MOLLUSCA.

Gastropods.

Lamellibranchs.

Ascidians.

RADIATA.

Echinoderms.

II. 9.—FREE SWIMMING AND SURFACE ANIMALS.

Under this head I have included all the animals found swimming free, whether in the bays and sounds, or in the colder region outside. Nor have I, in this case, attempted to separate those of the estuaries and other brackish waters, although such a distinction might be useful had we sufficient data to make it even tolerably complete. But hitherto very little surface-collecting has been done in waters that are really brackish; and, moreover, since every tide must bring in myriads of free-swimming creatures with the waters from outside, it will always be difficult to distinguish between those that are thus transported and those that properly belong to the brackish waters. A distinction between the free-swimming animals of the bays or sounds and those of the open coast has not been made, partly on account of the constant intermixture of the waters and their inhabitants by the tides, and partly because the observations that were made do not indicate any marked difference in the life or in the average temperature of the surface waters, though the waters of the shallow bays become more highly heated by the direct heat of the sun in summer. The waters of the open coast are evidently more or less warmed by the Gulf Stream, and in fact numerous species of animals that properly belong to the fauna of the Gulf Stream are constantly brought into Vineyard and Nantucket Sounds by the currents, showing conclusively that a portion of the Gulf Stream water must also take the same course.

In Vineyard Sound, during August and the first part of September, the temperature of the surface water in the middle of the day was generally from 68° to 71° Fahrenheit; September 9, off Tarpaulin Cove, the surface temperature was 66°; off to the west of Gay Head, in mid-channel, it was 67° Fahrenheit; but farther out, off No Man's Land, on the same day, it was 62°, (bottom, in 18 fathoms, 62½°;) a short distance west of No Man's Land it was 63°, (bottom, in 11 fathoms, 59°;) about sixteen miles off Newport, at the 29-fathom locality, it was 62° on September 14, (at the bottom 59°;) off Cuttyhunk, in 25 fathoms, it was 64° at the surface on September 13, (bottom 62½°.) According to the record made by Captain B. J. Edwards, during the past winter, from observations taken at 9 a. m. every morning, at the end of the Government wharf at Wood's Hole, (where the temperature must be nearly identical with that of Vineyard Sound,) the average temperature of the surface water was 31° Fahrenheit, from December 27 to February 28. The average temperature for that hour during January was 31.42°; the lowest was 29° on January 29, with the wind N. W.; the highest was 38° on January 17, with the wind S. W.; on the 18th, 19th, and 22d it was 35°. The average for February was 30.75°; the coldest was 29°, on February 24 and 25; the highest 33°, on February 8, 17, and 19. The temperature at the bottom (at the depth of nine feet) was also taken, but rarely differed more than one degree from that of the

surface, being sometimes a little lower and sometimes higher than that of the surface, but generally the same. The higher temperatures usually occurred with, or following, southerly or southeasterly winds, (from the direction of the Gulf Stream,) while the lowest ones generally accompanied or followed northerly winds. The tides must obviously also have some effect in modifying the temperature.

It must not be inferred from the preceding remarks that a distinct or constant current flows into these waters from the region of the Gulf Stream, for the facts do not warrant such a belief, nor is there any difficulty in explaining the phenomena in another way. All that is necessary to account for the higher temperatures of this region, and the frequent occurrence of Gulf Stream animals, is to suppose that when southerly or southeasterly winds blow continuously for a considerable time they cause a superficial flow or drift of warmer water from the Gulf Stream region toward these shores, which may also be aided by the tides; such a surface-drift will gradually lose its distinctness as it approaches the coast and mingles more and more with the cooler waters beneath, but the animals borne along by it will still serve to show its direction and origin, even after its temperature becomes identical with that of the adjacent waters. Such surface currents would necessarily be intermittent in character and variable in direction and extent, as well as in duration and temperature. They would also be more frequent in summer than in winter, according with the prevalent direction of the winds. So far as known to me all the facts are in harmony with this view. Accordingly the waters of Vineyard Sound are quite cold in winter, and only occasionally receive a little heat from the Gulf Stream region, and that, probably, largely through the medium of the air itself; but in summer these waters are very warm, for they not only receive frequent accessions of warm water from the Gulf Stream, but they are also favorably situated to be rapidly warmed by the direct heat of the sun.

The fauna of the surface in this region is very rich and varied, especially in summer. In winter, life is also abundant in the surface waters, but very different in character from that found in summer. Had collections been made in spring and autumn, still other groups of animals would doubtless have been found. Our knowledge of the surface animals of Vineyard Sound, in winter, is wholly based on a series of surface-dredgings made by Mr. Vinal N. Edwards in January, February, and March of the past winter. A separate list of the species contained in these collections, so far as identified, has been prepared to follow the general list. The most noticeable feature of the winter collections is the entire absence of the larval forms of crabs, shrimps, lobsters, star-fishes, sea-urchins, annelids, &c., which so abound in the same waters in summer. On the other hand there is a great abundance of Entomostraca, *Sagitta*, several northern Amphipods, species of *Mysis*, &c., together with eggs and young of certain fishes.

In the general list of surface species only those that have been actually observed are introduced, but it must be remembered that the greater part of the crustacea, annelids, mollusks, and echinoderms are well known to have free-swimming young, or larval forms, and that the list might easily be doubled by the introduction of such species, on theoretical grounds; but, by omitting them, the list serves to indicate how much yet remains to be done in this direction. There are large numbers of common species of which neither the young nor the eggs are known, and there are many others of which the eggs, or young, or both, are known, but the time required for the hatching of the eggs and the development of the young is not known. The dates given in the lists refer only to the time of actual capture of the species, and it must not be inferred that at other seasons of the year any of the species so designated are not to be found; for, doubtless, many of those that swim free when adult may be found all the year round. And possibly some species may breed during every month of the year. But the breeding season of most species is probably of short duration, and therefore the larvæ and young may occur only at particular seasons.

