and burrows like the last, but this species has its proper home on the muddy shores and in estuaries, and will, therefore, be mentioned again.

At certain times, especially in the spring, multitudes of the young shells of *Bittium nigrum* (p. 305, Plate XXIV, fig. 154) are found creeping on the surface of the moist sand in sheltered places, at low-water, and generally associated with large numbers of the *Astyris lunata*, (p. 306, Plate XXII, fig. 110.) But this is not the proper habitat of either of these species; the reason of this habit is not obvious, unless they may have been accidentally transported to such places. They may be found, however, on the eel-grass growing on sandy shores. The *Lacuna vincta* (p. 305, Plate XXIV, fig. 139) also frequently occurs on eel-grass and sea-weeds in such places.

The *Crepidula fornicata* (Plate XXIII, figs. 129, 129*a*) and *C. unguiformis* (Plate XXIII, fig. 127) occur on shells inhabited by the hermit crabs as well as on the living shells of *oysters*, *Pecten*, *Limulus*, &c; and the smaller and darker species, *C. convexa*, (Plate XXIII, fig. 128) occurs both on the eel-grass, and on the shells of *Ilyanassa obsoleta*, especially when occupied by the small hermit-crabs. Occasionally specimens of *Fulgur carica* (Plate XXII, fig. 124) and of *Sycotypus canaliculatus* are found crawling on sandy flats or in the tide pools, especially during the spawning season, but they do not ordinarily live in such situations, but in deeper water and on harder bottoms off shore. The curious egg-cases of these two species are almost always to be found thrown up by the waves on sandy beaches. They consist of a series of disk-shaped, subcircular, or reniform, yellowish capsules, parchment-like in texture, united by one edge to a stout stem of the same kind of material, often a foot and a half or two feet in length. The largest capsules, about an inch in diameter, are in the middle, the size decreasing toward each end. On the outer border is a small circular or oval spot, of thinner material, which the young ones break through when they are ready to leave the capsules, each of which, when perfect, contains twenty to thirty, or more, eggs or young shells, according to the season.

Dr. Elliott Coues, who has observed *F. carica* forming its cases at Fort Macon, North Carolina, states that the females bury themselves a few inches below the surface of the sand on the flats that are uncovered at low-water, and remain stationary during the process. The string of capsules is gradually thrust upward, as fast as formed, and finally protrudes from the surface of the sand, and when completed lies exposed on its surface. The string begins as a simple shred, two or three inches long, without well-formed cases; the first cases are small and imperfect in shape, but they rapidly increase in size and soon become perfect, the largest being in the middle; the series ends more abruptly than it begun, with a few smaller and less perfect capsules. The number of capsules varies considerably, but there are usually seventy-five to one hundred or more. At Fort Macon Dr. Coues observed this species

spawning in May, but at New Haven they spawn as early as March and April. It is probable that the period of spawning extends over several months. Mr. Sanderson Smith thinks that they also spawn in autumn, on Long Island. It is not known how long a time each female requires for the formation of her string of capsules. There are two forms of these capsules, about equally abundant in this region. In one the sides of the capsules are nearly smooth, but the edge is thick or truncate along most of the circumference, and crossed by numerous sharp transverse ridges or partitions, dividing it into facets. Dr. Coues states that these belong to *F. carica*. An examination of the young shells, ready to leave the capsules, confirms this. The other kind has larger and thinner capsules, with a thin, sharp outer edge, while the sides have radiating ridges or raised lines. Sometimes the sides are unlike, one being smooth and more or less concave, the other convex and crossed by ten or twelve radiating, elevated ridges, extending to the edge. This kind was attributed to *F. carica* by Dr. G. H. Perkins, and formerly by Mr. Sanderson Smith, but a more careful examination of the young shells, within the capsules, shows that they belong to *S. canaliculata*.

Among the sand-dwelling bivalve shells we find quite a number of species that burrow rapidly and deeply, some of them living in permanent holes or perpendicular burrows, into which they can quickly descend for safety, and others burrowing in the sand in all directions, without permanent holes.

The "razor-shell," *Ensatella Americana*, (Plate XXVI, fig. 182, and Plate XXXII, fig. 245,) is a common inhabitant of sand-flats and sand-bars, where the water is pure, generally living near low-water mark or below, but sometimes found considerably above low-water mark, as on the sand-bar at Savin Rock. This curious mollusk constructs a deep, nearly round, somewhat permanent burrow, which descends nearly perpendicularly into the sand to the depth of two or three feet. These holes can generally be recognized, by their large size and somewhat elliptical form, when the tide is out. Sometimes they are very abundant in certain spots and not found elsewhere in the neighborhood. They sometimes come to the top of the burrow, when left by the tide, and project an inch or two of the end of the shell above the surface of the sand; at such times, if cautiously approached, many can easily be secured by pulling them out with a sudden jerk, but if the sand be jarred the whole colony will usually take the alarm and instantly disappear. When thus warned it is generally useless to attempt to dig them out, for they quickly descend beyond the reach of the spade. They will often hold themselves so firmly in their holes by means of the expanded end of the long muscular foot, that the body may be drawn entirely out of the shell before they will let go. When not visible at the orifice they can often be secured by cutting off their retreat with a sudden oblique thrust of the spade below them. They are obliged to come up to the upper part of the burrow on account of the shortness of their siphons, or breathing-

