XXXVIII.—*On the Molluscan Fauna of the Gulf of Suez in its Relation to that of other Seas.* By Alfred Hands Cooke, M.A., Curator in Zoology, Museum of Zoology and Comparative Anatomy, Cambridge.

In his original article on the Mollusca of the Gulf of Suez (Ann. & Mag. Nat. Hist. 1870, vol. vi. pp. 429–450) Mr. MacAndrew wrote as follows:—"The total number of species of Mollusca I obtained in the Gulf of Suez amounts to some 818, of which 619 have been identified or described, the remaining 199 being still undetermined."

The result of my investigations (Ann. & Mag. Nat. Hist. April 1885, pp. 322–339, July 1885, pp. 32–50, Oct. 1885, pp. 262–276, Feb. 1886, pp. 128–142, Aug. 1886, pp. 92–109) has been materially to reduce the above estimate. As has been already remarked in the course of previous communications, the collection was originally identified largely with the view of discovering as many species as possible. I will make bold to say that out of the "199 species undetermined" not 30 have proved on examination new or different from species in the collection already identified.

Issel's list of Red-Sea Mollusca ('Malacologia del Mar Rosso,' Pisa, 1869) contains, exclusive of 35 species of Nudibranchs, about 356 species of Gasteropoda and about 172 of Lamellibranchiata, or a total of about 528 species. The MacAndrew collection, as now revised, contains about 419 species of Gasteropoda and about 189 of Lamellibranchiata, or a total of about 608 species.

The geographical range of the Red-Sea Mollusca is exceedingly interesting. Broadly speaking, the area of distribution extends over a vast extent of sea-coast, of which Suez forms the extreme western and the Sandwich Islands the extreme eastern point, while the north and south range extends from Japan to Natal, and even to the Cape of Good Hope. The point on the Japanese coast where the line should be drawn which may be said to separate the tropical Mollusca from those of decidedly northern character appears to lie off the mouth of the river Amur, the marine fauna of the Sea of Ochotsk being markedly northern. And it is remarkable to notice how sharply the line of demarcation is drawn at the Cape and at the Sandwich Islands. In the former case the great Antarctic current, sweeping up from the Pole along the west coast of South Africa, stops like a wall the progress of east-coast species, accustomed as they are to much warmer

water. In the latter the great distance between the Sandwich Islands and the opposite coasts of America, and the cold polar current which pours down from the north in a course parallel to those coasts, form obstacles too great for the fry of tropical Mollusca to overpass; and, so far as I am aware, it cannot be shown that a single species has succeeded in crossing them in this direction. It is quite true that a few Suez species (not more, perhaps, than half a dozen in all) are found on the West-Mexican coast; but there is no evidence to show that they got there *viâ* the Sandwich Islands. On the contrary, their existence (speaking more particularly of *Triton pilearis* and *Lucina quadrisulcata*) in the West Indies tends to show that their appearance on the W.-Mexican coast dates from a time when the Isthmus of Panama was not yet closed. And it appears to me that, though the distance may be far greater, yet the presence of East-Indian species in the West Indies and on the West-Mexican coast is far more easily accounted for by a trans-Atlantic than by a trans-Pacific migration, especially when it is borne in mind that the Isthmuses of Panama and Suez have both been open, each of them perhaps more than once, within late geological times. For in the case of the Atlantic we have a series of warm currents trending generally from the west coast of Africa towards Brazil *; while in the case of the Pacific the cold polar current sweeping down from the north parallel to the American coast, and the enormous distance without any perceptible set of current to the east, present just as insurmountable a barrier as the Antarctic current in S. Africa.

Of the enormous area of distribution whose normal limits have been indicated above, there is a district which may probably be regarded as the nucleus. If it is possible to approximate in any degree to the original birthplace of a single species, whether vertebrate or invertebrate, the same must be true, though of course in a wider and less specific sense, for groups of species also. If it is granted that a particular species develops at a particular place (using the term in a wide sense), and not, whether contemporaneously or at different periods, at different places, it is evident that indications may be discovered which will tend to show where that place was, and the process may be extended to groups of species as well. It appears to me that the Philippine district may be regarded as the centre of distribution of those species which radiate westward as far as Suez, northward as far as

* Studer states (Abh. Ak. Berlin, 1882, p. 5) that out of 541 marine shells from the west coast of Africa 55 are common to the opposite coast of America.

Japan, and eastward as far as the Sandwich Islands. There are, as is well known, special reasons which tend to make the marine fauna of the Philippines better known to us than that of, *e. g.*, the Seychelles or the Maldives; and possibly it is only because we have more detailed information as to the species of Mollusca resident at the former locality that we at present prefer it to the latter, as indicating a radiating point of distribution.

The annexed table, compiled from the latest sources of information, is an attempt roughly to indicate the geographical distribution of the Mollusca of Suez. The two localities about which I feel dissatisfaction, being sure that the figures given do not indicate their real relation to the Suez shells, are Natal and E. Australia. For the former Krauss's 'Südafrikanischen Mollusken' (1848) was my only authority; while the latter, north of Moreton Bay, is a region practically unexplored, but whose tropical climate and comparative nearness to the Philippines assure it a much closer relation to them than the figures given would seem to imply.

