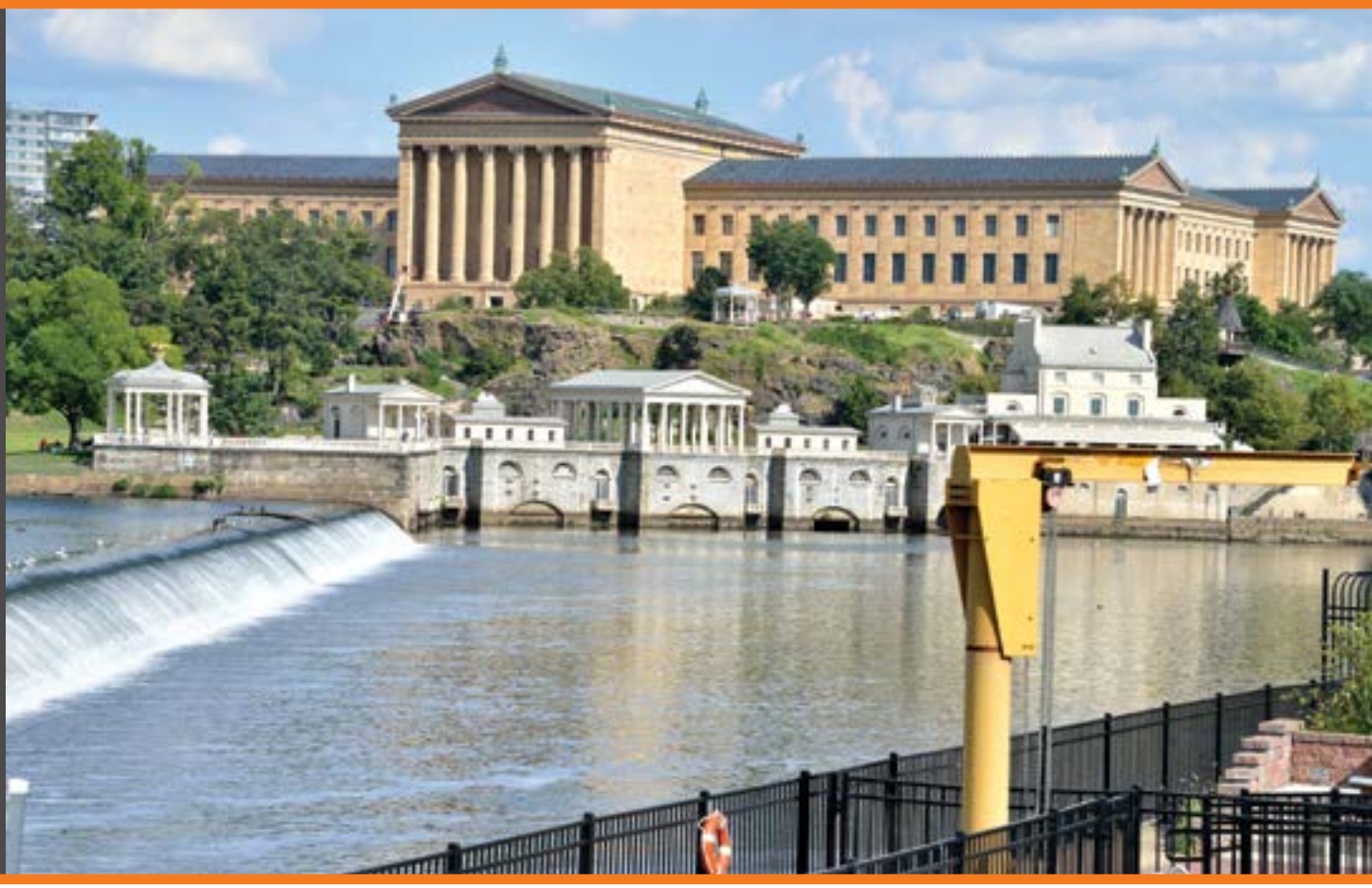
20

FRESHWATER SPONGE

(*Spongilla* [*Eunapius*] *fragilis*)



Spongilla fragilis **is a freshwater sponge first described from a specimen found in the Schuylkill River in Philadelphia in the nineteenth century. Freshwater sponges still inhabit the river here.**

Figure 20.1 Fairmount Dam, regarded in the late nineteenth century as one of the richest places for collecting freshwater sponges, including *Spongilla fragilis*. It diverted water to the Fairmount Water Works (middle of photo), which pumped water up to a reservoir whose site is now occupied by the Philadelphia Museum of Art, built after pollution of the river made the reservoir obsolete. In the foreground is the Fairmount fish ladder, which allows migrating fish to surmount the dam.

