there are many animals that find congenial resorts on such flats. Then there will sometimes be pools or rivulets of sea-water on the sandy flats, in which certain creatures often spend the short time while thus imprisoned by the tide.

The special localities where the sand-dwelling species of this region were chiefly studied, are the beaches on Naushon and adjacent islands; Nobska Beach and several other beaches near Wood's Hole; the extensive sand-beach between Falmouth and Waquoit; the beach at Menemsha Bight, on Martha's Vineyard; several beaches on the shores of Buzzard's Bay; the beaches at South End, Savin Rock, and other localities near New Haven; the beaches on Great South Bay, Long Island; the beaches at the mouth of Great Egg Harbor, New Jersey, &c., besides the outer beaches at various other points.

Along the upper part of the sand-beaches there is generally an almost continuous belt of dead sea-weeds, broken shells, fragments of crabs, lobsters, and various other débris cast up by the waves. Although many of the dead shells, &c., which occur in this way, belong really to the sandy shores near low-water, others have come, perhaps, from deeper water and other kinds of bottom. Therefore, although such rubbish-heaps may afford good collecting grounds for those who frequent the shores after storms, it would be useless to enumerate the species that more or less frequently occur in them. Beneath such masses of decaying materials many insects and crustacea occur, together with certain genuine worms. Part of these are truly marine forms, and are never found away from the sea-shores, but many, especially of the insects, are in no sense marine, being found anywhere in the interior where decaying matters abound. The two-winged flies (*Diptera*,) of many kinds, are especially abundant, and their larvæ occur in immense numbers in the decaying sea-weed. Some of these flies are, however, true marine species, and live in the larval state in situations where they are submerged for a considerable time by the tide. I have often dug such larvæ from the sand near low-water mark, and have also dredged them at the depth of four or five fathoms off shore. During unusually high tides immense quantities of the fly-larvæ will be carried away by the encroachment of the waters, and thus become food for fishes of many kinds, and especially for the young ones, which frequent the shallow waters along the shores. There are also many species of beetles (*Coleoptera*) which frequent these places, and several of them are genuine marine insects, living both in the larval and adult conditions in burrows between tides. Among these are two or three species of *Bledius*, belonging to the *Staphylinidæ*; several tiger-beetles (*Cicindela*,) and representatives of other families. The "tiger-beetles" are very active, carnivorous insects and frequent the dry sands just above high-water mark; when disturbed they rise quickly and fly away to the distance of several yards before alighting. They are so wary that it is difficult to catch them without a net. Most of the species reflect bright, metallic, bronzy or

green colors, and many of them have the elytra more or less marked with white. Mr. S. I. Smith found the larva of our largest species (*C. generosa*) at Fire Island, living in holes in the sand below high-water mark, associated with the species of *Talorchestia*.

Beneath the decaying sea-weeds on the sandy shores immense numbers of the lively little crustacean, *Orchestia agilis*, (p. 314, Plate IV, fig. 14,) may always be found. Two other related species, of larger size and paler colors, but having the same habit of leaping, though not in such a high degree, occur among the weeds, or burrowing in the sand, or beneath drift-wood, &c., a little below high-water mark. In fact the sand is sometimes completely filled with their holes, of various sizes. Both these species are stout in form, and become about an inch long when mature. One of them, *Talorchestia longicornis*, can be easily distinguished by its very long antennæ ; the other, *T. megalophthalma*, by its shorter antennæ and very large eyes. Both these species are pale grayish, and imitate the color of the sand very perfectly. When driven from their burrows by unusually high tides or storms they are capable of swimming actively in the water. They make dainty morsels for fishes and many shore birds, as well as for certain crabs, especially *Ocypoda arenaria*.

On sandy beaches near high-water mark, especially where the sand is rather compact and somewhat sheltered, one of the "fiddler-crabs," *Gelasimus pugilator*, is frequently found in great numbers, either running actively about over the sand, or peering cautiously from their holes, which are often thickly scattered over considerable areas. These holes are mostly from half an inch to an inch in diameter, and a foot or more in depth, the upper part nearly perpendicular, becoming horizontal below, with a chamber at the end. Mr. Smith, by lying perfectly still for some time on the sand, succeeded in witnessing their mode of digging. In doing this they drag up pellets of moist sand, which they carry under the three anterior ambulatory legs that are on the rear side, climbing out of their burrows by means of the legs of the side in front, aided by the posterior leg of the other side. After arriving at the mouth of their burrows and taking a cautious survey of the landscape, they run quickly to the distance often of four or five feet from the burrow before dropping their load, using the same legs as before and carrying the dirt in the same manner. They then take another careful survey of the surroundings, run nimbly back to the hole, and after again turning their pedunculated eyes in every direction, suddenly disappear, soon to reappear with another load. They work in this way both in the night and in the brightest sunshine, whenever the tide is out and the weather is suitable. In coming out or going into their burrows either side may go in advance, but the male more commonly comes out with the large claw forward. According to Mr. Smith's observations this species is a vegetarian, feeding upon the minute algæ which grow upon the moist sand. In feeding the males use only the small claw with which

they pick up the bits of algæ very daintily; the females use indifferently either of their small claws for this purpose. They always swallow more or less sand with their food. Mr. Smith also saw these crabs engaged in scraping up the surface of the sand where covered with their favorite algæ, which they formed into pellets and carried into their holes, in the same way that they bring sand out, doubtless storing it until needed for food, for he often found large quantities stored in the terminal chamber. Mr. T. M. Prudden has since ascertained that one of the other species of "fiddlers" on our shores (*G. minax*) is also a vegetarian and feeds upon similar algæ, which grow on the muddy salt-marshes.