Mr. A. Agassiz has made a very large collection of the surface animals in Vineyard Sound, Buzzard's Bay, and off Newport, and to his labors we owe the knowledge of a large proportion of the jelly-fishes. He has also described the larvæ and young of several Annelids and Nemerteans, and has described and beautifully illustrated the larvæ and young of the common star-fishes, (*Asterias*,) and the green sea-urchin, (*Strongylocentrotus Dröbachiensis.*) The *Salpa Cabotti* (Plate XXXIII, figs. 254, 255) was also well described and illustrated by him; and also other species, but a large part of the collection has not yet been elaborated.

Our surface collections were made both in the day and evening, at various hours, chiefly by means of towing-nets and hand-nets. The evening or night hours are generally more productive than the day-time in this kind of collecting, but we were unable, owing to lack of time and superabundance of other specimens, to do as much night-collecting as we desired.

Among the Crustacea there are a considerable number of species that swim at the surface when adult, and others till nearly half-grown, but the majority are free-swimmers only when quite young, or even only when in the zoëa and megalops stages, through which they seem, from Mr. S. I. Smith's observations on several of our species, to pass in a short time. The males of the common oyster-crab, *Pinnotheres ostreum*, (p. 367, Plate I, fig. 2,) were often caught in the day-time swimming at the surface in the middle of Vineyard Sound. The lady-crab, *Platyonichus ocellatus*, (p. 338,) of full size, was also occasionally caught swimming actively at the surface. The "blue-crab," or common edible crab, *Callinectes hastatus*, is well known to be an active swimmer, when adult, but most of those seen at the surface were young. The larvæ

of *Cancer irroratus*, (p. 312, Plate VIII, figs. 37, 37*a*,) and of *Platyonichus* in the zoëa and megalops stages, were taken in vast numbers, especially in bright sunshine, together with similar larvæ of many other species. The larvæ and young of the lobster (Plate IX, figs. 38, 39) were also abundant in mid-summer. The numerous specimens obtained have enabled Mr. S. I. Smith to describe the interesting metamorphoses of our lobster, which were entirely unknown before. The young swim actively at the surface, like a shrimp, until more than half an inch long. The larvæ and young of the various species of shrimps are also abundant. The curious larvæ of *Squilla empusa* (Plate VIII, fig. 36) were often met with.

Several species of Amphipods are also common at the surface. The most abundant were *Calliopius læviusculus*, of which Mr. V. N. Edwards also took numerous large specimens in February and March; *Gammarus natator*, which was usually common, and occurred in immense numbers August 10 and on several other occasions; and a *Hyperia*, which infests several species of large jelly-fishes, and also swims free at will. The *Phronima* is a related genus, but is very remarkable for its extreme transparency, which renders it almost invisible in water. *Idotea irrorata* (p. 316, Plate V, fig. 23) and *I. robusta*, Plate V, fig. 24) were very common among masses of floating eel-grass and sea-weeds, and the latter was also very often found swimming entirely free.

A species of *Sapphirina* (Plate VII, fig. 33) was found in great numbers among *Salpæ*, off Gay Head, on several occasions, early in September. This is one of the most brilliant creatures inhabiting the sea. It reflects the most gorgeous colors, blue, red, purple, and green, like fire-opal, although when seen in some positions, by transmitted light, it is colorless and almost transparent. Under the microscope, when living, it is a splendid object, whether seen by transmitted or reflected light, the colors constantly changing, as it is turned in different positions. When seen beneath the surface of the sea, in large numbers, the appearance is very singular, for each one as it turns in the right position reflects a bright gleam of light, of some brilliant color, and then immediately becomes invisible, and these scintillations come from different directions and various depths, many of them being much farther beneath the surface than any less brilliant object could be seen. In some cases one or more were found in the branchial cavity of *Salpæ*, but whether this is normal or accidental was not determined.

The species of *Argulus* are parasitic on the exterior of fishes, but we found at least three species swimming free at the surface. It is, therefore, probable that they are able to leave their hosts for a time, and thus to migrate from one fish to another. The species of *Caligus* are also parasites on fishes, to which they firmly adhere, but the half-grown young of one species was taken at the surface in the towing-nets.

Numerous species of Annelids, in the larval and young stages, were taken at the surface, but many of them have not yet been identified,

for owing to the great changes they undergo, this is often impossible, unless the specimens can be raised, or at least connected with the adults by a large series of specimens. For a few this has been done. Several species also swim at the surface in the adult state, especially in the evening. With some this seems to be a habit peculiar to the breeding season, and sometimes only the males are met with.

Among the species most frequently taken in the adult state at the surface, are *Nereis virens*, (Plate XI, figs. 47–50,) chiefly males; *Nereis limbata*, (Plate XI, fig. 51,) mostly males, which occurred both in the evening and day-time; *Nectonereis megalops*, (Plate XII, figs. 62, 63,) which was quite common in the evening; *Autolytus cornutus*, (Plate XIII, figs. 65, 66,) the males, females, and asexual forms; *Podarke obscura*, (Plate XII, fig. 61,) which was extremely abundant in the evening; and several other species. The *Sagitta elegans* was taken at Wood's Hole, July 1, and off Gay Head, among *Salpæ*, September 8. It is a very small and delicate species, and so transparent as to be nearly invisible in water. A larger and stouter species of *Sagitta* was taken in large numbers at Wood's Hole, by Mr. V. N. Edwards, January 30, Febuary 10, and February 27, and at Savin Rock, near New Haven, May 5. This species has a longer caudal portion, with a small terminal fin; some of the specimens were nearly an inch long and many contained in the cavity of the body, posteriorly, a parasitic nematode worm, about half as long as the body. This parasite is round, not very slender; the head has three prominent angles; tail with a small, acute, terminal mucro.

Many of the Mollusca swim free by means of vibrating cilia, for a short time in the larval stages of growth, but as such larvæ are very minute and the period often quite short, these young are not often taken in the nets.