tubes, which can be protruded only about an inch in specimens of the ordinary size, and as they depend upon one of these to bring them both food and oxygen, and on the other (dorsal) one to carry off the waste water and excretions, it is essential for their happiness that the orifices of these tubes should be at or near the opening of the burrow most of the time. In this respect the common "long clam," *Mya arenaria*, (fig. 179,) and many others that have very long and extensile tubes have a great advantage. But the "razor-shell" makes up for this disadvantage by its much greater activity. Its foot, or locomotive organ, (see fig. 182,) is long and very muscular and projects directly forward from the anterior end of the shell; at the end it is obliquely beveled and pointed, and it is capable of being expanded at the end into a large bulb, or even into a broad disk, when it wishes to hold itself firmly and securely in its burrow. In excavating its burrows it contracts the end of the foot to a point and then thrusts it beneath the surface of the sand; then, by forcing water into the terminal portion, it expands it into a swollen, bulbous form, and thus crowds the sand aside and enlarges the burrow; then, by using the bulb as a hold-fast, the shell can be drawn forward by the contraction of the foot; the latter is then contracted into a pointed form and the same operations are repeated. The burrow thus started soon becomes deep enough so that the shell will maintain an upright position, when the work becomes much easier and the burrow rapidly increases in depth. The "razor-shell," like all other bivalves, depends upon the minute infusoria and other organic particles, animal and vegetable, brought in by the current of water that supplies the gills with oxygen. It is preyed upon by several fishes that seem to be able to root it out of the sand, or perhaps seize it when at the surface. In this region its principal enemies are the tautog and skates. The latter appear to eat only the *foot*, for in their stomachs there are sometimes many specimens of this organ, but no shells or other parts.

The common "long clam," *Mya arenaria*, (p. 309, Plate XXVI, fig. 179,) is also found on sandy shores from low-water nearly up to high-water mark, but it prefers localities where there is more or less gravel or mud with the sand, so as to render it compact, and it has a decided preference for sheltered localities, and especially abounds on the shores of estuaries where there is a mixture of sand, mud, and gravel. It will, therefore, be more particularly mentioned among the estuary species. Yet it is often found even on the outer ocean-beaches, in favorable localities, but not in the loose sands. It lives in permanent burrows, and on account of its extremely long siphon-tubes, which can be stretched out to the length of a foot or more, it is always buried at a considerable depth beneath the sand. The specimens of this shell that live on the outer sandy beaches are much thinner, whiter, and more regular in form than those found in the estuaries; they are often quite delicate in texture, and covered, even when full grown, with a thin, yellowish epidermis, and look so unlike the homely, rough, and mud-colored specimens usually

sold in the markets, that they might readily be mistaken for another species.

The "sea-clam" or "surf-clam," *Mactra solidissima*, (Plate XXVIII, fig. 202,) is a large species which belongs properly to the sandy shores, and is seldom found elsewhere. It is common both in the sounds and on the outer ocean-beaches, but is not very often found above low-water of ordinary tides unless thrown up by the waves. Its proper home is on sandy bottoms in shallow water, just beyond low-water mark and down to the depth of four or five fathoms. It occurs all along our coast, wherever there are sandy shores, from North Carolina to Labrador. Its shells are extremely abundant and of very large size on the outer sand-beaches of New Jersey and the southern side of Long Island. This species grows very large, some of the shells being more than six inches long and four or five broad; and there is great variation in the form of the shell, some being oval, others more oblong or elliptical, and others nearly triangular; some are very swollen, others quite compressed; but all the intermediate grades occur. The siphon-tubes are quite short and the creature does not usually burrow very deeply, nor does it seem to construct any permanent burrows. But it has a very large muscular, compressed foot, with which it can quickly burrow beneath the surface of the sand. Nevertheless large numbers are always thrown on the beaches by violent storms, and once there they are very soon devoured by crows, gulls, and other large birds that frequent the shores. This species is not very largely used as food, and is seldom seen in our markets; partly because it cannot usually be so easily obtained in large quantities as the common "long clam" and "round clam," and partly because it is generally inferior to those species as an article of food, for the meat is usually tougher, especially in the largest specimens. But moderate-sized and young "surf-clams" are by no means ill-flavored or tough, and are quite equal in quality to any of the other clams, either "long" or "round," that are ordinarily sold in the markets.

The *Siliqua costata*, (Plate XXXII, fig. 244,) *Lyonsia hyalina*, (Plate XXVII, fig. 194,) and *Lævicardium Mortoni*, (Plate XXIX, fig. 208,) are usually to be found on sandy shores and beaches, often in considerable numbers, but they do not naturally live above low-water mark, and, when found higher up, have probably been carried there by the action of the waves. Their proper homes are on sandy bottoms, in shallow water off shore. They are all rapidly burrowing species, and can live, for a time at least, in the loose sand above low-water mark.

The *Angulus tener* (Plate XXVI, fig. 180, animal, and Plate XXX, fig. 223, shell) is a species that is partial to sandy bottoms and sandy shores, though it is also often found in soft mud. It frequently occurs living at low-water mark, but is more abundant in deeper water. It is a rapid burrower, and has remarkably long, slender, white siphons, which are entirely separate, from the base, and very flexible. On account of the length of these tubes it can remain buried to a considerable

depth beneath the surface of the sand, merely projecting the tubes upward to the surface. It is, nevertheless, like other bivalves, often rooted out of its burrows and devoured by many fishes, especially, in this region, by the "scup" and flounders. This species is found all along the coast, from the Gulf of Saint Lawrence to South Carolina.

The *Macoma fusca* (Plate XXX, fig. 222) is a related species, also furnished with similar, very long, slender, separate tubes, and is, therefore, able to live deeply buried beneath the surface. This species is much more abundant than the preceding, between tides, but it most abounds on shores that are more or less muddy, and in estuaries. But when living on the sandy shores, and where the water is pure, it becomes much smoother and more delicate, and is often of a beautiful pink-color and much larger than the specimen figured. When living in the muddy estuaries it generally has a rough or eroded surface, more or less irregular form, and a dull white or muddy color, often stained with black, resembling in color the *Mya arenaria*, with which it is sometimes associated. It is dug up and eaten by the tautog and other fishes.