The *Ocypoda arenaria* is a crab allied to the "fiddlers" and similar in some of its habits. It is a southern species, ranging as far as Brazil, and adult specimens have not yet been observed on the coast of New England, but Mr. Smith has observed the young in abundance at Fire Island, and we have the young from Block Island; it occurs at Great Egg Harbor, New Jersey, of larger size, and therefore it may be looked for on the beaches of Nantucket and Martha's Vineyard. This crab lives on the beaches at, and even far above, high-water mark. It digs large holes like the fiddlers, often in the loose dry sand, back from the shore, yet when disturbed it will sometimes take to the water in order to escape. though it soon returns to the shore. In digging its holes, according to Mr. Smith's observations, it works in the same way as the "fiddler-crabs," except that it is quicker in its motions, and often, instead of carrying the pellets of sand to a distance from the hole, it throws it away with a sudden and powerful jerk, scattering the sand in every direction, It is even more cautious in its movements, and is always on the alert, even the slightest movement on the part of one who is watching them is sure to send them all into their holes instantly. In color this species imitates the sand very perfectly, especially while young, when they are irregularly mottled and speckled with lighter and darker shades of gray. They also have the habit of crouching down closely upon or into the sand, when suddenly frightened, and aided by their colors will often thus escape observation. At other times they will trust to their speed and scamper over the sand with such swiftness that they are not easily captured. This crab is carnivorous in its habits and, according to Mr. Smith's observations, it lives largely upon the "beach-fleas" (*Talorchestia*) which inhabit the same localities. It will lie in wait and suddenly spring upon them, very much as a cat catches mice. It also feeds upon dead fishes and other animals that are thrown on the shore by the waves.

Another inhabitant of the upper part of the sand-beaches, just below high-water mark, is the *Scyphacella arenicola* SMITH, which has, as yet, been found only on the coast of New Jersey, but probably occurs farther north. It is a small, sand-colored Isopod crustacean, which has no near relatives, so far as known, except in New Zealand. It burrows in the sand, making a little conical mound around the mouth of the holes.

The only Annelid observed high up on the sand-beaches is the slender, white *Halodrillus littoralis*, referred to on page 324, which lives under the decaying sea-weeds in great numbers.

On the lower parts of the sand-beaches, toward low-water mark, and especially on the broad flats, which are barely uncovered by the lowest tides, a much larger number of species occurs.

Among the Crustacea of these sandy shores we frequently find the common *Cancer irroratus*, (p. 312,) which is very cosmopolitan in its habits. Occasionally we meet with a specimen of *Carcinus granulatus*, but this is not its favorite abode; but the "lady-crab" or "sand-crab," *Platyonichus ocellatus*, (Plate I, fig. 4,) is perfectly at home among the loose sands at low-water mark, even on the most exposed beaches. This species is also abundant on sandy-bottoms off shore, and as it is furnished with swimming organs on its posterior legs, it can swim rapidly in the water and was taken at the surface in Vineyard Sound in several instances, and some of the specimens thus taken were of full size. When living at low-water mark on the sand-beaches it generally buries itself up to its eyes and antennæ in the sand, watching for prey, or on the look-out for enemies. If disturbed it quickly glides backward and downward into the sand and disappears instantly. This power of quickly burrowing deeply into the sand it possesses in common with all the other marine animals, of every class, which inhabit the exposed beaches of loose sand, for upon this habit their very existence depends during storms. By burying themselves sufficiently deep they are beyond the reach of the breakers. The means of effecting this rapid burrowing are very diverse in the different classes. Thus one of the fishes (*Ophidium marginatum*), which lives in these places, has a long acute tail and by its peculiar undulatory motions can instantly bury itself tail-first in the sand. Others have acute heads and go in head-first.

The "lady-crab" is predacious in its habits, feeding upon various smaller creatures, but like most of the crabs it is also fond of dead fishes or any other dead animals. In some localities they are so abundant that a dead fish or shark will in a short time be completely covered with them, but if a person should approach they will all suddenly slip off backwards and quickly disappear in every direction beneath the sand; after a short time, if everything be quiet, immense numbers of eyes and antennæ will be gradually and cautiously protruded from beneath the sand, and after their owners have satisfied themselves that all is well, the army of crabs will soon appear above the sand again and continue their operations. The color of this crab is quite bright and does not imitate the sand, probably owing to its mode of concealment. The ground-color is white, but the back is covered with annular spots formed by specks of red and purple. It is devoured in great numbers by many of the larger fishes.

Another curious burrowing creature, living under the same circumstances as the last, is the *Hippa talpoida*, (Pate II, fig. 5.) But this

species burrows like a mole, head-first, instead of backward. It can also swim quite actively and is sometimes found swimming about in the pools left on the flats at low-water. It is occasionally dug out of the sand at low-water mark, and is often thrown up by the waves, on sand-beaches, but it seems to live in shallow water on sandy bottoms in great numbers, for in seining on one of the sand-beaches near Wood's Hole for small fishes, a large quantity of this species was taken. Its color is yellowish white, tinged with purple on the back. It is one of the favorite articles of food of many fishes. Mr. Smith found the young abundant at Fire Island, near high-water, burrowing in the sand. This species is still more abundant farther south.

The curious long-legged "spider-crab," *Libinia canaliculata*, is frequently met with at or just below low-water mark on sandy shores, but its proper home is on muddy bottoms.

Creeping, or rapidly running, over the bottom in shallow water, or in the tide-pools on the flats, the smaller "hermit-crab," *Eupagurus longicarpus*, (p. 313,) may almost always be observed ensconced in some dead univalve shell, most commonly that of *Ilyanassa obsoleta*. This species is still more abundant among eel-grass, and on muddy shores.

The common "sand-shrimp," *Crangon vulgaris*, (Plate III, fig. 10,) always occurs in great numbers on the sandy flats and in the tide-pools and rivulets, as well as on the sandy bottoms in deeper water off shore. This species is more or less specked irregularly with gray, and imitates the color of the sand very closely. When resting quietly on the bottom, or when it buries itself partially and sometimes almost entirely, except the eyes and long slender antennæ, it cannot easily be distinguished by its enemies, and, therefore, gains great protection by its colors. When left by the tide it buries itself to a considerable depth in moist sand. It needs all its powers of concealment, however, for it is eagerly hunted and captured by nearly all the larger fishes which frequent the same waters, and it constitutes the principal food of many of them, such as the weak-fish, king-fish, white perch, blue-fish, flounders, striped bass, &c. Fortunately it is a very prolific species and is abundant along the entire coast, from North Carolina to Labrador, wherever sandy shores occur. The young swim free for a considerable time after hatching, and were taken at the surface in the evening, in large numbers. The common prawn, *Palæmonetes vulgaris*, (Plate II, fig. 9,) often occurs, associated with the *Crangon*, but it is much more abundant among the eel-grass, and especially in the estuaries where it has its proper home. As this is one of the most abundant species and of great importance as an article of fish-food, it will be mentioned again, with more details, in connection with the fauna of the estuaries.