The Gasteropoda alone have been worked out, as the information with regard to the Lamellibranchiata was often so scanty as to lead to practically no result.

Gasteropoda. Suez.	Common to Philippines.	Common to Japan.	Common to Natal.	Common to E. or S. Australia.	Common to Sandwich Is.
419	214 or 51 p. c.	55 or 13 p. c.	35 or 8 p. c.	24 or 6 p. c.	38 or 9 p. c.

The 55 Suez Gasteropoda common to Japan are:—

Pteroceras bryonia, *Gmel.*
Terebellum subulatum, *Lam.*
Urosalpinx contractus, *Reeve.*
Fasciolaria trapezium, *L.*
Cantharus rubiginosus, *Reeve.*
Nassa gemmulata, *Lam.*
Columbella flavida, *Lam.*
Acus subulata, *L.*
Ricinula ricinus, *L.*
Rapana bulbosa, *Sol.*
Coralliophila madreporarum, *Sow.*
Ranella hians, *Schum.*
Triton tritonis, *L.*
—— pilearis, *Lam.*
Cassis vibex, *L.*
Mitra pretiosa, *Reeve.*
—— obeliscus, *Reeve.*
Cypræa fimbriata, *Gmel.*

Cypræa arabica, *L.*
—— moneta, *L.*
—— caurica, *L.*
—— erosa, *L.*
—— lynx, *L.*
Conus miliaris, *Hwass.*
—— textile, *L.*
Turris violacea, *Hinds.*
Pyramidella gracilis, *A. Ad.*
Obeliscus balteatus, *A. Ad.*
Syrnola pulchella, *A. Ad.*
—— aclis, *A. Ad.*
—— aciculata, *A. Ad.*
—— pupina, *A. Ad.*
—— cinctella, *A. Ad.*
Turbonilla fusca, *A. Ad.*
—— modica, *A. Ad.*
Styloptygma lendix, *A. Ad.*
Cingulina circinata, *A. Ad.*
Styliferina goniocheila, *A. Ad.*
Vertagus Kochi, *Phil.*
Triphoris corrugata, *Hinds.*
Planaxis sulcatus, *Born.*
Cyclostrema cingulifera, *A. Ad.*
Morchia obvoluta, *A. Ad.*
Hyala pumila, *A. Ad.*
Onoba mirifica, *A. Ad.*
Fenella pupoides, *A. Ad.*
—— scabra, *A. Ad.*
—— reticulata, *A. Ad.*
—— rufocincta, *A. Ad.*
Alaba imbricata, *A. Ad.*
—— lucida, *A. Ad.*
Diala varia, *A. Ad.*
Scutus unguis, *L.*
Hydatina physis, *L.*
Tornatina fusiformis, *A. Ad.*

The 35 Suez Gasteropoda common to Natal are :—

Strombus gibberulus, *L.*
—— floridus, *Lam.*
Fasciolaria trapezium, *L.*
Melongena paradisaica, *Reeve.*
Cantharus rubiginosus, *Reeve.*
Nassa pulchella, *A. Ad.*
Columbella turturina, *Lam.*
Engina mendicaria, *Lam.*
Ricinula ricinus, *L.*
Sistrum anaxares, *d'Orb.*
—— fiscellum, *Chemn.*
—— tuberculatum, *Blainv.*
—— asperum, *Lam.*
—— heptagonale, *Reeve.*
Ranella affinis, *Brod.*
—— pusilla, *Brod.*
Triton pilearis, *Lam.*
Cypræa fimbriata, *Gmel.*
Cypræa arabica, *L.*
—— annulus, *L.*
—— erosa, *L.*
—— lynx, *L.*
Conus lividus, *Hwass.*
Cerithium morus, *Lam.*
Colina contracta, *Sow.*
Planaxis sulcatus, *Born.*
Nerita polita, *L.*
—— histrio, *L.*
Monodonta australis, *Lam.*
—— obscura, *Wood.*
Littorina scabra, *L.*
Scutus unguis, *L.*
Hydatina physis, *L.*
Philine aperta, *L.*
Siphonaria kurrachensis, *Reeve.*

The 24 Suez Gasteropoda common to E. or S. Australia (including Tasmania) are :—

Fasciolaria trapezium, *L.*
Sistrum tuberculatum, *Blainv.*
Coralliophila madreporarum, *Sow.*
Ranella affinis, *Brod.*
Epidromus bracteatus, *Hinds.*
Cypræa arabica, *L.*
—— annulus, *L.*
—— caurica, *L.*
—— erosa, *L.*
—— lynx, *L.*
Daphnella vincentina, *Crosse.*
Defrancia tenuilirata, *Angas.*
Turbonilla fusca, *A. Ad.*
Myonia amœna, *A. Ad.*
Smaragdia pulcherrima, *Angas.*
? Cingulina circinata, *A. Ad.*
? Bittium tenue, *Sow.*
Littorina scabra, *L.*
Scutus unguis, *L.*
Acanthopleurus piceus, *Gmel.*
Actæon coccinatus, *Reeve.*
Hydatina physis, *L.*
Tornatina fusiformis, *A. Ad.*
Philine aperta, *L.*