The pretty little *Tottenia gemma* (Plate XXX, fig. 220) is a species peculiar to sandy shores, both above and below low-water mark; and it often occurs in immense numbers on the sandy flats laid bare by the tides, buried just beneath the surface of the sand. Owing to its small size it is, however, liable to be overlooked, unless particularly sought for. It is an active species and burrows quickly. It is peculiar in being viviparous, as was first observed by Mr. G. H. Perkins, who found, in January, from thirty to thirty-six, well-formed young shells, of nearly uniform size, in each of the old ones. This shell has a lustrous, concentrically grooved surface; the color is yellowish white or rosy, with the beaks and posterior end usually purple or amethyst-color. It occurs all along the coast from Labrador to South Carolina. The common "round clam" or "quahog-clam," *Venus mercenaria*, (Plate XXVI, fig. 184, animal,) is also common on sandy shores, living chiefly on the sandy and muddy flats, just beyond low-water mark, but is often found on the portion laid bare at low-water of spring-tides. It also inhabits the estuaries, where it most abounds. It burrows a short distance below the surface, but is often found crawling at the surface, with the shell partly exposed. It has short siphon-tubes, united from the base to near the ends, and a large, muscular foot, with a broad, thin edge, by means of which it can easily burrow beneath the sand when necessary. The lobes of the mantle are separate all around the front and ventral edge of the shell, and their edges are thin, white, and folded into delicate frills, some of which, near the siphon-tubes, are elongated and more prominent. Owing to the broad opening in the mantle, the foot can be protruded from any part of the ventral side, and has an extensive sweep, forward and backward. The foot and mantle edges are white; the tubes are yellowish or brownish orange toward the end,

more or less mottled and streaked with dark brown, and sometimes with opaque white.

This species is taken in large quantities for food, and may almost always be seen of various sizes in our markets. The small or moderate-sized ones are generally preferred to the full-grown clams. Most of those sold come from the muddy estuaries, in shallow water, and are fished up chiefly by means of long tongs and rakes, such as are often used for obtaining oysters. Sometimes they are dredged, and occasionally they can be obtained by hand at or just below low-water mark. These estuary specimens usually have rough, thick, dull-white, or mud-stained shells, but those from the sandy shores outside have thinner and more delicate shells, often with high, thin ribs, especially when young; and in some varieties the shell is handsomely marked with angular or zig-zag lines or streaks of red or brown, (var. *notata*.) These varieties often appear so different from the ordinary estuary shells that many writers have described them as distinct species, but intermediate styles also occur. This species is very abundant along the coast from Cape Cod to Florida; north of Cape Cod it is comparatively rare and local. It does not occur on the coast of Maine or in the Bay of Fundy, except in a few special localities, in small, sheltered bays, where the water is shallow and warm, as at Quahog Bay, near Portland; but in the southern parts of the Gulf of Saint Lawrence, as about Prince Edward's Island and the opposite coast of Nova Scotia, where the water is shallow and much warmer than on the coast of Maine, this species again occurs in some abundance, associated, in the same waters, with the oyster and many other southern species that are also absent from the northern coasts of New England, and constituting a genuine southern colony, surrounded on all sides, both north and south, by the boreal fauna.

The curious and delicate shell called *Solenomya velum* (Plate XXIX, fig. 210) is occasionally found burrowing in the pure, fine, siliceous sand near low-water mark, about two inches below the surface, but its proper home is in shallow water, beyond low-water mark, and it is, perhaps most abundant where there is mud mixed with sand, and it also lives in soft mud. Its shell is glossy and of a beautiful brown color, and is very thin, flexible, and almost parchment-like in texture, especially at the edges. It is a very active species, and has a very curious foot, which is protruded from the front end of the shell, and can be used in burrowing, very much as the "razor-shell," described above, uses its foot; but the *Solenomya* makes use of its foot in another way, for it can swim quite rapidly through the water, leaving the bottom entirely, by means of the same organ. The foot can be expanded into a concave disk or umbrella-like form at the end, and, by suddenly protruding the foot and expanding it at the same time, a backward motion is obtained by the reaction against the water; or, by suddenly withdrawing the foot and allowing it to remain expanded during most of the stroke, a for-

ward motion is obtained. It is a singular sight to see this shell swim swiftly many times around a vessel of water, at the surface, until, finally, becoming exhausted by its violent exertions, it sinks to the bottom for rest.

The common "scollop," *Pecten irradians*, (Plate XXXII, fig. 243,) is also frequently found living on sandy shores and flats, or in the pools, but it belongs more properly to the sheltered waters of the ponds and estuaries, where it lives among the eel-grass. It will, therefore, be mentioned again in that connection.

The "common muscle," *Mytilus edulis*, (p. 307,) is frequently found in large patches on sandy flats, fastened together by the threads of byssus. Some of the most beautifully colored varieties, (fig. 234,) with radiating bands of blue and yellow, are often found in such places, but the species is much more abundant and larger in other situations, especially in the shallow and sheltered waters of the bays, where there is more or less mud.

Ascidians are almost entirely wanting on the sandy shores, but *Molgula Manhattensis* (p. 311, Plate XXXIII, fig. 250) is sometimes found even on sandy shores, attached to eel-grass.

Of Bryozoa only two species are usually met with, and even these do not have their true stations on the sandy shores. The delicate and gracefully branched *Bugula turrita* (p. 311, Plate XXXIV, figs. 258, 259) is occasionally found growing attached to the eel-grass, which often grows in the sandy tide-pools, or at extreme low-water. It also occurs in great abundance among the masses of sea-weeds thrown up by the waves on the sandy beaches. Such specimens are often large and luxuriant, in some cases being more than a foot in length; these are derived from the bottom in deeper water, off shore.

The *Escharella variabilis* (p. 312, Plate XXXIII, fig. 256) is often found encrusting dead shells of various kinds, especially such as are inhabited by the larger "hermit-crabs." It is also cast up in abundance, on some beaches, from deeper water.

