CHAPTER XVII.

Imbedding of aquatic species in subaqueous strata—Inhumation of fresh-water plants and animals—Shell marl—Fossilized seed-vessels and stems of Chara —Recent deposits in the American lakes—Fresh-water species drifted into seas and estuaries—Lewes levels—Alternations of marine and fresh-water strata, how caused—Imbedding of marine plants and animals—Cetacea stranded on our shores—Their remains should be more conspicuous in marine alluvium than the bones of land quadrupeds—Liability of littoral and estuary testacea to be swept into the deep sea—Effects of a storm in the Frith of Forth—Burrowing shells secured from the ordinary action of waves and currents—Living testacea found at considerable depths.

We have hitherto treated of the imbedding of terrestrial plants and animals, and of human remains in the deposits that are now forming beneath the waters, and we come next to consider in what manner *aquatic* species may be entombed in strata, formed in their own element.

Imbedding of Fresh-water Plants and Animals.

The remains of species belonging to those genera of the animal and vegetable kingdoms, which are more or less exclusively confined to fresh-water, are for the most part preserved in the beds of lakes or estuaries, but they are oftentimes swept down by rivers into the sea, and there intermingled with the exuviæ of marine races. The phenomena attending their inhumation in lacustrine deposits, may be sometimes revealed to our observation by the drainage of small lakes, such as are those in Scotland which have been laid dry for the sake of obtaining shell marl for agricultural uses.

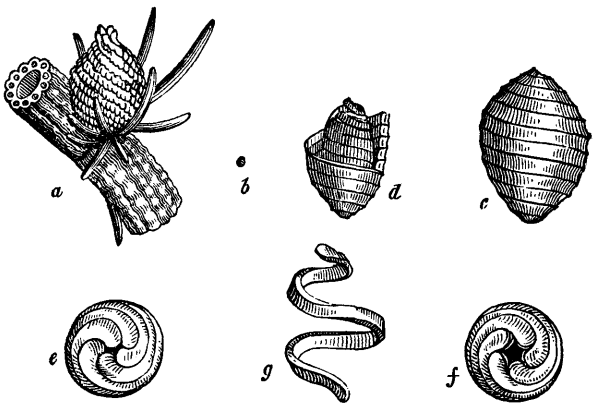
In these recent formations, as seen in Forfarshire, two or three beds of calcareous marl are sometimes observed separated from each other by layers of drift peat, sand, or fissile clay. The marl often consists almost entirely of an aggregate of shells of the genera limnea, planorbis, valvata, and cyclas, with some few others, species of all which now exist in Scotland. A considerable proportion of the testacea appear to have died

very young, and few of the shells are of a size which indicates their having attained a state of maturity. The shells are sometimes entirely decomposed, forming a pulverulent marl; sometimes they are in a state of good preservation. They are frequently intermixed with stems of charæ and other aquatic vegetables, which are matted together and compressed, forming laminæ often as thin as paper.

As the chara is an aquatic plant, which occurs frequently fossil in formations of different eras, and is often of much importance to the geologist in characterizing entire groups of strata, we shall describe the manner in which the recent species have been found in a petrified state. They occur in one of the lakes of Forfarshire, inclosed in nodules, and sometimes in a continuous stratum of a kind of travertin.

The seed-vessel of these plants is remarkably tough and hard, and consists of a membranous nut covered by an integument (fig. *d* diagram No. 2,) both of which are spirally striated or ribbed. The integument is composed of five spiral valves,

(No. 2.)



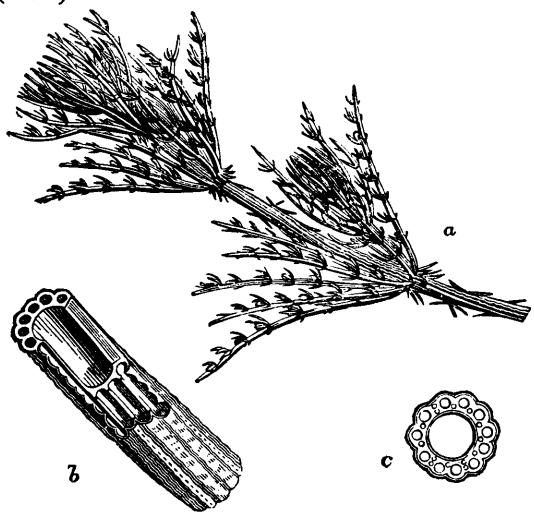
Seed-vessel of Chara hispida.

