driving force' is (minus) the gradient of the potential, and bears no relation to its absolute value, which includes a constant of integration which we may assign at will" (*3*). Philip concluded that "the most convenient datum of water potential for plant physiological purposes is the potential of pure water under atmospheric pressure; and convenience is the only pertinent criterion." The less familiar terms, as Slatyer (*4*) has pointed out, "will not be accepted generally until the parameters they describe can be shown to be necessary to a fuller understanding of plant water relationships."

Within the vascular system of a plant the water column is generally under tension. This tension results from the demands of the leaves for replacement of water lost to the atmosphere and from the inability of the roots to take up water rapidly enough from a progressively drying soil. When a twig is severed, the water column is broken and water withdraws into the twig a short distance. To measure the original tension, the twig can be placed in a bomb with the cut end protruding through a seal; pressure exerted on the leaves forces the water column back to the cut surface. The pressure at which water is observed is assumed to be the tension on the water column before it was severed.

To find what relation, if any, exists between pressure-bomb measurements of water stress in the twigs and a standard method of measuring water stress in the leaves of a plant, we made comparisons from 5 to 20 atm on Douglas fir (*Pseudotsuga menziesii*) by modifying Slatyer's (*5*) vapor equilibration technique and found agreement within the precision of the methods, which is about ± 1 atm. The relation at higher stresses has yet to be determined.

Our system is simple in operation. After a twig is cut from a plant, the bark and phloem are stripped back a short distance from the cut surface, and the exposed xylem is slipped through a rubber stopper and inserted into the cover that is screwed to the body of the bomb (Fig. 1). With the bleeder and flow-regulating valves closed and the gauge shutoff valve open, pressure is applied through the pressure regulator. The regulating valve is then opened, and the pressure is gradually increased. When water first appears on the cut surface, the regulating valve is closed. Finally, the pressure reading is recorded, and the bleeder valve is opened to vent the system and prepare