The 38 Suez Gasteropoda common to the Sandwich Islands are :—

Terebra babylonia, *Lam.*
—— columellaris, *Hinds.*
Triton rubecula, *Lam.*
Mitra filosa, *Born.*
—— annulata, *Reeve.*
—— cucumerina, *Lam.*
—— mucronata, *Swains.*
—— aureolata, *Swains.*
—— alauda, *Sow.*
—— litterata, *Linn.*
Cypræa carneola, *Lam.*
—— talpa, *L.*
—— isabella, *L.*
—— erosa, *L.*
—— lynx, *L.*
Trivia oryza, *L.*
—— tremeza, *Ducl.*
—— nucleus, *L.*
—— cicercula, *L.*
Conus lividus, *Hwass.*
—— ceylonensis, *Hwass.*
—— flavidus, *Lam.*
—— tessellatus, *Born.*
—— virgo, *L.*
—— miliaris, *Hwass.*
—— nussatella, *L.*
Turris monilifera, *Pease.*
Natica maroccana, *Chemn.*
Pyramidella corrugata, *Lam.*
Obeliscus sulcatus, *A. Ad.*
Cerithium rugosum, *Wood.*
Triphoris rubra, *Hinds.*
Gena nigra, *Quoy.*
Rissoina tridentata, *Mich.*
Littorina scabra, *L.*
Modulus tectum, *Gmel.*
Bulla ampulla, *L.*
Atys semistriata, *Pease.*

The following 2 Suez species appear to be common to Japan, Natal, E. or S. Australia, and the Sandwich Islands :—

Cypræa erosa, *L.* Cypræa lynx, *L.*

Taking together the two northern and the two southern of these localities we arrive at a result which, as we should expect, indicates a closer connexion between S. Africa and S. Australia than between Japan and the Sandwich Islands; thus :—

The following 10 Suez species are common to Natal and S. Australia :—

Fasciolaria trapezium, *L.*
Littorina scabra, *L.*
Sistrum tuberculatum, *Blainv.*
Ranella affinis, *Brod.*
Cypræa arabica, *L.*
Cypræa annulus, *L.*
—— erosa, *L.*
—— lynx, *L.*
Hydatina physis, *L.*
Philine aperta, *L.*

The following 3 Suez species are common to Japan and the Sandwich Islands :—

Cypræa erosa, *L.*
—— lynx, *L.*
Conus miliaris, *Hwass.*

The following 4 Suez species reach New Zealand * :—

Ricinula ricinus, *L.*
Cypræa annulus, *L.*
Scutus unguis, *L.*
Philine aperta, *L.*

* Tryon, in his 'Manual of Conchology,' vol. iii., gives, on what authority I do not know, New Zealand as a locality for *Triton tritonis*. It does not occur in Hutton's admirable list of the shells of New Zealand.

Three Suez species appear to occur at St. Helena * :—

Triton tritonis, *L.*
Cypræa moneta, *L.*
Cypræa turdus, *L.*

Two Suez species, which do not occur in the Mediterranean, occur at the Canary Islands :—

Natica maroccana, *Chemn.*, var.
Natica variabilis, *Récl.*

Four Suez species reach the West Indies, viz. :—

Triton pilearis, *Lam.*
Natica maroccana, *Chemn.*
Acanthopleurus piceus, *Gmel.*
Leuconia denticulata, *Mont.*

Two Suez species occur on the west coast of Central America, viz. :—

Triton pilearis, *Lam.*
Natica maroccana, *Chemn.*, var.

Further examination, and careful preparation of local collections will no doubt add enormously to the length of the lists here given ; but I do not anticipate that their relative proportions will be very largely modified.

The question whether any species of shells are common to the Red Sea and the Mediterranean has often been debated, and is still *sub judice*. But it seems a not unreasonable assumption that the MacAndrew collection of Suez shells affords an opportunity for making a considerable step in the direction of a settlement, not only because of the unusually fine series of specimens which it offers in every stage of growth, but because the same gentleman made very large collections in the Mediterranean, equally rich in series illustrating young and adult forms. It should be mentioned that he was most scrupulously careful in labelling his captures with the exact locality, so that the idea cannot be for a moment entertained that the specimens from the two seas have become mixed up in the cabinets. Thus we have the unusual opportunity of being able readily to compare large series of species, identical or related, drawn from both seas, and to form our conclusions accordingly.

* Since I wrote the above Mr. E. A. Smith has informed me that he has examined the actual specimens from which this statement (Melliss's 'St. Helena') was made. It appears, and I can confirm the observation, that the specimens identified as *Cypr. turdus* are all *Cypr. spurca*, while the two specimens of *Cypr. moneta* look most suspiciously like ballast shells.