(*a*) Part of the stem with the seed-vessel attached. Magnified.
(*b*) Natural size of the seed-vessel.
(*c*) Integument of the Gyrogonite, or petrified seed-vessel of Chara hispida, found in the Scotch marl-lakes. Magnified.
(*d*) Section showing the nut within the integument.
(*e*) Lower end of the integument to which the stem was attached.

of a quadrangular form (fig. *g*). In *Chara hispida* which abounds in the lakes of Forfarshire, and which has become fossil in the Bakie Loch, each of the spiral valves of the seed-vessel turns rather more than twice round the circumference, the whole together making between ten and eleven rings. The number of these rings differs greatly in different species, but in the same appears to be very constant.

The stems of charæ occur fossil in the Scotch marl in great abundance. In some species, as in *Chara hispida*, the plant when living contains so much carbonate of lime in its vegetable organization, independently of calcareous incrustation, that it effervesces strongly with acids when dried. The stems of *Chara hispida* are longitudinally striated, with a tendency to be spiral. These striæ, as appears to be the case with all charæ, turn always like the worm of a screw from right to left, while those of the seed-vessel wind round in a contrary direction. A cross section of the stem exhibits a curious structure, for it is composed of a large tube surrounded by smaller tubes, (diagram No. 3. fig. *b*, *c*,) as is seen in some extinct, as well

(No. 3.)



Stem and branches of Chara hispida.

(*a*) Stem and branches of the natural size.
(*b*) Section of the stem magnified.
(*c*) Showing the central tube surrounded by two rings of smaller tubes.

as recent species. In the stems of several species, however, there is only a single tube*.

The valves of a small animal called cypris (*C. ornata Lam.*) occur completely fossilized like the stems of charæ, in the Scotch travertin above mentioned. This cypris inhabits the lakes and ponds of England where it is not uncommon. Species of the same genus also occur abundantly in ancient fresh-water formations.

The recent strata of lacustrine origin above alluded to are of very small extent, but analogous deposits on the grandest scale have been formed in the great lakes of North America. By the subsidence of the waters of Lakes Superior and Huron, occasioned probably by the partial destruction of their barriers at some unknown period, beds of sand one hundred and fifty feet thick are exposed, below which are seen beds of clay, inclosing shells of the very species which now inhabit the lake †.

But no careful examination appears as yet to have been made of recent fresh-water formations within the tropics, where the waters teem with life, and where in the bed of a newly drained lake the remains of the alligator, crocodile tortoise, and perhaps some large fish might be discovered.

Imbedding of Fresh-water Species in Estuary and Marine Deposits.

We have sometimes an opportunity of examining the deposits which within the historical period have silted up some of our estuaries; and excavations made for wells and other purposes, where the sea has been finally excluded, enable us to observe the state of the organic remains in these tracts. The valley of the Ouse between Newhaven and Lewes is one of several estuaries from which the sea has retired within the last seven or eight centuries; and here it appears from the researches of Mr. Mantell, that strata of thirty feet and upwards in thickness have accumulated. At the top, beneath

* Geol. Trans., vol. ii., second series, p. 73. On Fresh-water Marl, &c. By C. Lyell, Esq. † Dr. Bigsby's Journal of Science, &c. No. 37, pp. 262, 263.

the vegetable soil, is a bed of peat about five feet thick, enclosing many trunks of trees. Next below is a stratum of blue clay containing fresh-water shells of about nine species, such as now inhabit the district. Intermixed with these was observed the skeleton of a deer. Lower down, the layers of blue clay contain with the above-mentioned fresh-water shells several marine species well known on our coast. In the lowest beds, often at the depth of thirty-six feet, these marine testacea occur without the slightest intermixture of fluviatile species, and amongst them the skull of the narwal, or sea-unicorn (*Monodon monoceros*), has been detected. Underneath all these deposits is a bed of pipe-clay, derived from the subjacent chalk *.

If we had no historical information respecting the former existence of an inlet of the sea in this valley, and of its gradual obliteration, the inspection of the section above described would show, as clearly as a written chronicle, the following sequence of events. First, there was a salt-water estuary peopled for many years by species of marine testacea identical with those now living, and into which some of the larger cetacea occasionally entered. Secondly, the inlet grew shallower, and the water became brackish, or alternately salt and fresh, so that the remains of fresh-water and marine shells were mingled in the blue argillaceous sediment of its bottom. Thirdly, the shoaling continued until the river water prevailed, so that it was no longer habitable by marine testacea, but fitted only for the abode of fluviatile species and aquatic insects. Fourthly, a peaty swamp or morass was formed where some trees grew, or, perhaps, were drifted during floods, and where terrestrial quadrupeds were mired. Finally, the soil being only flooded by the river at distant intervals, became a verdant meadow.