The Cephalopods of this region are all free-swimming species, from the time when they leave the eggs through life, though they may rest upon the bottom when depositing their spawn. Numerous specimens of the "squid," *Loligo Pealii*, (Plate XX, figs. 102–104, embryos and young,) were thus taken by the trawl in July, together with large clusters of their eggs. Later in the season the free-swimming young of this species, from a quarter of an inch to an inch in length, (fig. 105,) were often taken at the surface and were also found in the stomach of the red jelly-fish, *Cyanea arctica*, in considerable numbers. The adults were frequently taken during the whole summer in the pounds. Some of these were over a foot in length, but most of them were not more than five or six inches long. The color when living is very changeable, owing to the alternate contractions of the color-vesicles or spots, but the spots of different colors are much crowded, especially on the back, and the red and brown predominate, so as to give a general reddish or purplish brown color, and this is usually the color of preserved specimens. The clusters of gelatinous egg-capsules of this species were

found in great abundance off Falmouth, on a shelly and weedy bottom, as already mentioned, (p. 416;) and near New Haven light-house large clusters, apparently of the same species, were found by Professer Todd, earlier in the season, (June 19.) Some of these masses were six or eight inches in diameter, consisting of hundreds of capsules, like fig. 102, each of which is usually three or four inches long and contains numerous eggs. These last contained embryos in different stages of development, two of which are represented in Plate XX, figs. 103, 104. Even at this early period some of the pigment vesicles are already developed in the mantle and arms, and during life, if examined under the microscope, these orange and purple vesicles may be seen to rapidly contract and expand and change colors, as in the adult, only the phenomena may be more clearly seen, owing to the greater transparency of the skin in the embryos. They are, therefore, beautiful objects to observe under the microscope. At this stage of development the eyes were brown. In these embryos the yolk is finally absorbed through the mouth, which corresponds, therefore, in this respect, to an "umbilicus." The more advanced of these embryos (fig. 103) were capable of swimming about, when removed from the eggs, by means of the jets of water from the siphon.

Another species, *Loligo pallida* V., (Plate XX, figs. 101, 101*a*,) occurs abundantly, in autumn, in the western part of Long Island Sound, from whence Robert Benner, esq., has sent me numerous specimens. This is a pale, translucent, gelatinous-looking species, with much fewer spots than usual, even on the back, and is nearly white beneath. It is a stout species, commonly five or six inches long, exclusive of the arms, but grows considerably larger than that. It is often taken in the seines in large numbers with menhaden, upon which it probably feeds. These squids are eagerly devoured, even when full grown, by many of the larger fishes, such as blue-fish, black-bass, striped-bass, &c. When young they are preyed upon by a still larger variety of fishes, as well as by the jelly-fishes, &c.

Another species of "squid," *Ommastrephes illecebrosa*, has been recorded from Greenport, Long Island, by Mr. Sanderson Smith, but I have not met with it myself, south of Cape Cod. It is common in Massachusetts Bay and very abundant in the Bay of Fundy. Messrs. S. I. Smith and Oscar Harger observed it at Provincetown, Massachusetts, among the wharves, in large numbers, July 28, engaged in capturing and devouring the young mackerel, which were swimming about in "schools," and at that time were about four or five inches long. In attacking the mackerel they would suddenly dart backward among the fish with the velocity of an arrow, and as suddenly turn obliquely to the right or left and seize a fish, which was almost instantly killed by a bite in the back of the neck with the sharp beaks. The bite was always made in the same place, cutting out a triangular piece of flesh, and was deep enough to penetrate to the spinal cord. The attacks were not always successful, and were

sometimes repeated a dozen times before one of these active and wary fishes could be caught. Sometimes after making several unsuccessful attempts one of the squids would suddenly drop to the bottom, and, resting upon the sand, would change its color to that of the sand so perfectly as to be almost invisible. In this way it would wait until the fishes came back, and when they were swimming close to or over the ambuscade, the squid, by a sudden dart, would be pretty sure to secure a fish. Ordinarily when swimming they were thickly spotted with red and brown, but when darting among the mackerel they appeared translucent and pale. The mackerel, however, seemed to have learned that the shallow water is the safest for them and would hug the shore as closely as possible, so that in pursuing them many of the squids became stranded and perished by hundreds, for when they once touch the shore they begin to pump water from their siphons with great energy, and this usually forces them farther and farther up the beach. At such times they often discharge their ink in large quantities. The attacks on the young mackerel were observed mostly at or near high-water, for at other times the mackerel were seldom seen, though the squids were seen swimming about at all hours; and these attacks were observed both in the day and evening. But it is probable, from various observations, that this and the other species of squids are partially nocturnal in their habits, or at least are more active in the night than in the day. Those that are caught in the pounds and weirs mostly enter in the night, and evidently when swimming along the shores in "schools." They are often found in the morning stranded on the beaches in immense numbers, especially when there is a full moon, and it is thought by many of the fishermen that this is because, like many other nocturnal animals, they have the habit of turning toward and gazing at a bright light, and since they swim backwards they get ashore on the beaches opposite the position of the moon. This habit is also sometimes taken advantage of by the fishermen who capture them for bait for cod-fish; they go out in dark nights with torches in their boats and by advancing slowly toward a beach drive them ashore. They are also sometimes taken on lines, adhering to the bait used for fishes.