Several species of smaller crustacea also burrow in the sand at low-water mark. One of the most remarkable of these is an Amphipod, the *Lepidactylis dytiscus*, which by its external form reminds one of *Hippa*, with which it agrees in habits, for it burrows in the sand like a mole.

It is also occasionally found under stones in sandy places. Its color is pale yellowish white. The *Unciola irrorata* (Plate IV, fig. 19) often lives in tubes in the sand in abundance, but is by no means confined to such localities, for it occurs on all kinds of bottoms and at all depths down to at least 430 fathoms (off St. George's Bank,) and is abundant all along the coast, from New Jersey to Labrador. It is particularly abundant on shelly and rocky bottoms, and although it habitually lives in tubes, it does not always construct its own tube, but is ready and willing to take possession of any empty worm-tube into which it can get, and having once taken possession it seems to be perfectly at home, for it remains near the end of the tube protruding its stout claw-like antennæ, and looking out for its prey, in the most independent manner. It will also frequently leave its tube and swim actively about for a time, and then return to its former tube, or hunt up a new one. It seems, however, to be capable of constructing a tube for itself, when it cannot find suitable ones ready-made. Its color is somewhat variable, but it is generally irregularly specked with red and flake-white, and the antennæ are banded with red. It contributes very largely to the food of many fishes, such as scup, pollock, striped bass, &c.

On the moist sand-flats curious crooked trails made by the *Idotea cæca* (Plate V, fig. 22) may generally be seen. This little Isopod burrows like a mole just beneath the surface of the sand, raising it up into a little ridge as it goes along, and making a little mound at the end of the burrow, where the creature can usually be found. This species is whitish, irregularly specked with dark gray, so as to imitate the color of the sand very perfectly. It is also capable of swimming quite rapidly. The *Idotea Tuftsii* is another allied species, having the same habits and living in similar places, but it is much more rare in this region. It has also been dredged on sandy bottoms off shore. It is a smaller species and darker colored, with dark brown markings. The *Idotea irrorata* (p. 316, Plate V, fig. 23) also occurs on sandy shores wherever there is eel-grass, among which it loves to dwell.

The well known "horseshoe-crab" or "king-crab," *Limulus Polyphemus*, is also an inhabitant of sandy shores, just below low-water mark, but it is more abundant on muddy bottoms and in estuaries, where it burrows just beneath the surface and feeds upon various small animals. At the breeding season, however, it comes up on the sandy shores to deposit the eggs, near high-water mark. According to the statements of Rev. S. Lockwood, (in American Naturalist, vol. iv, p. 257,) the spawning is done at the time of high tides, during May, June, and July; they come up in pairs, the males, which are smallest, riding on the backs of the females and holding themselves in that position by the short feet, provided with nippers, which are peculiar to the males. The female excavates a depression in the sand and deposits the eggs in it, and the male casts the milt over them, when they again return to deeper water, leaving the eggs to be buried by the action of the waves.

In aquaria, under favorable circumstances, the eggs hatch in about six weeks, but in their natural conditions they probably hatch sooner than this; under unfavorable conditions the hatching may be delayed for a whole year. The eggs are very numerous. In addition to the interesting observations of Mr. Lockwood, Dr. A. S. Packard has since given more detailed accounts of the development of the embryos and young of *Limulus* in the proceedings of the American Association for the Advancement of Science, 1870, p. 247, and in the Memoirs of the Boston Society of Natural History, vol. ii, p. 155, 1872.

Annelids are quite numerous on the sandy shores where the conditions are favorable. It is evident that these soft-bodied creatures would be quickly destroyed by the force of the waves and the agitation of the sand, were they not provided with suitable means for protecting themselves. This is effected mainly in two ways: the sand-dwelling species either have the power of burrowing deeply into the sand with great rapidity, or else they construct long durable tubes, which descend deeply into the sand and afford a safe retreat. Many of the active burrowing species also construct tubes, but they usually have but little coherence and are not very permanent, nor do they appear to be much relied on by the owners. There is, however, great diversity both in the structure and composition of the tubes of different species, and in the modes by which the rapid burrowing is effected.

The large green *Nereis* (*N. virens*, p. 317) is found on the sandy shores in places that are somewhat sheltered, especially if there be an admixture of mud or gravel with the sand to give it firmness and solidity. This species burrows deeply beneath the surface and lines the interior of its large irregular burrows with an abundant mucus-like secretion, which gives smoothness and some coherency to the walls, but does not form a solid tube. With this, and in greater numbers, the smaller species, *Nereis limbata*, (p. 318,) is also found, and its habits appear to be essentially the same. Both this and the preceding can burrow rapidly, but much less so than some other worms, and consequently they are not well adapted to live on exposed beaches of moving sands, but prefer coves and harbors. The two large species of *Rhynchobolus* are much better adapted for rapid burrowing. Their heads are very small and acute, and destitute of all appendages, except four minute tentacles at the end; the body is long, smooth, and tapers gradually to both ends, and the muscular system is very powerful, and so arranged as to enable these worms to coil themselves up into the shape of an open spiral, like a corkscrew, and then to rapidly rotate themselves on the axis of the spiral. When the sharp head is inserted into the loose mud or sand and the body is thus rotated, it penetrates with great rapidity and disappears almost instantly. Both these species are found on sandy as well as on muddy shores and flats near low-water mark, and also in deeper water. The one usually most abundant is *R. dibranchiatus*, (Plate X, figs. 43, 44;) this is readily distinguished by hav-

ing a simple gill both on the upper and lower sides of the lateral appendages. The other, *R. Americanus*, (Plate X, figs. 45, 46,) has gills that are more or less branched on the upper side of the appendages, as shown in fig. 46, but none on the lower side; the appendages are also longer, especially posteriorly, and differently shaped. The proboscis is remarkably long and large, and when fully protruded it shows four large, black, sharp, fang-like jaws or hooks. Both these worms are destitute of true blood-vessels, such as most of the allied worms possess, but have the general cavity of the body filled, between the various organs, with bright red blood, which shows through the skin, giving a more or less red or purple color to the whole body and proboscis.