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In 1851, at a meeting of the Academy of Natural Sciences in Philadelphia, Joseph Leidy announced his discovery of a new species of freshwater sponge. He found it growing on the underside of stones below the low water mark in the tidal Delaware and Schuylkill Rivers in Philadelphia. He reported its diameter as one to two inches. Noting that most of the sponge disintegrates after it dies, he named it *Spongilla fragilis.* It has no common name.[1] The current name for the genus is *Eunapius* instead of *Spongilla,* but in this account I have retained *Spongilla*.

In 1870 he reported finding this sponge living in association with other invertebrates in the Schuylkill River below the Fairmount Dam. The other animals included ciliated polyps, mollusks, rotifers, protozoans, bryozoans, and polychaete worms.[2] He discovered one of these, a polyp he named *Urnatella gracilis,* the same year he discovered *S. fragilis.*

Sponges on Fairmount Dam, 1887

In 1887 Edward Potts, Leidy's colleague at the Academy, published the last account I could find of this sponge in the Schuylkill River in Philadelphia. In a monograph on freshwater sponges, he reported finding it on the timbers of the Fairmount Dam, which he ranked as one of the richest places in the world for freshwater sponges. At the time the dam powered turbines that drove pumps in the Fairmount Water Works, which pumped water to a reservoir on top of Fairmount Hill, now occupied by the Philadelphia Museum of Art. On the west side of the dam, across the river from the water works, was a navigation canal with locks, currently the site of a fish ladder. Potts gained access to the dam during summer months, when water spilling over the dam subsided. On one visit to the dam he found six species of freshwater sponge, including *S. fragilis.*[3]

Potts described a dense population of *S. fragilis* on the walls of the canal:

> Upon one occasion when the water was withdrawn from the canal basin at the head of the locks at Fairmount Dam, Philadelphia, the exposed, perpendicular walls of dressed stone were seen to be lined with them, probably hundreds in number; some of minute size, but many covering two or three square feet of surface. They were rarely much more than an inch thick near the middle and shaded off all around to filmy edges. They had no apparent preference for the comparatively rough surface of the stones, for some of the finest specimens were found upon the timbers of the gates, from which they were easily removed.[4]

Lower Schuylkill riverbed void of life, 1876

At the time Potts reported rich populations of *S. fragilis,* pollution in the lower Schuylkill River was already severe. A decade earlier, Josua Lindahl, secretary of the Swedish Commission, offered Joseph Leidy an opportunity to collect specimens from the Schuylkill riverbed, which a small steamer under Lindahl's command was prepared to dredge experimentally. Expecting a trove of small animals from the bottom of the river, Leidy accepted Lindahl's invitation, only to be disappointed:

> No living thing whatever was drawn up, as the mud and sand were black and saturated with bituminous oil. This latter fact was unexpected, and would appear to illustrate the mode of formation of more ancient bituminous shales. The refuse of the city gas-works, and probably of some coal-oil refineries, run into the river. The oils appear to have an affinity for the particles of clay carried down the river, and, precipitating, become bituminous sediments at the bottom.[5]

Pollution of the city's water supply

A year before the dredging, a commission of engineers appointed by the mayor submitted its report on pollution of the city's water supply in the Schuylkill River:

> For many years, and to within a recent period, the Schuylkill water has been remarkably pure and wholesome; but it has been impaired by impurities, accompanying the growth of population and the extension of industries. The contamination of this stream is not alarming, yet it is believed that unless a remedy be applied it will ultimately be rendered unfit for domestic uses. The principal causes of deterioration are, the sulphuric acid from the coal mines, and the refuse and the sewage from population and from the numerous manufactories which drain into the Fairmount pool.[6]

The commission reported that, since 1842, sulfur in the Schuylkill River at Fairmount, the source of the city's drinking water, had increased eightfold. It found that the causes of the pollution extended far beyond the city itself:

> The region drained by the river is estimated at something over 1,800 square miles, of which 1,200 square miles is below the mining region, a large portion of which is a highly cultivated, populous, and thriving region. Several cities and towns, numbering about 20, occupy closely its banks, and many of them have become centers of manufacturing interests, and are estimated to contain at present an industrious population of over 100,000, Reading alone containing nearly 40,000 people; and, in addition to the enormous coal mining operations of the upper Schuylkill, iron banks have been opened, and iron furnaces built upon its margin; cotton factories, carpet and dye works, woolen and hat manufactories, paper mills, tanneries, chemical and gas works, breweries, and indeed the advantages of the location are so obvious, that almost every branch of manufacture has found a convenient location on its banks, and some of them on a scale not exceeded by any in this country; nor should the recognized influence of railroads on the banks of rivers be lost sight of, in estimating the future probable distribution of the population and industries of this valley.[7]

Figure 20.2 Wharf on the east bank of the Schuylkill River at Walnut Street, 1888. Twelve years earlier, Joseph Leidy had found no living plants or animals in sediment dredged from the riverbed. (Photo courtesy of Philly-History.org, a project of the Department of Records of the City of Philadelphia)

The commission recommended new sewers and pumps and modification of reservoirs and freshwater intake pipes.