The Radiates are not numerous on sandy shores, yet several interesting species may be found. Among the Echinoderms we find four species of holothurians, one sea-urchin, one star-fish, and one ophiuran.

The most common holothurian is the *Leptosynapta Girardii*, (Plate XXXV, figs. 265, 266.) This is a long, slender, very delicate and fragile species, which burrows deeply in the sand or gravel near low-water mark. The holes are round and go down almost perpendicularly; they are usually not more than a quarter of an inch in diameter. The creature is not quick in its motions, and can usually be found in the upper part of its burrow when the tide is out. The skin is thin and quite translucent, so that the white muscular bands that run lengthwise of the body, on the inside, can be easily seen, as well as the large intestine, which is always quite full of sand and gives a dark appearance to the body. The tentacles are almost always in motion, and are used in

burrowing as well as for other purposes. The skin is filled with minute perforated oval plates, to each of which there is attached, by the shank, a beautiful little anchor, (fig. 266,) quite invisible to the naked eye. The flukes of these anchors project from the skin and give it a rough feeling when touched; they afford the means of adhesion to various foreign substances, having a rough surface, and are doubtless useful to them when going up and down in the burrows. When kept in confinement this species will generally soon commence to constrict its body, at various points, by powerful muscular contractions, which often go so far as to break the body in two, and after a few hours there will usually be nothing left but a mass of fragments.

Another related species, *L. roseola* V., also occurs in similar places and has nearly the same habits, but this species is of a light rosy color, caused by numerous minute round or oval specks of light red pigment scattered through the skin. The anchors are similar but much more slender, with the shank much longer in proportion. The perforated plates are also much smaller in proportion to the length of the anchors.

The *Caudina arenata* is much more rare in this region. It lives at extreme low-water mark, or just below, buried in the sand. Its skin is thicker and firmer than that of the preceding species, and its body is shorter and stouter, while the posterior part narrows to a long slender caudal portion. Its skin is filled with immense numbers of small, round, wheel-like plates, with an uneven or undulated border, perforated near the rim with ten to twelve roundish openings, and usually having four quadrant-shaped openings in the middle; or they may be regarded as having a large round opening in the middle, divided by cross-bars into four parts. This species appears to be rare in this region, and was met with only by Professor H. E. Webster, at Wood's Hole, but it is quite abundant in some parts of Massachusetts Bay, as at Chelsea Beach and some of the islands in Boston Harbor. These and all other holothurians are devoured by fishes.

The *Thyone Briareus* is a large purple species, often four or five inches long and one inch or more in diameter. It is thickly covered over its whole surface with prominent papillæ, by which it may easily be distinguished from any other found in this region. It is more common in the shallow waters off shore, on shelly bottoms.

The "sand-dollar," *Echinarachnius parma*, (Plate XXXV, fig. 267,) is the only sea-urchin that is commonly met with on sandy shores in this region, and this is not often found living on the shore, except at extreme low water of spring-tides, when it may sometimes be found on flats or bars of fine siliceous sand in great numbers, buried just beneath the surface, or even partially exposed. It creeps along beneath the sand with a slow gliding motion, by means of the myriads of minute extensile suckers with which it is furnished. It is far more abundant on sandy bottoms at various depths off shore. It has a very wide range, for it is found all the way from New Jersey to Labrador, and also on

the North Pacific coast; and in depth it ranges from low-water mark to 430 fathoms, off Saint George's Bank, where it was dredged by Messrs. Smith and Harger. When living its color is usually a rich purplish brown, but it soon turns green when taken from the water. It gives a dark green or blackish color to alcohol, which stains very injuriously any other specimens put in with it. The fishermen on the coast of Maine and New Brunswick sometimes prepare an indelible marking-ink from these "sand-dollars," by rubbing off the spines and skin and, after pulverizing, making the mass into a thin paste with water. A number of fishes have been found to swallow this unpromising creature for food, and the flounders consume large numbers of them.

The common green star-fish, *Asterias arenicola*, (p. 326, Plate XXXV, fig. 269,) is sometimes met with on sandy shores, but is much less abundant than on rocky shores. The curious "brittle star-fish," *Ophiura olivacea*, is sometimes found among the eel-grass on sandy shores, especially in tide-pools, in sheltered localities. It may be recognized by its nearly circular, disk-like body, about three-quarters of an inch in diameter, with five round, rather slender, tapering, stiff-looking arms, about three inches long. The color is bright green, much like that of the eel-grass among which it lives. When at home in the water it moves about over the sand quite rapidly by means of its arms. When taken from the water it does not usually break itself up into numerous fragments, as readily as most of its related species do. It is rather southern in its distribution, and Vineyard Sound is perhaps its northern limit. It extends southward at least to North Carolina.

Of acalephs there are no species known to me that properly belong to the sandy shores, but *Hydractinia polyclina* (p. 328) is often found on the shells carried about by the hermit-crabs, in such situations, and there are species of *Obelia* and other hydroids that sometimes grow on the eel-grass in the tide-pools, but they are much more frequent in other situations.

Among the Polyps we find several species proper to sandy shores and specially adapted to this mode of life. One of the most interesting of these is the *Halocampa producta*, (p. 330, Plate XXXVIII, fig. 285,) which has already been described. This often occurs in the sand at low-water mark, and makes round holes about a foot deep, which can sometimes be recognized by small cracks radiating from the hole when the tide leaves them uncovered.

The *Sagartia modesta* (p. 330) is also found buried in the sand at low-water, especially where there is also some gravel with the sand. The *Sagartia leucolena* (p. 329, Plate XXXVIII, fig. 284) is sometimes found in similar situations, but belongs properly to the rocky shores.