The two species of *Lumbriconereis* already referred to (p. 320,) occur in similar localities, and are usually associated with the two preceding species, but they are less rapid burrowers and require for their safety localities where the sand is compact and mixed more or less with mud, or where it is somewhat sheltered from the force of the waves. In sandy coves, and especially on the flats of sandy mud, close to low-water mark, the smaller species, *L. tenuis*, is generally very abundant, penetrating the sand, beneath the surface, in every direction. It is often a foot or more in length when extended, and not much larger than coarse thread or small twine, and bright red in color. When the sand in these localities is turned up with a spade, their drawn-out, red, thread-like bodies can usually be seen in large numbers, but they are so fragile that it is difficult to obtain an entire specimen. The head is obtusely conical, a little flattened, smooth, pale red, and iridescent, without eyes. The other species, *L. opalina* V., (Plate XIII, fig. 69,) is much larger, growing to the length of eighteen inches or more, and about .10 to .12 of an inch in diameter. Its color is dark bronze, or reddish brown, or pale red, the surface reflecting the most brilliant opal-like colors. It is easily distinguished from the *L. tenuis* by its four eyes in a row across the back part of the head. Both these species, when removed from their burrows, coil themselves in a long spiral. They burrow readily and deeply, but not so rapidly as many other worms, and do not seem to have permanent tubes. Another worm, found in similar places and readily mistaken for *L. tenuis* on account of its long, slender, almost thread-like body and red color, is the *Notomastus filiformis* V.; but in this species the head is very acute, the lateral appendages and setæ are very different, and the color is paler red, with bands or rings of bright red. This species has, moreover, a smooth, subglobular proboscis, without jaws, while the former has a powerful set of complicated jaws, without a distinct proboscis, and they are widely different in internal anatomy. The latter feeds upon the organic matter contained in the mud that it swallows, while the species of *Lumbriconereis* are carnivorous, feeding upon other worms, &c. A second and much larger species of *Notomastus* occurs in similar places, though apparently preferring a greater proportion of mud. This species, *N. luridus* V., grows

to be about ten inches long and .10 in diameter. Its color is a dark purplish or lurid brown, specked with white, and sometimes inclined to red. Its head is very acute, and it has a smooth, swollen, dark blood-red proboscis. It is a rapid burrower, penetrating deeply into the fine mud and sand. The *Maldane elongata* V. is another worm allied to the last, and usually associated with it, but this species constructs rather firm, round tubes out of the fine sand and mud, which are very long and descend deeply into the soil, and are often .20 to .25 of an inch in diameter. This worm is six or eight inches long, with a round body of nearly uniform diameter, which looks as if obliquely truncated at both ends, but the obliquely-placed upper surface of the head is bordered by a slight ridge or fold on each side and behind. The color is dark umber-brown, or reddish brown, the swollen part of each ring often lighter grayish or yellowish brown, but usually bright red, owing to the blood-vessels showing through. The intestine is large and filled with sand. Another worm, belonging to the same family with the last and, like it, constructing long, round tubes of agglutinated sand, is the *Clymenella torquata*, (Plate XIV, figs. 71, 72, 73,) but this species often lives where the sand is more free from mud, or even in nearly pure, siliceous sand, and sometimes considerably above low-water mark, though it is also found in deep water. It generally constructs its long and nearly straight tubes very neatly, of fine white sand, without mud. It loves, however, to dwell in sheltered spots, in coves, or in the lee of rocks and ledges, and is also partial to those spots on the sandy shores where eel-grass grows, building its tubes among the roots. It is a rather handsomely colored species, being usually pale red, with bright red bands around the swollen parts of the rings, but it is sometimes brownish red or dull brown. It can always be recognized by the peculiar collar on the fifth ring, and by the peculiar funnel-shaped caudal appendage, surrounded by small papillæ, and preceded by three segments or rings that are destitute of setæ.

The large and singular worm, *Anthostoma robustum* V., (Plate XIV fig. 76,) lives like the last, with which it often occurs, in nearly pure sand, where it is somewhat sheltered from the violence of the waves, but is also fond of places where there is more or less gravel mixed with the sand. It sometimes occurs some distance above low-water mark, and constructs a large, thick, somewhat firm tube by consolidating and cementing the sand around its burrow. These tubes descend nearly perpendicularly to a great depth, and can usually be distinguished by a slightly elevated mound of dirt around the opening, which is usually different in color from the surrounding sand; and sometimes there are recently-ejected cylindrical masses of such earth on the summit of the little hillocks. The worm itself, when full grown, is fifteen inches or more in length, and nearly half an inch in diameter. The head is very acute and the front part of the body is firm and muscular, with very small lateral appendages, and fascicles of setæ in four rows; but back

of the twenty-fourth body-segment an appendage develops below the lower fascicles of setæ, and farther back becomes broad, foliaceous, and divided into several lobes; back of the twenty-eighth segment the branchiæ appear in a row on each side of the back, and soon become long and ligulate; at the same time other ligulate appendages develop from the upper lateral appendages, which become dorsal, and these, with the gills, form four rows of processes along the back, outside of which are the elongated setæ and other appendages. The posterior part of the body is more slender and much more delicate than the anterior part, and so fragile that an entire specimen can rarely be obtained, and those that are obtained, when in confinement very soon detach fragment after fragment, until only the anterior part is left. In their natural habitations they would undoubtedly be able to reproduce their lost parts, like many other annelids. The color of this worm is ocher-yellow, tinged with orange, or dark orange; there are usually two rows of dark-brown spots along the back; the branchiæ are blood-red; and posteriorly there is a brownish red median dorsal line. The proboscis is very singular, for it is divided into several long, flat, digitate processes, separate nearly to the base, and somewhat enlarged at the end.

Another species of this genus, of smaller size, *A. fragile* V., often occurs in the sandy flats in great numbers, its small holes sometimes completely filling the sand over considerable areas and extending nearly up to half-tide mark. This species grows to the length of four inches or more, with a diameter of about .10. Its head is even more acute than in the last species, with a very slender, translucent apex. The body has the same form, but is more slender. The processes above and below the fascicles of setæ begin to appear at the fourteenth segment, and the setæ begin to be decidedly elongated at the fifteenth. The dorsal branchiæ begin on the sixteenth segment, and become long and ligulate at the twentieth. The color is yellowish orange to orange-brown; the dorsal surface, posteriorly, and the branchiæ are red. The body posteriorly is very slender and extremely fragile. The last or caudal segment is smooth, oblong, with two long filiform cirri at the end. The proboscis is large and broad, consisting of numerous, often convoluted, lobes or folds, united by a thinner membrane or broad web.

The *Aricia ornata* V. is another related species, living in similar places with the last and having similar habits. The head is acute in this species, but the dorsal branchiæ and lateral appendages commence much nearer the head, and the side appendages are developed into crest-like, transverse series of papillæ, which cover the lateral and ventral surfaces of the body anteriorly.