Philippi seems to have been the first to institute any comparison between the Molluscan fauna of the Red Sea and Mediterranean. On comparing his Sicilian and Italian collections with those made in the Red Sea and deposited at Berlin by MM. Hemprich and Ehrenberg, he came to the conclusion * that the following species were common to both seas :—

Patella cærulea, *L.*
—— lusitanica, *Gmel.*
—— tarentina, *Lam.*
—— fragilis, *Ph.*
Fissurella græca, *L.*
—— costaria, *Desh.*
—— rosea, *Lam.*
Bulla striata, *Brug.*
—— truncata, *Ad.*
Eulima polita, *L.*
Chemnitzia elegantissima, *Mont.*
Truncatella truncatula, *Mont.*
Paludina thermalis, *L.*
Rissoa glabrata, *v. M.*
Natica olla, *M. de S.*
—— millepunctata, *Lam.*
Nerita viridis, *L.*
Ianthina bicolor, *Mke.*
Haliotis tuberculata, *L.*
Tornatella tornatilis, *L.*
Trochus crenulatus, *Broc.*
—— striatus, *L.*
—— Adansoni, *Payr.*
Trochus varius, *Gmel.*
Cerithium vulgatum, *Brug.*
—— mammillatum, *Risso.*
—— lima, *Brug.*
—— perversum, *Brug.*
Fasciolaria lignaria, *L.*
Fusus corneus, *L.*
—— syracusanus, *L.*
—— rostratus, *Oliv.*
Murex trunculus, *L.*
Tritonium variegatum, *Lam.*
Ranella lanceolata, *Mke.*
Dolium galea, *L.*
Buccinum variabile, *Ph.*
—— mutabile, *L.*
—— gibbosulum, *L.*
Mitra lutescens, *Lam.*
Marginella clandestina, *Broc.*
—— miliacea, *L.*
—— minuta, *Pfr.*
Cypræa moneta, *L.*
—— erosa, *L.*

Solen vagina, *L.*
—— legumen, *L.*
Mactra stultorum, *L.*
—— inflata, *Bronn.*
Corbula revoluta, *Broc.*
Diplodonta rotundata, *Mont.*
Lucina lactea, *Poli.*
—— pecten, *Lam.*
Mesodesma donacilla, *Lam.*
Donax trunculus, *L.*
Venus verrucosa, *L.*
—— decussata, *L.*
Cytherea exoleta, *L.*
—— lincta, *Lam.*
Cardita calyculata, *Brug.*
Arca Noæ, *L.*
—— tetragona, *Poli.*
—— barbata, *L.*
—— diluvii, *Lam.*
Pectunculus violacescens, *Lam.*
Nucula margaritacea, *Lam.*
Chama gryphoides, *L.*
Modiola discrepans, *Lam.*
—— Petagnæ, *Scac.*
—— lithophaga, *L.*
Pinna squamosa, *L.*
—— nobilis, *L.*
Spondylus aculeatus, *Chemn.*
Ostrea cristata, *Born.*

It would be needless to demonstrate the utter incorrectness of this list, the proportions of which no succeeding investigations have in the slightest degree tended to confirm. It is very obvious that the collection of MM. Hemprich and Ehrenberg, which numbered 375 species in all, had in some

* 'Enumeratio Molluscorum Siciliæ,' pp. 248, 249 (Berlin, 1836).

way become impregnated with a very strong Mediterranean leaven.

The opposite pole of belief is occupied by M. Fischer. That distinguished writer, in an article * on the shells collected by M. Vaillant at Suez (in which, however, only 86 species in all are enumerated), concludes that "il n'existe aucune coquille commune à la mer Rouge et à la Méditerranée." In a later article † M. Fischer, reasoning on the analogy of closely allied species occurring on both sides of the Isthmus of Panama, suggests a common derivation for closely allied species in the Red Sea and Mediterranean, such derivation to date from the Miocene period, after which he supposes the isthmus to have been finally closed.

Unfortunately M. Fischer had not sufficient material to support his theory, which indeed he rested entirely on the occurrence of *Cardium edule* (fossil) at Suez and (recent) along the isthmus, and on the erroneous idea that *Nassa gibbosula*, Gmel., was common to both seas.

This theory, however, which is in its main point thoroughly scientific, and which only failed in M. Fischer's hands from want of material, was adopted and established by Sign. Issel. That author, in the preface to his 'Malacologia del Mar Rosso,' after referring to Fischer's assertion of the entire difference between the two faunas, makes some remarkable observations, which are worth translating:—

"Though it would be incorrect to assert that there does not exist one single species common to the Mediterranean and the Red Sea (species being understood in the sense commonly accepted by conchologists), yet it is none the less true that there do not exist in the two seas two identical shells. The fact is, Mediterranean species which have been brought from the Red Sea all differ more or less from their respective typical forms. *Nassa costulata* of the Red Sea is more elongated and smaller; *Solecurtus strigilatus*, while remaining constant in form, shows on its valves closer and more numerous striæ; *Gastrochæna dubia* is more deeply striated than Mediterranean specimens.