The specimens observed catching young mackerel were mostly eight or ten inches long, and some of them were still larger. The length of time required for these squids to become full grown is unknown, as well as the duration of their lives, but as several distinct sizes were taken in the pounds, and those of each school were of about the same size, it is probable that they are several years in attaining their full size. A specimen, recently caught at Eastport, Maine, was pale bluish white, with green, blue, and yellow iridescence on the sides and lower surface; the whole body was more or less thickly covered with small, unequal, circular, orange-brown and dark brown spots, having crenulate margins; these spots are continually changing in size from mere points, when they are nearly black, to spots 0.04 to 0.06 of an inch in diameter, when they are

pale orange-brown, becoming lighter colored as they expand. On the lower side the spots are more scattered, but the intervals are generally less than the diameter of the spots. On the upper side the spots are much crowded and lie in different planes, with the edges often overlapping, and thus increasing the variety of the tints. Along the middle of the back the ground-color is pale flesh-color, with a median dorsal band, along which the spots are tinged with green, in fine specks. Above each eye there is a broad lunate spot of light purplish red, with smaller brown spots. The upper surface of the head is deeply colored by the brown spots, which are here larger, darker, and more crowded than elsewhere, and situated in several strata. The arms and fins are colored like the body, except that the spots appear to be smaller. The suckers are pure white. The eyes are dark blue-black, surrounded by an iridescent border, and in this genus the eyes are provided with distinct lids. In this respect, *Ommastrephes* differs from *Loligo*, for in the species of the latter genus, the integument is continued directly over the eye, the part covering the eye being transparent.

Most of the higher Gastropods inclose their eggs in capsules, which they attach to stones, algæ, or shells, and within these the eggs hatch and the young have a well formed shell before they eat their way out of the capsules, and when free they crawl about by means of the "foot," like the adult. But in the lower orders of Gastropods most of the young, when first hatched, are furnished with vibrating cilia and swim free, by this means, for a short time. These larvæ are very different from the adults, and in case of the naked mollusks (Nudibranchs) the larvæ are furnished with a beautiful, little, glossy, spiral shell, which they afterwards lose.

The Pteropods swim free in all stages. The young and adults swim by means of two wing-like appendages, developed on each side of the neck, which may be compared to the anterior lateral lobes of the foot, seen in Æolis, (fig. 174,) and many other Gastropods, if we suppose these to become enormously enlarged, while the rest of the foot remains in a rudimentary or undeveloped condition, often serving merely for the attachment of the operculum.

The *Styliola vitrea* (Plate XXV, fig. 178) was taken in the day-time at the surface, September 8, among *Salpæ*, off Gay Head. Its shell is a thin, white, transparent, glassy cone, about a third of an inch long, and slightly curved toward the tip. The animal is also white. The *Spirialis Gouldii* has a delicate, white, transparent, spiral shell, when adult having seven whorls, which turn to the left. The shell is marked by very fine revolving lines, visible only under the microscope. This species is seldom met with at the surface in the day-time, but is often abundant in the early evening. According to the observations of Mr. A. Agassiz, in confinement they rarely left the bottom of the jars during the day, merely rising a few inches and then falling again to the bottom. After dark they became very active, swimming actively near

the surface of the water. "During the day they often remain suspended for hours in the water simply by spreading their wing-like appendages, and then suddenly drop to the bottom on folding them." Mr. Agassiz captured the specimens upon which his observations were made, at Nahant, Massachusetts, during the summer of 1869, and judging from the figures in Binney's Gould they were probably specimens, not quite adult, of this species. He has also taken adult specimens at Newport. Mr. S. I. Smith captured full grown specimens in the edge of the Gulf Stream, off St. George's Bank, and we have specimens taken from the stomach of mackerel, caught twenty miles south of No Man's Land.

The *Cavolina tidentata* (Plate XXV, fig. 177) is a beautiful and curious species, with a singularly shaped, amber-colored, translucent shell, much larger than that of either of the preceding species. We did not observe it living in these waters, but the shells were twice dredged off Martha's Vineyard, and one of them was perfectly fresh and glossy, as if just dead. It is a southern species which comes north in the Gulf Stream, but it had not been found previously on the coast of New England. Another Gulf Stream species, the *Diacria trispinosa*, is occasionally found at Nantucket, according to Dr. Stimpson, but whether it has been observed there alive is uncertain; eight or nine other species were taken in the Gulf Stream, off St. George's Bank, by Messrs. Smith and Harger in 1872, all of which may, perhaps, occasionally occur about Martha's Vineyard and Nantucket.

Another very interesting and beautiful Pteropod, the *Clione papilionacea*, was taken in considerable numbers at Watch Hill, Rhode Island, April 13, by Professor D. C. Eaton and myself. They were swimming at midday near the surface, associated with *Pleurobrachia rhododactyla*, and appeared to be common at that time. Mr. Vinal N. Edwards obtained two specimens in Vineyard Sound, April 30. This differs from those named above, in being destitute of a shell, as well as in many other characters. The body is stout, somewhat fusiform, tapering gradually to the pointed posterior end; in the largest specimens the length was about 1.5 inches. The head is rounded, with two small conical processes in front, on the upper side. Six tentacle-like organs, or "arms," bearing minute suckers, can be protruded. The wings or fins are large and broad oval in outline.

The body and wings are pale, transparent bluish, with opalescent hues; the mouth and parts around it, the "arms," and part of the head, and some of the internal organs, are tinged with orange; the posterior part of the body is bright reddish orange, for nearly half an inch. Some of the internal organs are orange-brown and olive-brown, and show through the transparent integuments as dark patches. This species has seldom been observed on our coast. Dekay, in 1843, mentioned its occurrence in a single instance, off New York. In 1869, it was taken in considerable numbers at Portland, Maine, by Mr. C. B.

Fuller. It may, nevertheless, occur annually in winter, and yet be seldom observed; for very few naturalists go out to collect marine animals in winter and early spring.

The bivalve shells mostly produce minute young, or larvæ, which are at first provided with vibrating cilia and swim free for several days, as is well known to be the case with the oysters, clams, muscles, *Teredo*, &c. But a few species, like the *Tottenia gemma*, (p. 359,) produce well developed young, furnished at birth with a well formed shell.