Two species of *Spio* also occur in similar situations inhabiting small round tubes or holes made in the sand near low-water, often occuring in great numbers in certain spots. They prefer localities that are not exposed to the full force of the storms. One of these, *S. setosa* V. (Plate XIV, fig. 77,) is remarkable for the length of the setæ in the dorsal

bundles; the two large tentacles (of which only one is drawn in the figure) are usually folded backward between the red dorsal branchiæ, which form a row along the back on each side. The other, *S. robusta* V., is a stouter species, which has much shorter setæ in the dorsal fascicles; the middle lobe of the head is emarginate in front and the lateral lobes are convex. Both species have four small eyes on the top of the head, those of the posterior pair nearest together. In similar places, and often associated with the two preceding species, another allied worm often occurs in great abundance, completely filling the sand, in its chosen abodes, with its round vertical holes, and throwing out cylinders of mud. It is so gregarious that in certain spots hundreds may be found within a square foot, but yet a few yards away, on the same kind of ground, none whatever may be found. This is *Scolecolepis viridis* V. This species, like the two preceeding, has a pair of large tentacles on the back part of the head, which are usually recurved over the back between the rows of ligulate branchiæ, and four eyes on the top of the head; the central lobe of the head is slightly bilobed in front, the lateral ones convex; the branchiæ are long, slender, ligulate, meeting over the back, and exist only on about one hundred segments, or on about the anterior third part of the body. The body is rather slender, depressed, and about three inches long when full grown. The color is usually dark green, or olive-green, but sometimes light green, or tinged with reddish anteriorly; the branchiæ are bright red; the large tentacles are light green, usually with a row of black dots, and often crossed by narrow flake-white lines or rings. This species has been found abundantly on Naushon Island, and other localities in that region; at New Haven; and at Somer's Point and Beesley's Point, New Jersey. With the last species at Great Egg Harbor, New Jersey, another more slender species of the same genus occurred, *Scolecolepis tenuis* V. This was three or four inches long and very slender; the body was pale green; the tentacles longer and more slender than in the last, whitish, with a red central line; the branchiæ red, often tinged with green, shorter than in the last. The head is relatively broad, with the central lobe rounded in front. The branchiæ are confined to the anterior part of the body. The setæ in the upper fascicles are much longer than in the last species, those of the three anterior segments longer than the others and forming fan-shaped fascicles, directed upward and somewhat forward.

Another singular Annelid, belonging to the same tribe and having nearly the same habits, is represented in Plate XIV, fig. 78, this has been found by Mr. A. Agassiz burrowing in sandy mud at about half-tide, both at Naushon Island and at Nahant, Massachusetts, and he has also described its development and metamorphoses, but I have not met with the adult myself in this region, although the young were frequently taken in the towing-nets in the evening. Mr. Agassiz regards it as perhaps identical with *Polydora ciliatum* of Europe. It occurred in large colonies, closely crowded together, building upright tubes in the

mud. The presence of a large group of peculiar stout setæ on each side of the fifth segment will distinguish this from all the preceding species. The young of this, like those of most of the annelids, swim free at the surface for some time, and are often taken in great numbers in the towing-nets.

The *Nerine agilis* V., is still another representative of the group to which the last five species belong, and like them it has two long and large tentacles on its head, but it is a far more active and hardy species than any of them, and much better adapted for rapid burrowing. It accordingly lives on exposed beaches even where the sand is loose, and can also maintain itself on the exposed sandy beaches of the outer ocean-shores, exposed to the full force of the surf, its extremely quick burrowing affording it the means of protecting itself against the action of the sea. It lives in small round holes near low-water mark; unlike the related species, already mentioned, it has a very sharp conical head. The two large tentacles are about half an inch long, and originate close together on the upper side of the back of the head, and are usually recurved over the back when the worm is swimming in the water, as it is capable of doing, but when it is wriggling about on the sand they are twisted about in all directions and variously coiled; and when in their holes the tentacles are protruded from the opening. The eyes are four, small, black, placed close together in front of the base of the tentacles. The upper lobe of the lateral appendages is large and foliaceous and connected with the branchiæ along the anterior part of the body, but partially free farther back. The body is two or three inches long and rather slender; the color is reddish or brownish anteriorly, greenish white on the sides, except on the anterior third; the branchiæ, which extend the whole length of the body, are light red; tentacles greenish white.

One of the largest and most beautiful Annelids of this region is the *Diopatra cuprea*, (Plate XIII, figs. 67 and 68.) This species grows to be more than a foot long, with the body depressed and often nearly half an inch broad. It constructs a very curious permanent tube in which it dwells very securely. The part of these tubes beneath the surface of the sand is composed of a tough parchment-like material, and often descends obliquely to the depth of two or three feet or more; the upper end of the tube projects two or three inches from the surface of the sand or mud, and is thickly covered with bits of eel-grass and sea-weeds, fragments of shells, and other similar things, all of which are firmly attached to the tube, but project externally in all directions, giving this part of the tube a very rough and ragged appearance externally, but it is very smooth within, and often it has an opening half an inch in diameter, or large enough so that the worm can turn around, end for end, inside of it. When undisturbed the occupant thrusts its head and the anterior part of the body out of the tube to the distance of several inches in search of food, or materials to add to its tube, ex-