We have stated when speaking of the delta of the Ganges, that on the sea-coast there are eight great openings, each of

* Mantell, Geol. of Sussex, p. 285; also Cata'ogue of Org. Rem., Geol. Trans., v. iii., part 1, p. 201. Second Series.

which has evidently, at some ancient periods, served in its turn as the principal channel of discharge. Now as the base of the delta is two hundred miles in length, it must happen that as often as the great volume of river-water is thrown in by a new mouth, the waters of the sea will at one point be converted from salt to fresh, and at another from fresh to salt; for, with the exception of those parts where the principal discharge takes place, the salt-water not only washes the base of the delta, but enters far into every creek and lagoon. It is evident then that repeated alternations of beds containing fresh-water shells, with others filled with corals and marine exuviæ, may here be formed, and each series may be of great thickness, as the sea on which the Gangetic delta gains, is of considerable depth, and intervals of centuries elapse between each alteration in the course of the principal stream.

It is evident that analogous phenomena must sometimes be occasioned by such alternate elevation and depression of the land as was shown in the last chapter to be taking place in the delta of the Indus. But the subterranean movements affect but a small number of the deltas formed at one period on the globe; whereas, the silting up of some of the arms of great rivers and the opening of others, and the consequent variation of the points at which the chief volume of their waters enters the sea, are phenomena common to almost every delta.

The variety of species of testacea contained in the recent calcareous marl of Scotland, before mentioned, is very small, but the abundance of individuals is extremely great, a circumstance which characterizes fresh-water formations in general as compared to marine; for in the latter, as is seen on sea-beaches, coral reefs, or in the bottom of seas examined by dredging, wherever the individual shells are exceedingly numerous there rarely fails to be a vast variety of species.

Imbedding of the Remains of Marine Plants and Animals.

Marine Plants.—We have alluded to the large banks of drift sea-weed which occur on each side of the equator in the

Atlantic, Pacific, and Indian oceans *. These when they subside may often produce considerable beds of vegetable matter. In Holland submarine peat is derived from fuci, and on parts of our own coast from *Zostera marina*. In places where algæ do not generate peat, they may nevertheless leave traces of their form imprinted on argillaceous and calcareous mud, as they are usually very tough in their texture.

Cetacea.—It is not uncommon for the larger cetacea, which can only float in a considerable depth of water, to be carried during storms or high tides into estuaries, or upon low shores, where, upon the retiring of high water, they are stranded. Thus a narwal (*Monodon monoceros*) was found on the beach near Boston, in Lincolnshire, in the year 1800, the whole of its body buried in the mud. A fisherman going to his boat saw the horn and tried to pull it out, when the animal began to stir itself †. An individual of the common whale (*Balœna mysticetus*), which measured seventy feet, came ashore near Peterhead, in 1682. Many individuals of the genus Balænoptera have met the same fate. We may content ourselves with referring to those cast on shore near Burnt Island, and at Alloa, recorded by Sibbald and Neill. The other individual mentioned by Sibbald, as having come ashore at Boyne, in Banffshire, was probably a Razor-back. Of the genus Catodon (*Cachalot*), Ray mentions a large one stranded on the west coast of Holland in 1598, and the fact is also commemorated in a Dutch engraving of the time of much merit. Sibbald, too, records that a herd of Cachalots, upwards of one hundred in number, were found stranded at Kairston, Orkney ‡. The dead bodies of the larger cetacea are sometimes found floating on the surface of the waters, as was the case with the immense whale exhibited in London in 1831. And the carcass of a sea-cow or Lamantine (*Halicora*) was, in 1785, cast ashore near Leith. We might enumerate many more examples de-

* Page 78.

† Fleming's Brit. Animals, p. 37; in which work may be seen many other cases enumerated.

rived from foreign as well as British shores, but the facts above cited will suffice to show that such occurrences are not rare.

To some accidents of this kind, we may refer the position of the skeleton of a whale seventy-three feet long, which was found at Airthrey, on the Forth near Alloa, imbedded in clay twenty feet higher than the surface of the highest tide of the river Forth at the present day. From the situation of the Roman station and causeways at a small distance from the spot, it is concluded that the whale must have been stranded there at a period prior to the Christian era*.

Other fossil remains of this class have also been found in estuaries, known to have been silted up in recent times, one example of which we have already mentioned near Lewes, in Sussex. When we reflect on the facility with which these marine mammalia are thus shown to run aground upon shoals, even when there have been no great convulsions, such as hurricanes or earthquakes extending under the ocean, but merely such disturbances as the tides and storms of our seas may cause, we may be better enabled to form a sound opinion, in regard to the probability of certain geological theories, which have acquired no small share of popularity. It has been suggested, that if the ocean, displaced by the sudden upheaving of some great mountain-chain, such as the Andes, should make a transient passage over the land, a covering of alluvium might be left strewed over the hills and valleys, and that, in this alluvium, might be contained the remains of mammalia exclusively terrestrial. The skeleton of the gigantic whale, the long horn of the narwal (harder than ivory), the strong grinders of the lamantine, these and other marine relics of the era