The common fixed Ascidians, both simple and compound, mostly produce eggs that hatch into tadpole-shaped young, which swim about for a short time by the undulatory motions of the tail, but finally become fixed by the head-end, and losing, or rather absorbing, the tail-portion, rapidly develop into the ordinary forms of the ascidians. This process, although often very rapid, is a very interesting and complicated one

In *Molgula Manhattensis* there is, according to the observations of Dr. Theodore A. Tellkampf, an alternation of generations. He states that the minute yellow ova were discharged July 18, invested in a viscid yellowish substance, which become attached to the exterior of many specimens. In a few days the "viscid substance" had changed its appearance and became contractile; the ova became larger, round, and of different sizes; "after two or three days the largest protruded somewhat above the surface of the common envelope, and presented a circular or oval aggregation, like that of the *Mammaria* found a year ago;" on the 11th day, the round ova had increased in size, with a central round or oval orifice through which the motion of the ciliæ of the branchial meshes were visible. "The orifice had approached on the 1st of August more or less to one apex; in some specimens, which were now oval, it was terminal." In this stage he names it *Mammaria Manhattensis*, regarding the *Mammaria* as a "nurse;" within each of the *Mammariæ*, at the end opposite the branchial orifice, there was seen a mass of cells, which ultimately developed into a tadpole-shaped larva, similar to that of other ascidians. He observes that the *Mammariæ* increase after the discharge of the larvæ, and that gemmation takes place within the common envelope.* These observations, if correct, are very interesting and important, but they need farther confirmation. The development of the larvæ from the *Mammariæ* into *Molgula* was not traced; neither did he witness the *actual discharge* of the ova, which produced the *Mammariæ*, from the *Molgula*. They may possibly have no relation with one another.

Several kinds of Ascidians, however, swim free in the water during their entire life. The most common Ascidian of this kind is the *Salpa Cabotti*, (Plate XXXIII, figs. 254, 255.) This, like the other species, exists under two different forms; or, in other words, it is one of those animals having alternations of generations. The sexual individuals (fig. 255) are united together into long chains by processes (*c*) from the sides

* Annals of the Lyceum of Natural History of New York, Vol. 10, p. 83, 1872.

of the branchial sac; these chains are often a foot or even a foot and a half long, and contain two rows of individuals, which are united together in such a way that they stand obliquely to the axis of the chain, the branchial openings being all on the upper side of the chain as it floats in the water, while the posterior openings are all on the lower side of the chain, close to the edge. Each individual is connected both with its mate on the right or left side, and to those immediately in front and behind on the same side. The succeeding individuals in the chain overlap considerably. The chains do not appear to break up spontaneously, but when broken apart by accident the individuals are capable of living separately for several days. The chains, when entire, swim about quite rapidly by means of the streams of water passing out of all the cloacal orifices in one direction. The individuals composing the chains, when full grown, are about three quarters of an inch long. They are transparent and white, or pale rose, often with the edges of the mantle and the nucleus bright Prussian blue, and with delicate reticulations of the same blue over the surface of the mantle. Each of the individuals in the chains is hermaphrodite, and each produces a single egg, which develops into an embryo before it is discharged, and finally when it grows to maturity produces an asexual individual, which is always solitary, (Plate XXXIII, fig. 254.) These are larger than those in the chains and are quite different in form, but the color is the same. These when mature produce, by a budding process in their interior, a series of minute individuals united together along a tube into a small chain, (s, fig. 254,) which may be seen coiled up around the nucleus. The chain consists of three sections, those individuals in the section first formed being largest and nearly equal in size; those in the next much smaller; while new ones are just forming at the other end; as the chain grows longer, and the component individuals larger, it projects more and more, and finally the end protrudes from an opening in the tunic, and the little chain becomes detached and is discharged into the sea. These chains consist of twenty to thirty pairs of individual zoöids. This operation is frequently repeated during the summer, and these chains of all sizes, from those just liberated up to the full-grown ones, may be taken at the same time. They appear to grow very rapidly. Thus by autumn these *Salpæ* became exceedingly abundant, at times completely filling the water for miles in every direction, from the surface to the depth of several fathoms, and are so crowded that a bucket of water dipped up at random will often contain several quarts of *Salpæ*. They were found in wonderful abundance on September 8, off Gay Head and throughout the outer part of Vineyard Sound, and on several other occasions were nearly as abundant.

Two species of *Appendicularia* and a species of *Doliolum* were also found in these waters by Mr. A. Agassiz, but we did not observe them. These are also free-swimming Ascidians, related to *Salpa*, but very different in form.

Among the Echinoderms there are no species that swim at the surface when adult, but most of them produce eggs which hatch into very remarkable larvæ, entirely unlike their parents in form and structure, and these swim free in the water, often for a considerable period, by means of vibrating cilia.

The young star-fish or sea-urchin develops gradually within the body of the larva, on the water-tubes, and as it grows larger it gradually absorbs the substance of the larva into its own body. The development of the larvæ of *Asterias vulgaris* (*A. pallida* AG.) and *A. arenicola* (*A. beryllinus* AG.) has been described by Mr. A. Agassiz, from the time previous to hatching from the eggs till they become young star-fishes, with the essential characters of the adults. He has also described the young of the common green sea-urchin (under the name of *Toxopneustes Drö-bachiensis*) in the same way. The *Cribrella saguinolenta*, (p. 407,) like several other star-fishes, does not have free swimming larvæ, but retains and protects the eggs by holding them by means of the suckers around the mouth, curving the body around them at the same time. In this position the eggs hatch and pass through a metamorphosis different from that of *Asterias*, though somewhat analogous to it. The development of this species was described by Professor M. Sars many years ago. Some of the Ophiurans are viviparous, among them the *Amphipholis elegans* (p. 418) found in this region, but others have free-swimming larvæ, and pass through a metamorphosis similar to that of *Asterias*, though the larvæ are quite different. Some of the Holothurians are also viviparous, while others have free-swimming larvæ, but the young of most of the species of this region are still unknown.