posing the curious bright red gills, which are shaped something like miniature fir trees. The central stem is long and tapering, with a blood-vessel winding spirally up to its summit, and another winding in the opposite direction down to its base; the basal part is naked, but above this slender branches are given off, forming spirals all along the stem and gradually decreasing in length to the tip; each of the branches contains two slender blood-vessels. These branchiæ commence at the fifth segment and do not extend to the end of the body, the last ones being much smaller, with few branches. The first four setigerous segments have an acute, conical, papilliform ventral cirrus at the base of the lateral appendages; on the fifth and following segments these become low, broad, rounded, whitish tubercles, with longitudinal wrinkles or grooves, and with a dark spot in the middle; these appear to contain the glands which secrete the cement used in constructing the lining of the tube, for when attaching any additional object at the end, after adjusting it in the desired position the worm constantly rubs this part of the lower surface backward and forward over the edge of the tube and the object to be cemented to it, until a perfect adherence is effected, and a smooth coating of firm mucus is deposited, and this operation is repeated for every piece added to the tube. It is very interesting to watch these worms, when in confinement in an aquarium, while engaged in constructing their tubes. By placing bits of bright colored shells, tinsel, cloth, or even pieces of bright colored feathers, near the tubes, they can be induced to use them, and thus some very curious looking tubes will be produced; but they evidently prefer the more rough and homely materials to which they are accustomed, when they can be had. The iridescent, opaline colors of this species are usually very brilliant and beautiful, especially on the back, head, and bases of the antennæ. The general color of the body is reddish brown, or deep brown, thickly specked with gray; the antennæ are paler brown; the lateral appendages yellowish brown, finely specked with white and dark brown; the gills usually blood-red, but varying from light red to dark brown. There are two, small, black eyes between the bases of the odd median and upper lateral antennæ. This species is often quite abundant on the sand-flats near low-water mark, especially where there is more or less mud mixed with the sand, but it is still more abundant in the shallow or moderately deep waters off shore, on muddy and shelly bottoms. It is difficult, however, to obtain entire specimens with the dredge, for it usually merely cuts off the upper end of the tube, while the occupant retreats below; occasionally the head of the worm is cut off in this way. On the shore, also, it is not easy to obtain entire specimens unless the tubes be cautiously approached and the retreat of the worm prevented by a sudden and deep thrust of the spade below it, so as to cut off the tube. This species is carnivorous and has a very powerful set of black jaws, which are unequal on the two sides of the mouth, (fig. 68.)

The *Marphysa Leidyi* (p. 319, Plate XII, fig. 64) is allied to the pre-

ceding species, and has somewhat similar habits, but does not construct such perfect tubes. It is occasionally dug out of the sand at low-water, but is much more common in deeper water.

The *Staurocephalus pallidus* V. is also an inhabitant of these sandy shores, burrowing in the sand at low-water. It is a slender species, about two inches long and one-tenth broad. It is peculiar in having four long, slender antennæ or tentacles on the front of the head, arranged in a cross-like manner, to which the generic name alludes. There are also four, small, dark red eyes on the upper side of the head. The color is pale yellowish, the red blood-vessels showing through anteriorly. This worm is allied to the two preceding, and to *Lumbriconereis*, and like them it is predacious in its habits and has a very complicated set of jaws, consisting of numerous sharp, fang-like pieces of various shapes, arranged in several rows on both sides.

The *Sthenelais picta* V. is another curious Annelid, which is sometimes found burrowing in the sand at low-water mark, but it also occurs on shelly and muddy bottoms in deep water. It has a long, slender body, six inches or more in length, and the back is covered with two rows of thin, smooth scales, which are very numerous. The head is usually brownish, with a whitish spot on each side; there is generally a dark brown band along the back; the scales are translucent, and vary in their color-markings, but more commonly there is a border of dark brown or blackish along the inner edge, which is usually connected with a similar border along the anterior edge, or with an anterior angular spot, and often with a dark border along the posterior edge, leaving more or less of the central part of each scale white and translucent.

The *Nephthys picta* (Plate XII, fig. 57) is also sometimes found burrowing in sandy mud at low-water mark, but it is much more frequent in the deeper waters of the sounds. It can be distinguished at once from all the other species of *Nephthys* found in this region by its greater slenderness, and by having the body whitish and variously marked or mottled on the back, toward the head, with dark brown; it sometimes has a dark brown median dorsal-line. The shape of the head and position of the tentacles are also peculiar.

In sheltered situations, where there is some mud with the sand, the *Cirratulus grandis* V., (p. 319, Plate XV, figs. 80, 81,) is often met with burrowing beneath the surface. In similar places, and also in nearly pure, compact sand, and in sand mixed with gravel, the large tubes of *Amphitrite ornata* (p. 320, Plate XVI, fig. 82) are often to be seen; these show a round opening, a quarter of an inch or more in diameter, surrounded by a slightly raised mound of sand, often different in color from that of the surface, and sometimes there are cylinders of such sand around the opening. These tubes are scarcely to be distinguished from those of *Anthostoma robustum*, described above, and are found in

similar places. But the worms are very unlike in appearance and structure.

Several species of slender, greenish worms, belonging to the genera, *Phyllodoce*, *Eumidia*, *Eulalia*, and *Eteone*, are occasionally dug out of the sand. In all these the head is well-developed and provided with four *antennæ* at the end, and in the three last with an odd median one on its upper side, and they all have two well-developed eyes, and oval or lanceolate, leaf-like branchiæ along the sides of the back. They are very active species, and most of them belong properly to the shelly and rocky bottoms in deeper water, where they are often very abundant. In sheltered coves, where there is mud with the sand, *Cistenides Gouldii* V., (p. 323, Plate XVII, figs. 87, 87*a*,) often occurs, but it is more partial to the muddy shores. On various dead shells, as well as on certain living ones, and on the back of *Limulus*, &c., the masses of hard, sandy tubes, built and occupied by the *Sabellaria vulgaris* V., (p. 321, Plate XVII, figs. 88, 88*a*,) often occur.

Of the Nemerteans the largest and most conspicuous is the *Meckelia ingens* (p. 324, Plate XIX, figs. 96, 96*a*.) This species lives in the clear sand, near low-water mark, as well as in places that are more or less muddy, and notwithstanding its softness and fragility, by its means of burrowing rapidly, it can maintain itself even on exposed shores, where the sands are loose and constantly moved by the waves. The young, several inches or even a foot in length, are quite common, but the full-grown ones are only occasionally met with. The largest that I have found were at least 15 feet long, when extended, and over an inch broad, being quite flat; but they could contract to two or three feet in length, and then became nearly cylindrical and about three-quarters of an inch in diameter; the body was largest anteriorly, tapering very gradually to the posterior end, which was flat and thin, terminated by a central, small, slender, acute, contractile process one-quarter of an inch or less in length. The proboscis of the largest one, when protruded, was fifteen inches long, and about one-fifth of an inch in diameter where thickest. This proboscis, which is forcibly protruded from a terminal opening in the head, appears to be an organ of locomotion, at least to a certain extent, for when it penetrates the loose sand in any direction it makes an opening into which the head can be thrust, and then, by enlarging the opening, it can easily penetrate. But the proboscis is probably used, also, as an instrument for exploring the sand in various directions, either in search of food or to test its hardness or fitness for burrowing, thus economizing time and labor. At any rate, the ways in which this remarkable instrument is used by these worms, when kept in confinement with sand, suggest both these uses. But the proboscis is by no means the principal organ of locomotion, for the head itself is used for this purpose, urged forward by the undulatory movements of the muscular body, and aided by the constantly changing bulbous expansions, both of the head and body, which both crowd