"It might be objected that these forms, being so decidedly different, ought therefore to constitute distinct species, and therefore the assertion formulated by M. Fischer would be perfectly correct.

"To this we would answer that the distinctive characters observed by us in some Red-Sea varieties are not sufficient to characterize separate and distinct species (species being under-

* 'Journal de Conchyliologie,' 1865, pp. 97–127, 241 248.

† *Ib.* 1870, pp. 161–179; 1871, pp. 209–926.

stood in the narrowest acceptation of the term), because they are not sufficiently constant and because the groups in which they occur are subject to considerable variations in form (*sono i più polimorfi*).

"We, and other followers of the English school, while looking upon species as in theory very useful and, indeed, necessary for the study of the science, regard them as being to a large extent conventional and arbitrary, and believe that species vary according to the physical conditions in which they find themselves placed. Thus we should regard it as an abnormality, an exception to every rule, if there occurred in the Red Sea a Mediterranean species which had not undergone some modification.

"Besides the varieties indicated above there exist in the Red Sea certain shells differing indeed from their Mediterranean congeners, but sufficiently akin to them to stand as their representatives, so to speak, on the further side of the isthmus.

"Instances of this parallelism are found in *Nassa gibbosula* and *circumcincta*, *Cerithium vulgatum* and *Rüppellii*, *Cerith. conicum* and *Caillaudi*, *Chiton siculus* and *affinis*, *Diplodonta rotundata* and *Savignyi*, *Cardium edule* and *isthmicum*.

"Ought we to comprehend under the heading of *geographical variety* shells from the Red Sea, so near to the Mediterranean?

"Under this denomination are usually distinguished forms derived from a recognized type, which, by removal from the central point of their creation, have become gradually modified, and differ from it the more the greater is the distance which separates them from the point of departure. This is not the case with the shells now under consideration, because at certain points of the isthmus scarcely 100 kilometres separate the two faunas, and because such a short distance is not enough to constitute the existence of a geographical variety.

"These considerations have suggested the idea of distinguishing by a comprehensive term Red-Sea varieties and species which correspond to Mediterranean species. We will therefore give the name of *equivalent varieties* to those Mediterranean species which occur on the further side of the isthmus only slightly modified; and the name of *equivalent species* to those representatives of Mediterranean species which occur in the Red Sea modified to a larger extent.

"It is our belief that from any type, existent in a given place, there can be derived equivalent species and equivalent varieties if the locality has undergone more or less considerable changes; that, again, there can be derived geographical

varieties and geographical species, if the same type shall have become diffused over distant regions, gradually assuming new characters.

"It may reasonably be supposed, in the present case, that the species which in tolerably remote times (*e. g.* the Pliocene period) passed from the Mediterranean to the Arabian Gulf have undergone very considerable alterations of form, and have originated certain *equivalent species*, while those whose passage from one sea to the other was effected at a later (the Postpliocene) period have formed our *equivalent varieties*."

Issel then proceeds to give the following lists, which I have slightly rearranged for the sake of clearness:—

Mediterranean Species.	*Equivalent Varieties in the Red Sea.*
Gastrochæna dubia, *Penn.*	Gastrochæna dubia, *Penn.*, var.
Solecurtus strigilatus, *L.*	Solecurtus strigilatus, *L.*, var.
Arca lactea, *L.*	Arca lactea, *L.*, var. erythræa.
Nassa costulata, *Ren.*	Nassa costulata, *Ren.*, var. erythræa.

Mediterranean Species.	*Equivalent Species in the Red Sea.*
Tellina exigua, *Poli.*	Tellina arsinoensis, *Issel.*
—— serrata, *Ren.*	—— Belcheriana, *Sow.*
Tapes geographicus, *Gmel.*	Tapes Deshayesii, *Hanl.*
Artemis exoleta, *L.*	Artemis radiata, *Reeve.*
Cardium edule, *L.*	Cardium isthmicum, *Issel.*
—— minimum, *Phil.*	—— sueziense, *Issel.*
Cardita sulcata, *Brug.*	Cardita angisulcata, *Reeve.*
—— trapezium, *L.*	—— variegata, *Brug.*
Diplodonta rotundata, *Mont.*	Diplodonta Savignyi, *Vaill.*
Lucina reticulata, *Poli.*	Lucina erythræa, *Issel.*
Arca diluvii, *Lam.*	Arca auriculata, *Lam.*
Modiola adriatica, *Lam.*	Modiola, sp.
Lima squamosa, *Lam.*	Lima bullifera, *Desh.*
Marginella minuta, *Pfr.*	Marginella sueziensis, *Iss.*
—— clandestina, *Br.*	—— pygmæa, *Iss.*
—— miliaria, *L.*	—— Savignyi, *Iss.*
Purpura hæmastoma, *L.*	Purpura, sp.
Nassa gibbosula, *L.*	Nassa circumcincta, *Reeve.*
Cerithium vulgatum, *L.*	Cerithium Rüppelli, *Phil.*
—— conicum, *Blainv.*	—— Caillaudi, *Pot. & Mich.*
Philine aperta, *L.*	Philine Vaillanti, *Iss.*
Ringicula buccinea, *Ren.*	Ringicula acuta, *Phil.*
Eulima Philippii, *Weink.*	Eulima Gentilomiana, *Iss.*
Neritina viridis, *L.*	Neritina Feuilleti, *Aud.*
Fissurella græca, *L.*	Fissurella Rüppellii, *Sow.*
Chiton siculus, *Gray.*	Chiton affinis, *Iss.*