The Acalephs all swim free in one stage or another of their existence. Some of the Hydroids, like *Sertularia* and allied genera, are only free-swimmers while in the early embryonic stages, when they are covered by vibrating cilia; but they soon become fixed and ever after remain attached in one place. Others, like the species of *Obelia*, swim free in the embryonic state, and then develop into attached hydroids, which by budding may produce large branching colonies of similar hydroids, but ultimately they produce another kind of buds, which are developed within capsules or gonothecæ. These soon become elegant, little, circular, and disk-shaped jelly-fishes, which are then discharged and swim free in the water; they soon grow larger, acquire more tentacles, and ovaries or spermaries develop along the radiating tubes, the eggs are formed, discharged, and fertilized, and each egg may develop into a ciliated embryo, which in its turn may become attached and start a new hydroid colony. Thus among these animals we find an alternation of generations, complicated by different modes of budding.

In the case of the large red jelly-fish, *Cyanea arctica*, and the common whitish jelly-fish, *Aurelia flavidula*, (Plate XXXVI, fig. 271,) the history is somewhat different. These jelly-fishes produce immense numbers of minute eggs, which are discharged into the water and develop

into minute, oblong, ciliated larvæ; these soon become attached by one end and grow up into broad-disked young, like hydroids with long, slender tentacles; each of these after a time sends out stolon-like tubes from the base, and from these tubes buds are developed, each of which grows up into a "scyphostoma," or hydroid-form, like the first one; all these eventually become much elongated, then circular constrictions begin to form along the body, which grow deeper and deeper until they separate the body into a series of concave segments, which are held together by a pedicle in the middle of each, their borders at the same time becoming divided into eight lobes, or four bilobed ones; in the mean time the long tentacles around the upper end or original disk of the "scyphostoma" gradually grow shorter and are finally entirely absorbed; then the first or upper disk breaks off, and finally all the rest, one after another, until a mere stump is left at the base; after becoming detached each of the disks swims about in the water, and gradually develops its mouth, stomach, tentacles, and other organs, and, turning right side up and rapidly growing larger, eventually becomes a large and complicated jelly-fish, like its grandparents or great-grandparents that produced the egg from which the original "scyphostoma" was developed. The stump of the hydroid produces another set of tentacles, even before the separation of all the segments, and grows up again into the elongated or "strobila" form, and again undergoes the same process of transverse division, thus producing successive crops of jelly-fishes. In these cases there are alternations of generations, accompanied both by budding and fissiparity. The young of this species in the "ephyra" stage were found April 17, and at several other times during April, in abundance, by Mr. Vinal N. Edwards. These were less than a quarter of an inch in diameter, and must have become free only a short time before. On April 30 he took young specimens from half an inch to about an inch in diameter. The young of various sizes, up to nearly three inches in diameter, were common at New Haven May 5. All these young specimens were taken in the day-time.

In some jelly-fishes buds may even be produced upon the proboscis of the adult jelly-fish, which develop directly into free jelly-fishes, like the parent. This is the case with the *Dysmorphosa fulgurans*, found in these waters, and with *Lizzia grata*, found farther north.

On the other hand there are many jelly-fishes that do not have a hydroid state, nor bud, nor pass through any marked metamorphosis. This is the case with our *Pleurobrachia rhododactyla*, *Idyia roseola*, and other Ctenophoræ. In these the young, even before hatching, become perfect little jelly-fishes, and swim round and round within the egg by means of the miniature paddles or flappers along their sides. The young are, nevertheless, very different from the adults in form and structure.

It will be apparent, from the preceding remarks, that a complete list of free-swimming animals would necessarily include all the Acalephs of the region, but, as this would uselessly swell the list, only

those that have been actually taken at the surface will be here included. Quite a number of the species were not observed by us, but have been recorded by Mr. A. Agassiz, but in some cases he has given neither the time nor date of capture.

A fine large specimen of the beautiful jelly-fish, *Tima formosa*, has been sent to me by Mr. V. N. Edwards, who captured it at Wood's Hole, April 30. He states that the same species was very abundant in February, 1872. It has not been previously recorded as found south of Cape Cod. The specimen received differs from the description given by Mr. A. Agassiz, in having thirty-six tentacles instead of thirty-two.

Among the most common of the larger species in summer were *Mnemiopsis Leidyi*, which occurred in abundance at nearly all hours of the day and evening, and was very phosphorescent at night; *Cyanea arctica*, which ocurred chiefly in the day-time, and was here seldom more than a foot in diameter; *Aurelia flavidula*, (Plate XXXVI, fig. 271,) which was not unfrequently seen in the day-time; *Dactylometra quinquecirra*, (Plate XXXVI, fig. 272,) which was quite common both by night and day in August and September; and *Zygodactyla Grœnlandica*, (Plate XXXVII, fig. 275,) which was common in July, both in the day and evening, but was seldom seen later in the season.

The two species last named, and also the *Cyanea arctica*, were frequently found to be accompanied by several small fishes, of different sizes up to three inches long, which proved to be young "butter-fishes,' *Poronotus triacanthus*. These fishes swim beneath the broad disk of these jelly-fishes, surrounded on all sides by the numerous tentacles, which probably serve as a protection from larger fishes that are their enemies, for the tentacles of the jelly-fishes are capable of severely stinging the mouths of most fishes, evidently causing them great pain. As many as ten or twelve of these fishes were often found under a single jelly-fish, and in one case twenty-three were found under a *Cyanea* about ten inches in diameter. They do not appear to suffer at all from contact with the stinging-organs of the tentacles, and are, perhaps, protected from them by the thick coating of tenacious mucus which constantly covers the skin, and gives them their common English name. Mr. A. Agassiz states* that he constantly observed a "Clupeoid" fish under the *Dactylometra* in this region, which had essentially the same habits, according to his account, as the species observed by us, though, if a Clupeoid, it must have been a very different fish.