the sand aside, making the burrow larger, and furnish points of resistance toward which the parts behind can be drawn, or against which the head and anterior parts can push in continuing the burrow. The head, moreover, is extremely changeable in form, at one time being spear-shaped, with a pointed tip and thin edges, and constricted at the neck; in the next minute broadly rounded; then perhaps truncate or even deeply emarginate at the end; then gradually losing its distinctness and blending its outlines continuously with those of the body; or perhaps shrinking down to a small oval form, not more than one-third as wide as the body just back of it. All these and many other changes can often be witnessed within a very few minutes, and are so effected as greatly to aid the creature in burrowing This worm can also leave the bottom and swim rapidly in the water, the body being usually kept up edgewise and impelled forward by the undulations of the body, which thus become horizontal. When swimming in this way the motion reminds one of the swimming of a snake or an eel. In addition to the terminal pore, for the proboscis, there is a deep lateral slit or fossa on each side of the head, and a large ventral orifice beneath. The latter is very changeable in form, changing from elliptical, long oval, oblong, or hour glass-shape, to circular in rapid succession. There are no eyes. Along each side of the greater part or the length of the body, the voluminous, transversely-banded lateral organs can be imperfectly distinguished through the translucent integument, as well as the median cavity, in which a dark pulsating tube can sometimes be seen. The lateral organs commence at about the anterior fourth in small specimens, but in the larger ones relatively nearer the head, for in the largest they originate only six or eight inches back of it. The portion in front of the lateral organs is thicker and more cylindrical than the rest of the body.

The color of the largest specimens is generally light red or flesh-color, with the lateral edges and central band translucent grayish white, the lateral organs showing through as dull yellowish transverse branches, with diverticula between them; head yellowish. But one large specimen was dull brownish yellow; others are yellowish white, with the lateral organs deep chestnut-brown, crossed by white lines. The small specimens are generally paler, usually pale flesh-color or yellowish white and often milk-white. Some of the diversity in color may be due to sexual differences. This species has also been dredged on sandy and shelly bottoms in six to eight fathoms in the sounds.

Dr. Leidy has also described another similar species, from Great Egg Harbor, under the name of *Meckelia lactea*, which I have not been able to distinguish, unless it be what I have regarded as the light-colored young of *M. ingens;* the white color seems to have been the principal character by which it was distinguished from the latter.

The *Meckelia rosea* is, however, a very distinct species, but it lives in similar places and is often associated with the *M. ingens.* It has very sim-

ilar habits, but does not grow to a very large size. The largest specimens observed are only six or eight inches long, and about a fifth of an inch broad. The body is also more cylindrical, the flattened part being relatively thicker and narrower, and not thin at the edges; in contraction it becomes nearly cylindrical. The lateral fossæ of the head are long and deep; the ventral opening is relatively much smaller than in *M. ingens* and usually round. The proboscis is very long, slender; color, light purplish red or rose-color. The integument is rather firm and secretes a tenacious mucus to which a thin coating of sand often adheres when the worms are taken from their burrows. This species seems to construct an imperfect tube by slightly cementing the sand with its mucus. All these species of *Meckelia* when caught and when kept in confinement generally break off portions from the posterior part of the body, one after another, until nothing but the head and a lot of short segments remain. Under favorable conditions they would doubtless be able to restore the lost parts, for other Nemerteans, having the same habit, are known to do so, and in some cases even the small fragments from the central parts have been known to again become entire worms. Various fishes feed upon these *Meckeliæ*, and it is probable that the habit of dismembering, or rather disarticulating themselves, may serve an important purpose, by enabling them to escape, in part at least, when seized by fishes or crabs, for if even half the body should be lost the remaining half would be much better than nothing, for it could soon restore either a head or a tail.

Another Nemertean, which lives in sand at low water, is the *Tetrastemma arenicola* V., (Plate XIX, fig. 98.) This is slender, subcylindrical, and four or five inches long when extended. The head is versatile in form, usually lanceolate or subconical, and has four eyes on the upper side. There is a deep fossa on each side of the head. The ventra opening, which is behind the lateral fossæ, is small, triangular. The color is deep flesh-color or light purplish.

The *Balanoglossus aurantiacus* is a very remarkable worm, related to the Nemerteans, which lives in the clear, siliceous sand near low-water mark. It is gregarious in its habits and occurs abundantly in certain spots, although not to be found in other similar places near by. It makes tubes or holes in the sand, twelve or fourteen inches deep, and lined with a thick and smooth layer of mucus. It throws out of the orifice peculiar elliptical coils of sand, by which the nature of the occupant may be known. This species was found by our party on the shore of Naushon Island, but Mr. A. Agassiz has found it abundantly at Newport, and on the beach just beyond Nobska Light, and also at Beverly, Massachusetts. Dr. Packard informs me that he has collected it at Beaufort, North Carolina, and I have received specimens found at Fort Macon, from Dr. Yarrow. The specimens first discovered were found at Charleston, South Carolina, by Dr. William Stimpson, twenty years ago, but they were only briefly and imperfectly described by Mr. Girard, at