These interesting, and in many respects valuable, remarks of Issel appear to me to be open to a certain amount of criticism. And, first, as to his denial of the term "geographical variety" to Red-Sea "equivalents" of Mediterranean species. He

seems to think that a geographical variety can only exist "at a great distance from the central point of the creation" of the type. Why? What is "a great distance"? One hundred kilometres, we are told, is too short a distance to constitute the existence of a geographical variety. Would two hundred kilometres be enough? Would a thousand? One is tempted to ask, How many kilometres make a geographical variety? *Arca lactea* occurs in the Philippines in a form precisely identical with that found at Suez. Are Philippine specimens to be called a "geographical variety" because they live a long way off the Mediterranean, but Red-Sea specimens an "equivalent variety" because they live nearly within 100 kilometres of it?

Nor is it easy to see the force of the adjective in the term under consideration. If "geographical" is meant to denote that the intervention of distance between one geographical point and another constitutes or compels variation, it states what is not true; if, on the other hand, that the type exists at one place and the variety at another, it is merely an "epitheton otiosum" and may be dispensed with altogether.

Again, the argument about the "central point of creation" is surely rather confused. Issel says (1) that geographical varieties originate at a great distance from the central point of creation, and (2) that the Red-Sea "equivalents" cannot be geographical varieties because they exist within 100 kilometres of the Mediterranean. It looks as if he placed the "central point of creation" for his four Mediterranean species, which have "equivalent varieties" in the Red Sea, at Port Said! And if it is replied that the central point of creation of a Mediterranean species cannot be established, but may be assumed to be any point where the type occurs, the answer is that in that case "central point of creation" is only a synonym for "area of distribution."

The truth is, distance *quâ* distance has nothing to do with the production or non-production of a variety. One can easily imagine a stretch of sea-bottom two thousand miles in length, and the same species of Mollusca existing, without the slightest variation, at one end and at the other. What prevents variation is not shortness of distance, but similarity of environment; and in the case of some of the Mollusca it is not even necessary that the area of similar physical conditions shall be unbroken. In the case of a species which, in a certain stage of its existence, is free-swimming, the typical form is possessed of means of locomotion far surpassing those of the more sedentary species.

This is no doubt the explanation, though it has not yet

been proved in every case, of the enormous range of distribution shown by some of the Mollusca, not as varieties, but as constant *typical* forms. It is not to be imagined, for instance, that the whole extent of coast-line, littoral or sublittoral, from Suez to Hawaii, offers a suitable home to *Cypræa erosa*. But if the larval form is free-swimming, and if, when it returns from the open sea to the shore, it perishes at unsuitable lines of coast, but lives and flourishes on those which offer conditions of existence similar to those in which its ancestors have lived, we can understand why the typical form is preserved unvaried over a distance of many thousand miles. The distribution in a *typical form* of several of the large *Tritons* will, I have no doubt, have to be explained in a similar way.

Again, Issel's theory of "equivalent species" and "equivalent varieties" seems open to serious objection. He has made a list, as we have seen, of twenty-six "equivalent species" and of only four "equivalent varieties." But what is to determine the difference between the one and the other? What is to prevent our classifying *Tapes Deshayesii* as an equivalent variety and *Arca erythræa* as an equivalent species? Issel tells us that equivalent varieties are Mediterranean species "only slightly modified," and equivalent species are Mediterranean species "modified to a larger extent;" but who is to draw the line, and how? For since certain genera are notoriously liable to variation while others are remarkably constant, the amount of variation from the type which in some genera suffices to constitute a species, will in another genus be regarded as unimportant. The question is something more than a mere matter of words, if we go on to assume, as Issel does, that the "equivalent species" entered the Red Sea during the Pliocene period, while the "equivalent varieties" did not effect their passage from the Mediterranean till a later, or Postpliocene age.

Issel's grounds for refusing to classify his four "equivalent varieties" (*Nassa costulata*, *Solecurtus strigilatus*, *Gastrochæna dubia*, and *Arca lactea*) as "equivalent species" are two in number:—(1) the distinctive characters are not sufficiently constant; (2) the groups in which they occur are subject to considerable variation in form. These two reasons are really only two different ways of stating the same fact, namely, that the genera concerned are remarkably liable to variation. I should dispute this statement at the outset with regard to half the genera in question. Whatever may be said of the capacities of variation in *Gastrochæna* and *Arca*, I should be inclined to select the Solenidæ and Nassidæ, parti-