None of these recommendations addressed pollution from coal and oil, or discharge of waste upstream in the river's vast watershed.[8] At the time Leidy discovered *S. fragilis,* coal shipped to Philadelphia by rail and boat from mines along the Schuylkill watershed totaled 15 million tons per year and was increasing.[9] These mines dumped silt and culm, consisting of fine particles of coal, directly into streams and onto stream banks.[10] Locally, the Philadelphia Gas Works manufactured illuminating gas from coal in a factory on the riverbank about 100 meters downstream from the water works.[11] Ruth Patrick, limnologist at the Academy of Natural Sciences, recalled seeing the river colored black from pollution from coal in the first half of the twentieth century.[12] Coal dust dumped into the river must have challenged the river's populations of sponges, which are filter feeders that consume bacteria and algae they sieve from the water. Fine sediment suspended in water clogs their pores.[13]

Figure 20.3 "East bank of the Schuylkill, below Spring Garden Street Bridge. The banks have long been a disgrace to Philadelphia." Photo and caption from *The Redemption of the Lower Schuylkill* by John Frederick Lewis, published by the City Parks Association, Philadelphia, 1924.

Schuylkill River Project, 1951

In 1951 the Commonwealth of Pennsylvania and the United States Army Corps of Engineers issued their final report on the Schuylkill River Desilting Project,[14] a monumental effort to dredge and remove 38 million tons of culm along 208 kilometers of river.[15] After the desilting project ended, Patrick noted that the river no longer turned black, but lack of funding prevented completion of the project:

> Although the removal of the sediments improved the quality of water in the Fairmount Park area of the Schuylkill River, conditions were not ideal for aquatic life. In our 1958 studies, we found many organisms on the banks and substrates that were above the riverbed. The rocks that protruded from the surface of the bed often supported a fair amount of aquatic life, whereas very little was found in the bed of the river itself.
>
> One tangible evidence of improvement in aquatic life was the finding of a bryozoan described by Joseph Leidy in 1851 from the Schuylkill. Its name is *Urnatella gracilis*. Leidy wrote in 1870 that it was abundant, but by 1883 it had vanished because of the city's sewage and industrial pollution. I am sure he would have been pleased to know that it was again established in 1958.[16]

Figure 20.4 Schuylkill River desilting project discharging dredged materials into an impounding basin upstream at Stouds Ferry, Berks County. (From *The Schuylkill River Desilting Project, Final Report of the Schuylkill River Project Engineers, 1 July 1951*[17])

The City of Philadelphia has since constructed three sewage treatment plants and introduced new sewage treatment technology.[18] It installed steel bulkheading along the Schuylkill shoreline in Center City and transformed the riverbank into a landscaped park.[19] Erection of a fish ladder enabled fish to migrate over the Fairmount Dam.[20] Dredging to reduce Schuylkill culm resumed.[21] Coal mining decreased,[22] as did the city's population.[23] Federal legislation, especially the Clean Water Act of 1972 and its amendments, improved monitoring and management of waste.[24]

Reduction in pollution

Based on monitoring from 2001 to 2005, water quality of the Schuylkill River in Philadelphia was rated "good" with respect to suspended sediment, and "improved" with respect to phosphorus, but still "poor" for phosphorus and nitrogen.[25] Sodium and chloride concentrations have increased, especially in the winter, due to road salt and suburban sprawl,[26] while sulfur near the mines in the upper Schuylkill decreased.[27]

Surveys of fish sampled by electrofishing in the spring in the tidal Schuylkill from 2002 to 2006 found thirty-three species; four additional species were found by video monitoring inside the fish ladder.[28] A survey of macroinvertebrates in the lower Schuylkill in 1975–1976 identified twenty-two genera, including mollusks, insects, crustaceans, and the polychaete worm *Manayunkia speciosa*.[29] Joseph Leidy discovered this worm in the Schuylkill River in 1858 and named the genus *Manayunkia* in reference to an Indian name for the Schuylkill River. This worm was part of the faunal community Leidy associated with *S. fragilis* below the Fairmount Dam in 1870.[30]

Figure 20.5 September 2012, same location as in figure 20.3.