The *Paractis rapiformis* is a species that is still little known. It lives buried deeply in the sand at and below low-water mark. It appears to be common on the coast of North Carolina, at Fort Macon, where it is often thrown up by storms, and it has also been found at Great Egg Har-

bor and near New Haven light. The body is three or four inches long when extended, and an inch or more in diameter, and is very changeable in form. The surface is nearly smooth, slightly sulcated lengthwise, and the color is usually pink, or pale flesh-color, translucent. The tentacles are numerous, short, tapering, pale greenish olive, with a dark band around the base, connected with a dark line radiating from the mouth. Toward the upper part of the body the surface is somewhat wrinkled and is capable of attaching grains of sand to itself. When thrown up by the waves it contracts into a globular or pyriform shape and "somewhat resembles a boiled onion or turnip."

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II. 3.—FAUNA OF THE MUDDY SHORES OF THE BAYS AND SOUNDS.

The muddy shores in this region grade almost insensibly into the sandy shores; and shores that are entirely of mud, without any admixture of fine sand, rarely occur except in the estuaries and lagoons. Therefore we find, as might have been anticipated, that it is difficult to draw a very definite line between the animals living upon the sandy shores and those living upon the muddy shores and flats. Many of the species seem, also, to be equally at home, whether living in mud or sand, and many others prefer a mixture, although capable of living in either. But if we were to compare the animals living in pure sand with those living in clear mud, the two lists would be quite different, although a considerable number would be common to both lists. Moreover, the eel-grass grows in considerable quantities both upon sandy and muddy shores, in certain localities, and a large number of species which inhabit the eel-grass will, therefore, be found in both lists.

In discussing the species found on sandy shores, in the preceding pages, references have constantly been made to other stations inhabited by many of the species, and especially in the case of those that are common to the sandy and muddy shores. Therefore it will not be necessary to repeat the facts in this connection, but the species will be enumerated in the list at the end of this section.

A considerable number of species have their place in this list chiefly because they occur on beds of oysters planted on muddy shores, at and just below low-water mark. Without these artificial stations some of them would hardly be found on such shores, or at least but rarely. It is evident that the shells of oysters, when in large quantities, supply, to

a certain extent, conditions similar to those of rocky shores, and consequently it is natural that certain rocky-shore species should be found in such situations. Only the more common and most important of these have been introduced into the list, however, for to include all the species to be found among oysters would uselessly extend the catalogue.

Among the Crustacea we find a considerable number of species which have their proper homes on the muddy shores. Of the true crabs there are at least eleven species that constantly occur in these situations, but several of them, viz., *Cancer irroratus*, (p. 312,) *Panopeus depressus*, (p. 312,) *P. Sayi*, (p. 312,) and *Carcinus granulatus*, (p. 312,) are found in greater numbers elsewhere, and depend largely upon the oyster-beds for their safety on these shores. The *Carcinus granulatus*, however, often resorts to the holes and cavernous places under the peaty banks of the shores, or along the small ditches and streams cutting through the peaty marshes near the shore. The marsh "fiddler-crab," *Gelasimus pugnax*, is usually very abundant in the peaty banks and along the ditches and streams at and just above high-water mark, where it excavates great numbers of deep holes, often completely riddling the soil. This species is, however, more at home along the borders of the estuaries and lagoons and will be described more fully in that connection, as well as the *Sesarma reticulata*, which often occurs with it in both situations.

The "oyster-crab," *Pinnotheres ostreum*, (Plate I, fig. 2, male,) is found wherever oysters occur. The female lives, at least when mature, within the shell of the oyster, in the gill cavity, and is well known to most consumers of oysters. The males (fig. 2) are seldom seen, and rarely, if ever, occur in the oyster. We found them, on several occasions, swimming actively at the surface of the water in the middle of Vineyard Sound. They are quite unlike the females in appearance, being smaller, with a firmer shell, and they differ widely in color, for the carapax is dark brown above, with a central dorsal stripe and two conspicuous spots of whitish, as indicated in the figure; the lower side and legs are whitish. The female has the carapax thin and translucent, whitish, tinged with pink. The *Pinnixa cylindrica* (Plate I, fig. 1) is a related species which is occasionally met with on muddy shores. It lives in the tubes of certain large *Annelids* in company with the rightful owner. The specimens hitherto met with in this region were either found free, or dug out of the mud, and it is uncertain with what worm they associate, though it is most likely to be the *Nereis virens*, but on the coast of South Carolina it lives, according to Dr. Stimpson, in the tubes of *Arenicola cristata* STIMPSON. It has been found in the stomach of the ocellated flounder.

The common edible-crab or "blue-crab," *Callinectes hastatus*, is a common inhabitant of muddy shores, especially in sheltered coves and bays. It is a very active species and can swim rapidly; it is therefore often seen swimming at or near the surface. The full-grown individuals generally keep away from the shores, in shallow water, frequenting muddy bottoms, especially among the eel-grass, and are also found in large

numbers in the somewhat brackish waters of estuaries and the mouths of rivers. The young specimens of all sizes, up to two or three inches in breadth, are, however, very frequent along the muddy shores, hiding in the grass and weeds or under the peaty banks at high-water, and retreating as the tide goes down; when disturbed they swim away quickly into deeper water. They also have the habit of pushing themselves backward into and beneath the mud for concealment. They are predacious in their habits, feeding upon small fishes and various other animal food. They are very pugnacious and have remarkable strength in their claws, which they use with great dexterity. When they have recently shed their shells they are caught in great numbers for the markets, and these "soft-shelled crabs" are much esteemed by many. Those with hard shells are also sold in our markets, but are not valued so highly. This crab can easily be distingushed from all the other species found in this region by the sharp spine on each side of the carapax.

The common "spider-crab," *Libinia canaliculata*, (p. 339,) is very common on muddy shores and flats. It hides beneath the surface of the mud and decaying weeds or among the eel-grass, and is very sluggish in its motions. Its whole surface is covered with hairs which entangle particles of mud and dirt of various kinds; and sometimes hydroids, algæ, and even barnacles grow upon its shell, contributing to its more ready concealment. The males are much larger than the females, and have long and stout claws. They often spread a foot or more across the extended legs. The females have much smaller and shorter legs and comparatively weak claws.