cularly the former, as including genera which, as genera go, are fairly constant in form. And further, if the reason Issel gives for distinguishing "equivalent varieties" from "equivalent species" be a valid one, it ought to be true for the one set of genera but inoperative with regard to the other; in other words, his "equivalent varieties" ought to belong to genera which are markedly variable, while his "equivalent species" ought to belong to genera which are fairly constant. So far is this from being the case, that half of the genera which supply him with "equivalent varieties" supply "equivalent species" as well. Why is *Arca auriculata* the "equivalent species" of *Arca diluvii*, but *Arca erythræa* only the "equivalent variety" of *Arca lactea*? Why, again, is *Nassa circumcincta* the "equivalent species" of *N. gibbosula*, while *N. costulata* (Ren., = *variabilis*, Forb.) of the Mediterranean has only an "equivalent variety" in the Red Sea? Again, what genera are more notoriously liable to variation than *Tapes*, *Modiola*, and *Purpura*? Yet all the Red-Sea "equivalents" of Mediterranean species of these genera are classed by Issel as species, not as varieties. The reply will be, that it is a question of greater or less modification of form. But who is to measure "greater or less"? And what has become of the "groups of genera which are subject to considerable variation of form"?

These terms, "a variable genus," a genus "liable to variation," seem to me misleading, because they attempt to cover too much ground, but at the same time do not grasp all the facts as they present themselves to us. What one notices is, that certain genera, from their mode of life and habitat, are, so to speak, compelled to vary. Such genera, including *Ostrea*, *Vulsella*, *Chama*, *Avicula*, *Littorina*, *Vermetus*, *Crepidula*, *Patella*, &c., I should term genera necessarily variable. Again, one notices that certain other genera, while not necessarily variable, possess individual species which exhibit capacities for variation, while the bulk of the species remain fairly constant to the type. Such genera are:—*Conus*, fairly constant as a whole, but exhibiting such extremely variable species as *textile* and *hyæna*; *Natica*, with the variable *maroccana* and *mamilla*; *Nassa*, with the variable *gaudiosa* and *variabilis*; *Cardium*, with the variable *edule*. Thus, while a variable genus implies variation in the subordinate species, a variable species by no means implies a variable genus. Why some species should vary while others remain constant to the type is as yet unknown, but the fact is unquestionable.

It appears to me, then, that Issel's refusal of the term

"geographical varieties" to Red-Sea species akin to Mediterranean and his distinction between "equivalent species" and "equivalent varieties" alike fail, and fail for the very reasons he gives for establishing them. That Mediterranean species migrated into the Red Sea both in Pliocene and Postpliocene times no one can deny; but I do not believe that an examination of the recent species alone, as now existent on both sides of the isthmus, will enable us even approximately to conclude at which of the two periods particular species migrated. Issel assumes that the amount of variation from a supposed Mediterranean type is a fair measure of the time at which the variation began; in other words, of the time when the separation took place. *Nassa circumcincta* varies much from *N. gibbosula*, *therefore* it came over in the Pliocene period; *N. costulata*, var. *erythræa*, varies little from *N. costulata*, *therefore* it did not come over till the Postpliocene. This I should deny entirely, because it assumes as a basis of comparison what does not rest upon a shadow of foundation, viz. that all species form varieties with equal rapidity, and that it takes a longer time for a species to form a marked variety than it does to form a slight one.

The following marine shells, now living in the Mediterranean, occur in Postpliocene beds at Suez:—

Gastrochæna, sp. (*prob.* dubia, *Penn.*).
Solecurtus strigilatus, *L.*
Petricola Hemprichii, *Issel* (=lithophaga, *Retz*).
Arca lactea, *L.*
—— Noæ, *L.*
Modiolaria cœnobita, *Vaill.* (=marmorata, *Forb.*).
Nassa mutabilis, *L.*
—— costulata, *Ren.*
Murex trunculus, *L.*
Calyptræa chinensis, *L.*
Patella cærulea, *L.*

Donax trunculus, L., and *Cardium isthmicum*, Issel (=*edule*, L., var.), occur in the raised beaches of the Bitter Lakes, but not at Suez.

Five of these species (if *Arca Noæ* is not a misidentification of *arabica*, Forsk., and *Patella cærulea* of *rota*, Chemn.) are no longer living in the Red Sea, viz. *Nassa mutabilis*, *Murex trunculus*, *Calyptræa chinensis*, *Patella cærulea*, and *Arca Noæ*. Why these species should have ceased to exist in the Red Sea while others have lived and flourished is a point of which no satisfactory explanation can be offered. It is certainly not a case where littoral species have succumbed to a great increase of temperature. On the other hand, it is noticeable that of the remaining six species, Issel allows that two, viz. *Petricola Hemprichii* and *Modiolaria cœnobita*, still live in the Red Sea in the typical form. (*Murex trunculus* and *Nassa mutabilis* have both been reported as living in the Red

Sea, but on insufficient grounds.) It seems therefore likely, on *à priori* grounds alone, that representatives of the remaining four species exist also in the Red Sea in the typical form, and not, as Issel holds, as varieties.