> Omne cum Proteus pecus egit altos
> Visere montes,

might, we are told, be entirely wanting. Not one of them would be conspicuous amongst the refuse of the "bated and retiring flood," but instead of them we should discover the bones, tusks, and teeth of the elephant or rhinoceros, the hip-

* Quart. Journ. of Lit. Sci., &c. No. 15, p. 172. Oct. 1819.

popotamus, ox, and horse, with occasionally, perhaps, some intermixture of terrestrial and lacustrine shells! Such, we are taught, would be the memorials of a marine deluge sweeping over our continents! We are, however, willing to admit that they who invent causes without reference to known analogies, are guilty of no inconsistency when they claim some license in the use which they make of their extraordinary agents. If we allow them to "call spirits from the vasty deep" to do their bidding, and to uplift colossal chains, like the Andes, suddenly within the historical era, we must not complain that the effects of such mighty powers are not always such as the analogy of the ordinary laws of Nature would have led us to anticipate.

Marine Testacea.—The aquatic animals and plants which inhabit an estuary are liable, like the trees and land animals which people the alluvial plains of a great river, to be swept from time to time far into the deep. For as a river is perpetually shifting its course, and undermining a portion of its banks with the forests which cover them, so the marine current alters its direction from time to time, and bears away the banks of sand and mud, against which it turns its force. These banks may consist in great measure of shells peculiar to shallow, and sometimes brackish water, which may have been accumulating for centuries, until at length they are carried away and spread out along the bottom of the sea, at a depth at which they could not have lived and multiplied. Thus littoral and estuary shells are more frequently liable even than fresh-water species, to be intermixed with the exuviæ of pelagic tribes.

After the late storm of February 4, 1831, when several vessels were wrecked in the estuary of the Forth, the current was directed against a bed of oysters with such force, that great heaps of them were thrown *alive* upon the beach, and remained above high-water mark. Many of these oysters, as also the common whelks (*buccina*), which were thrown up with them, in a living state, were worn by the long attrition of sand which had passed over them as they lay in their native

bed, and which had evidently not resulted from the mere action of the tempest by which they had been cast ashore.

From these facts we may learn that the union of the two parts of a bivalve shell does not prove that it may not have been transported to a certain distance; and when we find shells worn, and with all their prominent parts rubbed off, they may still have been imbedded where they grew.

It sometimes appears extraordinary when we observe the violence of the breakers on our coast, and see the strength of the current in removing cliffs and sweeping out new channels, that many tender and fragile shells should inhabit the sea in the immediate vicinity of this turmoil. But a great number of the bivalve testacea, and many also of the turbinated univalves burrow in sand or mud. The solen and the cardium, for example, which are usually found in shallow water near the shore, pierce through a soft bottom without injury to their shells; and the pholas can drill a cavity through mud of considerable hardness. The species of these and many other tribes can sink, when alarmed, with considerable rapidity, often to the depth of several feet, and can also penetrate upwards again to the surface if a mass of matter be heaped upon them. The hurricane, therefore, may expend its fury in vain, and may sweep away even the upper part of banks of sand or mud, or may roll pebbles over them, and yet these testacea may remain below secure and uninjured.

We have already stated that at the depth of nine hundred and fifty fathoms between Gibraltar and Ceuta, Captain Smyth found a gravelly bottom, with fragments of broken shells carried thither probably from the comparatively shallow parts of the neighbouring straits, through which a powerful current flows. Beds of shelly sand might here, in the course of ages, be accumulated several thousand feet thick. But, without the aid of the drifting power of a current, shells may accumulate in the spot where they live and die, at great depths from the surface, if sediment be thrown down upon them; for, even in our own colder latitudes, the depths at which living marine

animals abound is very considerable. Captain Vidal ascertained, by soundings lately made off Tory island, on the north-west coast of Ireland, that crustacea, star-fish, and testacea, occurred at various depths between fifty and one hundred fathoms; and in the tropics testacea and zoophytes have been found still deeper.

During the survey of the west coast of Africa, now in progress, Captain Belcher found, by frequent soundings between the twenty-third and twentieth degrees of north latitude, that the bottom of the sea at the depth of from twenty to about fifty fathoms, consists of sand, with a great intermixture of shells often entire, but sometimes finely comminuted. Between the eleventh and ninth degrees of north latitude, on the same coast, at soundings varying from twenty to about eighty fathoms, he brought up abundance of corals and shells mixed with sand. These also were in some parts entire, and in others worn and broken.

In all these cases it is only necessary that there should be some deposition of sedimentary matter, however minute, such as may be supplied by rivers or currents preying on a line of cliffs, and stratified formations, hundreds of feet in thickness, will result in the course of ages, containing throughout organic remains, in a more or less perfect state of preservation.