Another similar species, *Libinia dubia*, is also found on muddy shores and has nearly the same habits. It has a much longer rostrum, more deeply divided at the end.

The two common species of "hermit-crabs" are both found on muddy shores, especially among eel-grass, but the larger one, *Eupagurus pollicaris*, (p. 313,) is comparatively rare. The small one, *E. longicarpus*, (p. 313,) is very common and usually occupies the dead shells of *Ilyanassa obsoleta*, though many may be found in other species of shells.

The *Gebia affinis* (Plate II, fig. 7) is a crustacean somewhat resembling a young lobster three or four inches in length. It lives on muddy shores and digs deep burrows near low-water mark, in the tenacious mud or clay, especially where there are decaying sea-weeds buried beneath the surface. The burrows are roundish, half an inch to an inch in diameter, very smooth within, and go down obliquely for the distance of one or two feet, and then run off laterally or downward, in almost any direction, to the depth of two or three feet, and are usually quite crooked and winding. We have found them most abundant on the shore of Great Egg Harbor, New Jersey, near Beesley's Point, but they also occur at New Haven and Wood's Hole, &c. This species is quite active; it swims rapidly and jumps back energetically. It is eagerly devoured

by such fishes as are able to capture it. When living the colors are quite elegant. Along the back there is a broad band of mottled, reddish brown, which is contracted on the next to the last segment; each side of this band the mottlings are fewer, and the surface somewhat hairy. The last segment and the appendages of the preceding one are thickly specked with reddish brown; their edges are fringed with gray hairs. The *Calianassa Stimpsoni* SMITH, (Plate II, fig. 8, large claw,) is also a burrowing species, but its habits are at present little known, owing to its rarity. It has been found in the stomach of fishes, and is probably more common farther south.

The *Squilla empusa* is a very interesting creature, whose habits are still imperfectly known. It is often thrown on the beaches by the waves, and probably it usually burrows in the mud below low-water mark, but in certain localities it has been found burrowing at or near low-water mark of spring-tides, forming large, irregular holes. The very curious, free-swimming young (Plate VIII, fig. 36) were often taken in the towing-nets. Large specimens are eight or ten inches long and about two broad. The body is not so stout built as that of the lobster, and the carapax or shell is much smaller and softer, while the abdomen is much larger and longer in proportion. The legs and all the other organs are quite unlike those of the lobster, and the last joint of the great claw, instead of forming a pair of pincers with the next, is armed with a row of six sharp, curved spines, which shut into corresponding sockets, arranged in a groove in the next joint, which also bears smaller spines. By means of this singular organ they can hold their prey securely, and can give a severe wound to the human hand, if handled incautiously. It also uses the stout caudal appendages, which are armed with spines, very effectively. The colors of this species are quite vivid, considering its mud-dwelling habits. The body is usually pale green or yellowish green, each segment bordered posteriorly with darker green and edged with bright yellow; the tail is tinged with rose and mottled with yellow and blackish; the outer caudal lamellæ have the base and spines white, the last joint yellow, margined with black; the inner ones are black, pale at base; the eyes are bright emerald-green; the inner antennæ are dark, with a yellow band at the base of each joint; and the flagellum is annulated with black and white.

The common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10,) is frequent on muddy shores, where it has a darker color than when living on sandy shores. The common prawn, *Palæmonetes vulgaris*, (p. 339, Plate II, fig. 9,) is also common in such situations, especially where there is eel-grass, among which it finds its favorite resorts, but it is still more abundant in the estuaries. Another shrimp, the *Virbius zostericola* SMITH, also occurs among the eel-grass, in similar places. It is usually greenish in color.

Two other species of shrimp-like crustacea, belonging to the genus *Mysis*, are also found on muddy shores, especially among eel-grass.

The *Mysis stenolepis* SMITH, (Plate III, fig. 12, female,) is often very abundant in such situations. The small young ones have been taken in May, and the half-grown ones later in the season. In the early spring the adult females, with eggs, occur in great numbers among the eel-grass, in estuaries and ponds. Mr. Vinal N. Edwards caught a large number in a small pond at Wood's Hole, April 1. No males were found at this time with the females; the only adult males observed were taken in autumn. Possibly the males do not survive the winter. The adult females have not been observed in summer, and they probably die after hatching their young in the spring. The whole body is translucent; each segment of the body has a stellate black spot; and there is more or less blackish pigment on the caudal lamellæ, telson, antennal scales, and inner flagellum and peduncle of the antennulæ. This species contributes largely to the food of many fishes. The other species, *M. Americana* SMITH, also lives among eel-grass, as well as in deeper water off shore among algæ. This has been found in large numbers in the stomachs of the shad and the spotted flounder.

Of Amphipods there are comparatively few species. The *Unciola irrorata* (p. 340, Plate IV, fig. 19) is pretty common here, as elsewhere. The *Amphithoë valida* SMITH (p. 315,) is often met with among eel-grass. Another species, *A. compta* SMITH, also occurs in the same places. It differs from the preceding in many characters, but may easily be distinguished by its red eyes. A third species of the genus, *A. longimana* SMITH, is also found among eel-grass. It has black eyes. The *Corophium cylindricum* and *Gammarus mucronatus* occur among eel-grass and algæ, often in great numbers.

Of Isopods there are several species. The *Idotea irrorata* (p. 316, Plate V, fig. 23) is common wherever eel-grass is found. The *Erichsonia attenuata* HARGER, (Plate VI, fig. 27,) is also found clinging to eel-grass in muddy situations. The *Epelys trilobus* (Plate VI, fig. 28) is found creeping about over the bottom or among and beneath the decaying vegetable matter and mud usually to be found in sheltered situations. It is usually so covered up with adhering dirt as readily to escape observation. The *Epelys montosus* also occurs in similar situations.