that time, under the name of *Stimpsonia aurantiaca.* Mr. A. Agassiz has recently described and illustrated this worm, very fully, under the new name, *B. Kowalevskii*, in the Memoirs of the American Academy of Arts and Sciences, vol. ix, p. 421, and he has also given an account of its remarkable development and metamorphoses, proving that the larva is a free-swimming form, long known as *Tornaria*, and generally supposed to be the larva of a star-fish. This worm, when full grown, attains a length of six inches or more and a diameter of about a quarter of an inch. The body is elongated, tapering gradually, with a long, slender posterior portion. The body is somewhat flattened dorsally throughout most of its length. At the anterior end it is furnished with a broad thickened collar, in which large numbers of mucus-secreting glands are situated; the anterior border of the collar is undulated, and from within the concavity, on the dorsal side arises a large muscular proboscis, which has a distinct peduncle, or narrower basal stem, above which it swells out into a somewhat flattened, long, pyriform, or elongated and subconical form, the shape constantly changing during life. The proboscis is somewhat wrinkled longitudinally, and more strongly horizontally, being furnished with muscles running in both these directions, and its surface contains mucus-secreting glands. According to Mr. Agassiz the cavity of the proboscis is not connected with the alimentary canal, but opens externally by a pore at the end, and by a narrow slit on the ventral side near the base, in advance of the mouth. The mouth is large and situated at the base of the proboscis on the ventral side. For some distance along each side of the back, behind the collar, is a row of complex gills; these are remarkable on account of their structure and position; they are formed from diverticula of the œsophagus and finally communicate with a row of external orifices situated along each side of the median dorsal-vessel. The gills are supported by a system of solid supports, constituting a sort of internal skeleton; the base of the proboscis is also connected with a firm internal frame-work. The color of this species is somewhat variable; in young specimens the body was brownish yellow with lighter mottlings, the collar red, and the proboscis white; in large specimens the proboscis is pale reddish yellow, the collar darker colored, the body purplish or brownish, the sides mottled with greenish and whitish, owing to the lateral organs or liver showing through. The proboscis of this worm, according to the observations of Mr. Agassiz, is the principal organ of locomotion, but the collar also aids in the movements. The proboscis appears to be used much as certain bivalve mollusks, such as *Solen*, *Petricola*, &c., use their foot in burrowing; the end being contracted to a point, is thrust forward into the sand; water being then forced into it, by the muscles farther back, the end expands into a bulb, enlarging the hole and giving a point of resistance toward which the rest of the body can be drawn; the front part of the proboscis being again contracted and the water

expelled, the point can be again thrust forward and the movements repeated.

Two species of Sipunculoid worms are also found living in the sand at low-water. The largest and most common of these is the *Phascolosoma Gouldii*, (Plate XVIII, fig. 93.) This species grows to the length of a foot or more, and is often nearly half an inch in diameter, though more commonly about a quarter of an inch. The body is round and constantly changing in size and shape, owing to its contractions and expansions; the surface is smoothish, but longitudinally lined with muscular fibers anteriorly, and transversely wrinkled posteriorly. The integument is firm and parchment-like. The mouth is surrounded by numerous short tentacles, which are partially connected together by a thin web, and crowded together in several circles. The color is yellowish white, grayish white, or yellowish brown. It burrows deeply in the sand and gravel, using its body for this purpose very much as the *Balanoglossus*, just described, uses its proboscis.

Another much smaller species of the same genus occurs in sand at low-water, and has similar habits, but it appears to be rather uncommon and has not been satisfactorily identified.

Comparatively few species of Mollusks naturally inhabit sandy shores, though the shells of many species may be found on the beaches. On the more exposed beaches of loose siliceous sand none but those which have the power of burrowing quickly and deeply beneath the surface can exist. We find, however, that quite a number of our species, both of gastropods and bivalves, possess this power in a high degree and do habitually live on the exposed beaches of loose sand.

Among the Gastropods one of the largest and most conspicuous is the *Lunatia heros*, (Plate XXIII, figs. 133–136.) This species occurs all along our coast, from the Gulf of St. Lawrence to Cape Hatteras or beyond, wherever sandy shores and pure waters are to be found, and it even seems to prefer the outer ocean beaches, where the waves break with full force, for it is abundant and of very large size on the outer beaches of the coast of New Jersey. When in motion (Fig. 134) the white soft parts are protruded from the shell to a remarkable extent and spread out broadly on all sides, so as to nearly conceal the shell; the foot is large, flat, and broadly expanded, with thin edges, and by means of it the animal is able to burrow, like a mole, beneath the surface of the sand, both for protection and in search of the bivalve shells upon which it preys. The foot when well expanded is concave below and lubricated by a very abundant secretion of mucus, and therefore, when extended beneath the surface of the moist sand, it acts like a great sucker, holding the animal in place pretty firmly by the atmospheric pressure, thus serving as a sort of anchor in the sand. But nevertheless large numbers of these mollusks are uncovered, overturned, and thrown high up on the beaches by the storms, especially in winter and early spring. This species, like many others of its tribe, drills round holes through the sides of various

bivalve shells by means of the small flinty teeth on its lingual ribbon, which acts like a rasp, and having thus made an opening it inserts its proboscis and sucks out the contents. All sorts of burrowing bivalves in this way fall victims to this and the following species, nor do they confine themselves to bivalves, for they will also drill any unfortunate gastropods that they may happen to meet, not even sparing their own young.

A variety of this species (var. *triseriata*, Plate XXIII, figs. 135, 136) has three revolving rows of chestnut or purplish spots, and has been regarded by most writers as a distinct species, and sometimes as the young; but both the plain and spotted shells occur of all sizes, from the the youngest to the oldest, and they are nearly always found together. In some cases, however, a shell that has the spots well defined until half grown, afterwards loses its spots and becomes perfectly plain, showing that the difference is only a variation in the color, but each style varies considerably in form.

Another allied shell, growing nearly as large and generally much more abundant, except on the outer beaches, is the *Neverita duplicata*, (Plate XXIII, fig. 130.) This species has the same habits as the preceding and in this region they are often found together; but this is a more southern species, extending to the Gulf of Mexico and even to Texas, but it is not very common north of Cape Cod and does not extend to the eastern coast of Maine and Bay of Fundy.

The curious egg-cases of this and the last species are often met with on the sandy and muddy flats at low-water. They consist of a broad, thin ribbon of sand, coiled up into a circle and shaped something like a saucer, but without a bottom; the ribbon is composed of innumerable little cells, each containing one or more eggs and surrounded with grains of fine sand cemented together by mucus. The cells can easily be seen by holding one of these ribbons up to the light and looking through it. The peculiar form of these egg-masses is due to the fact that they are molded into shape by being pressed against the body of the shell when they are being extruded, and while they are still soft and gelatinous; they thus take the form and spiral curvature of that part of the shell, and when laid in the sand the fine grains at once adhere to and become imbedded in the tenacious mucus, which soon hardens.

The *Tritia trivittata* (Plate XXI, fig. 112) is also frequently found on sandy shores and flats. When left by the tide it creeps along the surface of the sand, leaving long crooked trails, and sometimes burrows beneath the surface, and when burrowing it moves with the aperture downward and the spire pointing obliquely upward, but when at rest in its burrow it reverses its position and rests with the spire downward and the aperture toward the surface.

The *Ilyanassa obsoleta* (Plate XXI, fig. 113) is also generally to be found in considerable numbers creeping over the flats, and making trails