He says, however, that the fishes observed by him were occasionally devoured by the jelly-fish: "It is strange that the fish should go there for shelter, for every once in a while one of them pays the penalty by being swallowed, without this disturbing the others in the least; they in their turn find food in the lobes of the actinostome, and even eat the folds themselves, until their turn comes to be used as food. I have seen in this way three fishes eaten during the course of as many days.

* Catalogue of North American Acalephæ, p. 49.

The specimens measured about an inch in length." The fishes found by us were from a quarter of an inch to three inches long, and we never saw them swallowed, and never found them in the stomachs of any among the several dozen jelly-fishes, of the different kinds that we found accompanied by the fishes, although we found young squids and other kinds of marine animals in a half-digested condition. It is possible that the observation of Mr. Agassiz was made on them when kept in confinement, and that the fishes devoured were not in a perfectly healthy and natural condition, so as to resist the stings of the nettling organs. But if his fish belonged to a family different from ours, the difference may be peculiar to the respective fishes. Yet our observations afford only negative evidence, and it may be that this is one of the peculiarities of this remarkable companionship; though, if so, we should suppose that the race of *Poronotus* would soon become extinct, for we never observed the young under any other circumstances. The adult fishes of this species, when five or six inches long, were often taken in the pounds in considerable numbers.

Among the mouth-folds and lobes of the ovaries, beneath the disk of *Cyanea*, we very often found large numbers of living specimens of a delicate little jelly-fish, nearly globular in form, the *Margelis Carolinensis*, which we also frequently took in the towing-nets in the evening.

In the winter season the *Mnemiopsis Leidyi* is often abundant in Long Island Sound, and I have also observed it in New York harbor in February, in large numbers. At Wood's Hole Mr. V. N. Edwards found the *Pleurobrachia rhododactyla*, both young and nearly full-grown, very abundant in February and March; at Watch Hill, April 13, I found both adult specimens and young ones not more than an eighth of an inch in diameter. It probably occurs through the entire year, for we frequently met with it in mid-summer in Vineyard Sound. Mr. S. I. Smith also found it very abundant at Fire Island, on the south side of Long Island, in September.

In July and August we obtained several large and perfect specimens of the curious "Portuguese man-of-war," *Physalia Arethusa*. This species occurs as far west as Watch Hill, Rhode Island, where it was observed by Professor D. C. Eaton. The boatmen at that place state that it is frequent there in summer. The float of this species was generally deep, rich crimson or purple, and the hydroids beneath it were commonly bright blue in the specimens observed by us. The float or air-bag is, however, sometimes blue and sometimes rose-color.

According to Professor Agassiz, (Contributions, vol. IV, p. 335,) the floating bag in windy weather always presents the same side to the wind, and it is upon the windward side that the bunches of very long locomotive hydroids of the lower surface are situated, and these at such times are stretched out to an enormous length, and thus act as anchors to retard the motion by friction in passing through the water. The smaller locomotive hydroids, the feeding hydroids, and the reproductive hydroids, are on the lee side.

This species is capable of stinging the hands very severely if they be brought into contact with the hydroids attached to the lower surface of the floating air-bag.

The *Idyia roseola*, so abundant on the coast of New England north of Cape Cod, was only occasionally met with, and in small numbers, while the *Bolina alata*, which is one of the most abundant species on the northern coast of New England, was not seen at all. The *Aurelia flavidula* is less common than north of Cape Cod, but was found in abundance in Buzzard's Bay, in May, by V. N. Edwards.

Many of the Polyps have free-swimming, ciliated embryos, but others, like many of the sea-anemones, are viviparous, discharging the young ones through the mouth. These young are of different sizes, and furnished with a small but variable number of tentacles, but in most other respects they are similar to their parents. Mr. A. Agassiz has, however, recently ascertained that the young of a species of *Edwardsia* swims free in the water for a considerable period, or until it develops at least sixteen tentacles. In this condition it has been described as a different genus and species, (*Arachnactis brachiolata* A. AG.) Whether the other species of this genus all have free-swimming young is still uncertain; if so, these young must differ considerably among themselves, for *Edwardsia farinacea* V., of this coast, has but twelve tentacles when adult, and *E. elegans* V. has but sixteen, while others have as many as forty-eight tentacles, when full grown. Among the Protozoa there are great numbers of free-swimming forms included among those commonly known as Ciliated Infusoria, but those of our coast have been studied but little. The germs of sponges also swim free in the water, by means of cilia. Species of Polycystina would probably be found, if carefully sought for, but we have not yet met with any of them.

List of species taken at the surface of the water on the southern coast of New England.

In this list no attempt has been made to enumerate the numerous species of free Copepod Crustacea, which are very abundant, but have not been carefully studied.

ARTICULATA.

Crustacea.

Pinnotheres ostreum, males and young, (438.)
Cancer irroratus, in the zoea and megalops stages; June, July, (438.)
Platyonichus ocellatus, young and adult; megalops; June, July, (438.)
Callinectes hastatus, young, (438.)
Many other species of Brachyura in the zoea and megalops stages.
Hippa talpoida, young, 5 or 6^{mm} in length; early in September, (339.)
Eupagurus, several species in the larval stages; July to September.
Gebia affinis, young, 4^{mm} long; early in September.
Homarus Americanus, larvæ and young; July, (395.)
Crangon vulgaris, larvæ and young; June and July.