Whenever lumber or drift-wood has been left for some time on the muddy shores it is found to be more or less eaten by the *Limnoria lignorum*, (Plate VI, fig. 25.) This small isopod gnaws its galleries in the wood to a depth of about half an inch from the surface, and after a time these galleries become so numerous that the superficial layer will be completely honey-combed, and it will then scale off and another layer will be attacked. This little creature often does great damage to the piles of wharves and other kinds of submerged wood-work in this region, and will be mentioned again in discussing the animals inhabiting piles, &c.

The "horse-shoe crab," *Limulus Polyphemus*, (p. 340,) is also common

on muddy shores, burrowing beneath the surface, at or just below low-water mark.

Many of the Annelids found on muddy shores occur also on sandy shores, especially where there is a mixture of mud with the sand, and consequently they have been mentioned in the preceding pages. Among these are *Nereis virens* (p. 317, Plate XI, figs. 47–50) and *N. limbata*, (p. 318, Plate XI, fig. 51,) both of which are common on muddy shores; also *Diopatra cuprea*, (p. 320, Plate XIII, figs. 67 and 68;) *Lumbriconereis opalina*, (p. 342, Plate XIII, figs. 69, 70;) *L. tenuis*, (p. 342;) *Maldane elongata*, (p. 343;) *Notomastus luridus*, (p. 342;) *Notomastus filiformis*, (p. 342;) *Cirratulus grandis*, (p. 319, Plate XV, figs. 80, 81;) *Cistenides Gouldii*, (p. 323, Plate XVII, figs. 87, 87*a*;) all of which are found both in mud and sand, but prefer, perhaps, a mixture of the two. *Rhynchobolus Americanus* (p. 342, Plate X, figs. 45, 46) and *R. dibranchiatus* (p. 341, Plate X, figs. 43, 44) are also found in mud, though perhaps more common in fine sand, or sandy mud.

The "blood-drop," *Polycirrus eximius*, (p. 320, Plate XVI, fig. 85) is however, a species that belongs properly to muddy localities, and it delights in the softest and stickiest mud of the shores, near low-water mark. The larger blood-drop, *Chætobranchus sanguineus*, (p. 320,) is also found in similar situations, and the soft mud, filled with decaying vegetable matter, seems to be its most congenial home.

Of Mollusks there are comparatively few species that are peculiar to muddy shores, but there are many that live almost equally well in such localities and on shores or bottoms of other kinds.

Among the Gastropods, the proper mud-dwelling species are few. The *Ilyanassa obsoleta* (p. 354, Plate XXI, fig. 113) is the most abundant, for it occurs everywhere over the mud-flats in great numbers, and, in cold weather, often crowds in large numbers into the pools left on the flats. The *Nassa vibex* (Plate XXI, fig. 114) has nearly the same habits, but is comparatively rare. It is more frequently found among the eel-grass, and is more common farther south.

The *Eupleura caudata* (Plate XXI, fig. 117) is usually found rather sparingly in this region, but in one locality, at Waquoit, it occurred in considerable numbers in the small streams and ditches in the muddy marshes near the shore. It occurs occasionally at low-water, but is more often met with on muddy and shelly bottoms in the shallow water of the bays and sounds, and is much more common farther south. The *Crepidula convexa* (p. 355, Plate XXIII, fig. 128) is very common on the shells of *Ilyanassa obsoleta*, especially when they are inhabited by "hermit-crabs." It is also frequently found on the eel-grass, where, in August, it often deposits its bright yellow eggs inclosed in small, gelatinous masses, which are grouped in clusters.

The *Bulla solitaria* (Plate XXV, fig. 161) is a species restricted to muddy shores and bottoms, in sheltered situations, and is found also in muddy ponds and estuaries. The color of the animal of this species is

quite peculiar, and when it is fully extended it has a singular appearance. The general color is usually orange-brown, and it is thickly speckled with darker brown. This shell is devoured in large numbers by the flounders, and doubtless by other fishes.

A number of species which habitually live clinging to eel-grass are to be found in the localities where this plant flourishes, either in the pools or at low-water mark, but they are not peculiar to or characteristic of muddy shores. Among these the most common are *Astyris lunata*, (p. 306;) *Bittium nigrum*, (p. 305;) *Triforis nigrocinctus*, (p. 305;) and *Lacuna vincta*, (p. 305.) The *Littorina irrorata* is occasionally found in sheltered situations, but this region is north of its true range, and such specimens as are found may have been introduced from farther south with oysters. It is very abundant on the southern coast. The *Urosalpinx cinerea* (p. 306) occurs wherever there are beds of oysters, upon which it feeds.

Most of the bivalve shells to be found on muddy shores have already been enumerated as living also on the sheltered sandy shores, and the majority of them flourish equally on both kinds of shores, and on those of a mixed or intermediate character. Among these are *Mya arenaria*, (p. 309;) *Macoma fusca*, (p. 358;) *Angulus tener*, (p. 358;) *Venus mercenaria*, (p. 359;) *Argina pexata*, (p. 309;) *Mytilus edulis*, (p. 307;) *Pecten irradians*, (p. 361.) There are, however, other species that are almost peculiar to muddy shores, and are highly characteristic of them. The *Pholas truncata* (Plate XXVII, fig. 200) excavates deep holes in deposits of tenacious clay at all elevations between tides, and is still more frequently found living in holes in the borders of peat-bogs, or marsh deposits, which have been encroached upon by the sea. In such places they sometimes occur nearly up to the ordinary high-water mark. Their holes are round and nearly perpendicular, and increase in size from the orifice downward. They vary in depth according to the size of the shell; the deeper ones are often a foot or a foot and a half in depth and often an inch in diameter. The shell remains near the bottom and stretches out its long siphon tubes, which are united together quite to the end, until the tips reach the external orifice of the burrow These tubes are generally yellowish white except at the end, where they are blackish or brownish; the orifices and papillæ are also variously marked with purplish brown or dark brown. The dark coloration of the end of the siphon tubes is doubtless for purposes of protection from predacious fishes, crabs, &c. Its foot is short and stout, obliquely truncated, and bevelled at the end. The *Petricola pholadiformis* (Plate XXVII, fig. 199) is generally associated with the preceding species and is more abundant. Its habits are nearly the same, but it does not make its burrows so deep; it is more active in its motions, and can easily climb up to the upper part of its hole by means of its long, thin, white foot, which is tongue-shaped and very extensible and flexible. The siphon-tubes are long and slender, tapering, and united for about a