Whether populations of *S. fragilis* have survived in the lower Schuylkill River has not been reported. The distribution of the species is cosmopolitan. By 1884, *S. fragilis* had been found from Florida to Nova Scotia, and from the Great Lakes west to the Columbia River.[31] The species has since been reported from all continents, in climates ranging from tropical to subarctic, and in diverse freshwater habitats, including caves.[32]

Pollution could have transiently eliminated this sponge, as in the case of *Urnatella gracilis.* Sponges can be transported as minute dormant propagules, called gemmules. The gemmules of *S. fragilis* are minute (up to 1 mm in diameter),[33] and tolerate salt, desiccation, anoxia, freezing and thawing, and long periods of inactivity.[34] Ships theoretically could have reintroduced *S. fragilis* in the form of gemmules on wooden hulls[35] and in ballast tanks.[36] The mystery of its cosmopolitan distribution has generated speculation about its dissemination, such as by wind, insects, birds, and mammals, including people.[37]

A search for *Spongilla fragilis*

I recently hunted for *S. fragilis* just below the Fairmount Water Works at low tide in the early fall, the season when the size of the sponge is largest. Leidy found the species in this location a century and a half ago. I waded into the river and inspected stones and logs, looking for sponges and encrusted gemmules. Exposed to light, sponges can look green due to symbiotic algae, which can confound identification. I looked for sponges on stones' undersurfaces, which were shielded from light. I did not identify any sponges, but green encrustations were common and may have been sponges coated with algae.

Up the river about a kilometer I found a grapefruit-sized gelatinous ball floating just below the surface in an inlet. I suspected it might be a sponge, but Richard J. Horwitz at the Academy of Natural Sciences identified it as the bryozoan *Cristatella* (*Pectinatella*) *magnifica,* which Leidy discovered in Philadelphia and named the same year he discovered and named *S. fragilis.*[38] Like sponges, bryozoans are filter feeders, but they have microscopic tentacles.[39]

Discovery of spongillaflies

Although I failed to identify *Spongilla fragilis* in the river, I discovered spongillaflies (*Climacea areolaris*) attracted to a black light in our backyard a few blocks from the river. The larvae of these spongillaflies are aquatic and feed exclusively on freshwater sponges (family Spongillidae), including *Spongilla fragilis*.[40] Adults fly and feed on nectar and, under laboratory conditions, live for two to three weeks.[41] They resemble brown lacewings and belong to the same order (Neuroptera) of insects. They are weak fliers, so they likely emerged from the Schuylkill River close by.

Figure 20.6 Spongillafly (*Climacia areolaris*), attracted to black light in our backyard a couple of blocks from the Schuylkill River. Its larvae feed exclusively on freshwater sponges (members of the family Spongillidae).

The Schuylkill River is part of the Delaware River basin, home to 835 documented species of aquatic invertebrates, including 10 species of freshwater sponge.[42] The sponges inhabiting the lower Schuylkill today have yet to be systematically surveyed. Viewed in the context of a river black from coal dust less than a century ago, the presence of even one species of sponge would appear to be evidence of the river's resilience.

A long history of corrective action contributed to the restoration of the health of the river. The report of the city's engineers who documented the Schuylkill River's pollution[43] preceded Rachel Carson's *Silent Spring*[44] by almost a century. The city protected its supply of potable water primarily to serve its citizens, not aquatic wildlife, but its actions served both.

Tolerance and intolerance of pollution

Credit for the presence of freshwater sponges in the Schuylkill River may belong less to the remediation of the river than to the toughness of some freshwater sponges, especially *Spongilla fragilis*. Edward Potts reported it thriving on the Fairmount Dam[45] one decade after Joseph Leidy had discovered that industrial pollution had destroyed all life in the lower Schuylkill riverbed[46] and city engineers had determined that refuse, sewage, and sulfuric acid had polluted the pool behind the dam.[47] On the Fairmount Water Works in 1884, freshwater sponges were so numerous that Potts considered them to be *causes* of pollution.[48]

A review of studies on the tolerance of *Spongilla fragilis* to pollution found that this sponge is practically insensitive to hydrogen ion concentration and siltation. Even though it is a filter feeder, healthy colonies have been found growing on substrates submerged in mud; it has been collected in water with coliform counts of 24,500 colonies/ml; and it tolerates pollution in the form of nitrates, phosphates, sulfates, and many other contaminants.[49]

Spongilla fragilis tolerates pollution better than does its enemy the spongillafly, *Climacea areolaris*.[50] It likely tolerates pollution better than do many of its other enemies. Animals known to feed or live on freshwater sponges include fish, crayfish, mites, nematodes, protozoans, rotifers, bivalves, oligochaetes, and insects (dipterans and trichopterans as well as neuropterans).[51] The protection that pollution offers *Spongilla fragilis* may account for this sponge's paradoxical abundance in polluted water.