Virbius zostericola, larvæ and young ; July to September.
Palæmonetes vulgaris, larvæ and young ; July to September.
Larval forms and young of other species of Macroura.
Squilla empusa, larvæ in different stages ; August, (439.)
Mysis Americana, young and adult; April, May, (396.)
Heteromysis formosa, young and adult.
Thysanopoda, sp. Vineyard Sound; April 30, (V. N. Edwards.)
Cumacea, several species.
Lysianassinæ, several species, young and adult.
Urothoë, sp.
Monoculodes, sp.
Calliopius læviusculus, adult and young; summer and winter, (439.)
Pontogeneia inermis, full grown ; winter.
Gammarus natator, adult and young; summer and winter, (439.)
Mœra levis.
Ampelisca, sp., young.
Amphithoë maculata, young.
A. longimana, young even 5 or 6^{mm} long.
Hyperia, species ; summer, (439.)
Phronima, sp. ; September 8, (439.)
Idotea irrorata, (439.)
I. robusta, (439.)
I. phosphorea.
Erichsonia filiformis.
Epelys trilobus.
Tanais filum.
Sapphirina, sp. ; September, (439.)
Free Copepods of many genera and numerous species.
Argulus laticauda; August, (439.)
A. latus; July.
A. megalops; September 8.
Caligus rapax ; September 8, (439.)
Balanus balanoides, larvæ; April, May, June, (304.)
Lepas fascicularis ; June and July, in Vineyard Sound, (382.)
Limulus Polyphemus, young, (340.)

Worms.

Phyllodoce, sp., adult; July 3 ; evening.
Phyllodoce, sp., young ; evening.
Eulalia, sp., young; September 3 ; evening.
Eulalia, sp., young; evening.
Eumidia, sp., young; September 8 ; evening.
Eteone, sp., young ; evening.
Autolytus cornutus, male, female, and asexual forms; July 29 to August 18; evening. Watch Hill; April 13, asexual form, (440.)
Autolytus, sp., asexual individuals, (398.)

Gattiola, sp., young; September 3; evening.
Syllis (?), sp., young; September 3; evening.
Rhynchobolus Americanus, young; September 3; evening.
Nereis virens, adult males; April; day-time, (440.)
N. limbata, adult males filled with milt, September 3, evening; September 5, at Fire Island, day. Females, September 3, (few;) young, common, August, September, evening, (440.)
N. pelagica, young; August, September; evening.
Nectonereis megalops; July 3, 11; September 3, 8; evening, (440.)
Podarke obscura, adult; June 26 to August; evening, (440.)
Spio setosa, young; evening.
Scolecolepis viridis, young; evening.
Polydora ciliatum, young; September 3; evening.
Nicolea simplex, young; August, September; evening.
Amphitrite ornata, young; evening.
Lepræa rubra, young; evening.
Polycirrus eximius, young; August, September; evening.
Spirorbis, sp., young; evening.
Tomopteris, sp., young; evening.
Sagitta elegans, adult; July 1, September 8; day-time, (440.)
Sagitta, sp., adult and young; January 30 to May 5; day, (440.)
Balanoglossus aurantiacus; larvæ in the "tornaria" state, (351.)
Meckelia ingens; specimens up to ten inches long; evening, (349.)
Pontonema marinum, adult; February; day-time.
Several other small Nematodes with the last.
Slender round worm, up to six inches long; June 29, July 13; evening.
Young of many other worms; undetermined.

MOLLUSCA.

Cephalopods.

Ommastrephes illecebrosa, adult; July, August, (441.)
Loligo Pealii; June to September; young, July, August, (440.)
L. pallida, adult; October, November, (441.)

Pteropods.

Clione papilionacea, adult; April 13, April 30, (444.)
Styliola vitrea, adult; September 8; day-time, (443.)
Spirialis Gouldii, adult; August; evening, (443.)
Diacria trispinosa, (444.)
Cavolina tridentata, (444.)

Lamellibranchs.

Teredo navalis, larvæ; May, June, (386.)
Mytilus edulis, larvæ; April, (308.)
Ostræa Virginiana, larvæ; June, July, (310.)
Larvæ of many other species, undetermined.

Ascidians.

Salpa Cabotti, adults and young; August and September, (445.)
Doliolum, sp.; summer, (A. AGASSIZ,) (446.)
Appendicularia, sp., (like A. furcata;) summer, (A. AGASSIZ,) (446.)
Appendicularia, sp., (like A. longicauda;) summer, (A. AGASSIZ.)
Larvæ of fixed Ascidians, (445.)

RADIATA.

Echinoderms.

Strongylocentrotus Dröbachiensis, larvæ, (447.)
Asterias arenicola, larvæ; evening, (447.)
A. vulgaris, larvæ; evening, (447.)

Acalephs.

Mnemiopsis Leidyi; February, July to September; day-time, (449.)
Lesueuria hyboptera, adult; September; day-time.
Pleurobrachia rhododactyla, adult and young; January to May, July to September; day-time and evening, (448.)
Idyia roseola, adult; September; day-time, (451.)
Cyanea arctica, adult; August, September; day-time. Young in the "ephyra" stages; April; young of all sizes up to four inches across; May, (449.)
Aurelia flavidula; August, September; day-time, young; May, (449.)
Dactylometra quinquecirra, adult and young; July to September; day and evening, (449.)
Trachynema digitale, young; Wood's Hole, July 1; day-time.
Tiaropsis diademata; Wood's Hole; April 17, (V. N. Edwards.)
Oceania languida, medusæ; June to September; day-time.
Eucheilota ventricularis, young medusæ; evening.
E. duodecimalis, medusa; July.
Obelia, several species, medusæ; evening chiefly, (447.)
Rhegmatodes tenuis, medusæ; September; evening.
Zygodactyla Grœnlandica, medusæ; June to September; day and evening, (449.)
Æquorea albida, medusæ; September; evening.
Tima formosa, adult; February, 1872; April 30, 1873, (449.)
Eutima limpida, medusæ; September; evening.
Lafoëa calcarata, medusæ; September; evening.
Nemopsis Bachei, medusæ; June to September; evening.
Bougainvillia superciliaris, medusæ, April, May, June; evening.
Margelis Carolinensis, medusæ; August and September, chiefly in the evening, (450.)
Dysmorphosa fulgurans, medusæ; evening, (448.)
Modeeria, sp., medusæ.
Turritopsis nutricula, medusæ; July to September; evening.