quarter of their length, beyond which they are separate and divergent. They are yellowish white, more or less spotted, especially toward the end, with orange, brownish, or blackish, which, in large specimens, forms streaks near the ends or even becomes confluent, making the tips very dark colored. The branchial orifice is surrounded by a circle of numerous bipinnate papillæ, which usually alternate with smaller and more simple ones ; the papillæ of the dorsal tube are similar, but more simple.

The *Tagelus gibbus* (Plate XXVI, fig. 181, animal; Plate XXX, fig. 217, shell) is another inhabitant of muddy shores, which burrows deeply into the mud. This species is confined, on the shores, chiefly to the zone near low-water mark, but probably lives also in shallow water beyond the reach of the tides. In this species the foot is large and muscular, thick, tongue-shaped, and has a very wide range of motion, for the mantle is open along the whole length of the ventral edge of the shell. The tubes are separate, from the base, and are round, white, and capable of very great extension, for a specimen of ordinary size, kept in confinement, extended the tubes to the length of nine inches. These tubes are translucent, and at the end have small rounded lobes around the aperture, each lobe being furnished at its base, inside, with a small, orange, eye-like spot, which is probably an imperfect visual organ, and with two others on the inside lower down. The branchial tube has six of these lobes and ocelli ; the dorsal one has eight. On each tube there is a row of small, white, slender, obtuse papillæ, corresponding to each terminal lobe, and running along the whole length of the tubes. The color of the animal is white throughout. This bivalve makes deep burrows in the tenacious mud, each of which has two orifices, not far apart, for the two tubes. By this peculiarity their burrows may be at once recognized, whenever seen.

The *Mulinia lateralis* (Plate XXVI, fig. 185, B, animal) is occasionally found living at extreme low-water mark, on muddy flats, but its true home is on the soft muddy bottoms in shallow water, where t is often excessively abundant. In this species the foot is relatively large and muscular, more or less pointed at the end, and capable of assuming many different forms and positions ; it has a wide sweep in its motions and can be thrust forward or backward. The siphon-tubes are united nearly to the end, but the separation is indicated by a groove between them for nearly half the length. The branchial tube is the largest, and its orifice is surrounded by a circle of twelve to twenty-four, slender, elongated, simple papillæ, each of which usually has a small, black, eye-like spot at its base ; a little below this terminal circle there is another, composed of smaller, very short, blunt papillæ. The dorsal tube also has a subterminal circle of similar papillæ, above which the tip forms a retractile cone, with the small, simple orifice at the tip. The animal is yellowish white, the tubes generally pale yellow. This species burrows just beneath the surface of the mud, and it is eaten in large numbers by the scup and other fishes.

The *Cumingia tellinoides* (Plate XXX, fig. 221) and *Kellia planulata* (Plate XXX, fig. 226) are sometimes found living in the mud at low-water, but are rare in such situations. They are more common at the depth of a few fathoms on muddy and shelly bottoms.

The ribbed muscle, *Modiola plicatula*, (p. 307, Plate XXXI, fig. 238, is very abundant near and even above high-water mark, along the muddy borders of the marshes and banks and among the roots of grass. The *Modiola hamatus* is occasionally met with, especially on oyster-beds, adhering to the shells, where it is sometimes very abundant. It has probably been introduced with the oysters, from the South, where it is common. It somewhat resembles the preceding species, but it is shorter, broader, with strong radiating ribs, many of which are forked. Its color is yellow or yellowish brown.

The common "scollop," *Pecten irradians*, (p. 361, Plate XXXII, fig. 243,) occurs among the eel-grass on muddy shores in great abundance, in many localities, especially in sheltered places. The young shells may be found during the whole summer, but the adult specimens come up to the shallow waters and shores in great numbers in the autumn. This species is very active and can rise from the bottom and swim through the water with great rapidity by opening and energetically closing its valves, thus expelling the water from the gill-cavity, the reaction sending the shell backward. It often remains up among the leaves of the eel-grass, resting upon them, where they are matted together, but if alarmed the creature suddenly swims away in the manner described, and takes to the bottom. It is very watchful and quickly perceives its enemies. The thickened outer edge of the mantle, both above and below, is fringed with rows of numerous tapering papillæ or tentacles, the inner ones largest, and among the bases of these there is a row of very bright silvery or bluish eyes, thirty to forty or more to each valve the number increasing with the size of the shell; a short distance within the outer fringe of tentacles there is a raised yellow or orange ridge, which bears another series of smaller papillæ, and the space between these and the outer ones is radiately striated. The central muscle which closes the valves of this shell is large and powerful. This is the portion which is sold in our markets in large quantities, and is highly esteemed by many as an article of food. Its decided sweetish taste is, however, objectionable to some persons. To some, also, it proves actually injurious, sometimes producing nausea and even worse symptoms. After storms this shell is sometimes found thrown upon the beaches in immense quantities.

The oyster, *Ostræa Virginiana*, (p. 310,) is often planted upon the muddy shores at and below low-water mark, in many parts of Long Island Sound and elsewhere, but for this purpose the muddy estuaries are preferred, where the water is more brackish and the bottom less disturbed by the storms. The mud, however, should not be too deep, and ought to have a solid substratum, a few inches beneath.