My own views, as will have been gathered from preceding papers, while entirely discarding the extravagancies of Philippi, recognize a much closer connexion between the Mediterranean and Red-Sea species than does Issel. The similarity or dissimilarity, the union or separation of species cannot be settled in an offhand manner by the brief examination of a few picked museum specimens, but must be the result of a patient comparison of large numbers of examples *in every stage of growth* and in different phases of modification. Forms at first sight distinct will often be united by the discovery of an intermediate form, combining or modifying the peculiarities of both; and the more the investigation of the sea-bottom is carried on, the more these intermediate forms will inevitably occur. In the old days, when the conchologist was the collector and nothing else, an intermediate form was to him a *bête noire*—a creature which ran foul of his monographs and threatened to diminish the number of his species, and accordingly had to suffer suppression or destruction. The science has taken a turn since then, or rather has begun to deserve the name, and an intermediate form is now welcomed as an explanation, not scouted as a puzzle.

After the most careful examination of large series, drawn from both seas, I have come to the conclusion that the following species are, at the present time, common to the Mediterranean and the Red Sea; that is to say, that between specimens taken from the two seas no point of permanent varietal difference, however small, can be named which is not disproved by the examination of a large number of specimens. I believe, too, that if such specimens were mixed up together, a thoroughly good conchologist would be unable to separate them:—

Cerithium (Pirenella) mammillatum, *Risso* (=Caillaudi, *Pot. & Mich.*).
Emarginula elongata, *Costa.*
Chiton (Lophyrus) siculus, *Gray* (=affinis, *Issel*).
—— (Acanthochites) discrepans, *Brown.*
Volvula acuminata, *Brug.*
Philine aperta, *L.* (=Vaillanti, *Issel*).
(Leuconia denticulata, *Mont.*)
Pecten varius, *L.*
Lima inflata, *Chemn.*
Spondylus gæderopus (=species known as *aculeatus*, Chemn.).
Modiolaria marmorata, *Forb.* (=cœnobita, *Vaill.*).
Arca lactea, *L.*
Venerupis irus, *L.* (=macrophylla, *Desh.*, + derelicta, *Desh.* &c.).
Petricola lithophaga, *Retz.* (=Hemprichii, *Issel*).
Tellina balaustina, *Poli* (=Isseli, *H. Ad.*).
Gastrochæna dubia, *Penn.* (=Rüppellii, *Desh.*).
?Pholas dactylus, *L.* (=erythræa, *Gray*).

Besides the above seventeen species I should add the following two (which MacAndrew did not find at Suez) on the strength of Issel regarding them as varieties :—

Nassa costulata, *Ren.* Solecurtus strigilatus, *L.*

Thus, while holding to the undoubted fact that variation must be due to modification of physical conditions, I should maintain with Semper* that the converse is not necessarily the case, and that modification of physical conditions does not, in some cases, produce a measurable amount of variation. Why this should be the case must remain unexplained. It is possible that different conditions of temperature, different chemical constituents of water, &c., act less on certain species than on others, and that while a particular genus or a particular species would be profoundly modified by such differences as exist between the waters of the Red Sea and the Mediterranean, other genera and other species would remain practically unaffected. The facts seem to point in this direction, for how otherwise can we account for the extraordinary parallelism of species exhibited in Issel's list of equivalent species, and the simultaneous similarity of the species enumerated in the list given above. It has been shown that earlier or later dates of migration cannot be relied upon to explain these facts; the only true explanation must be that altered physical conditions act very unequally upon different genera, and even upon different species of the same genus.

It may at the same time be remarked that, for purposes of comparison between the water of the two seas, it will not be a fair test to take the mean amount of saltness, temperature, &c. of the Mediterranean generally and compare it with that of the Red Sea. The mean surface-temperature of the Mediterranean is, of course, considerably below that of the Red Sea, probably as much as 10° F., and, on *à priori* grounds, it would seem unlikely that Mollusca could endure a change of 10° F. in the temperature of the water in which they live without undergoing considerable modification. But the comparison must be made between the water from which the species actually migrated and that where they now are, viz. the water at Port Said and Suez, and then, as far as temperature at least is concerned, there is no very marked difference. The mean annual surface-temperature † of the sea at Port Said is 70°–71° F.,

* "Hence every change, as for example in the composition of the water of a lake or river, will not affect the fauna inhabiting it equally and as a whole, but will act on individuals; some will bear the change without being in any way affected by it, others will die, while others again will survive; but their habits of life will be changed, and at the same time their structure will be modified."—*Semper, 'Animal Life,'* p. 177.

† Taken from the publications of the Meteorological Office.

the minimum being 62°, the maximum 80°; the same at Suez is 74°–75° F., minimum 68°, maximum 80°. This, it must be remembered, is the surface-temperature, and any difference therein exhibited would have a tendency to diminish when the water at several fathoms' depth was examined. It does not appear that the amount of salt contained in the sea-water at these places has ever been definitely compared by experiment; but, judging from what one can learn of the water at Suez *, and of the average saltness of the Mediterranean †, there does not appear to be any large difference between them.

That separation from the parent stock will in the end prevail, and that these Red-Sea shells will gradually become more and more unlike their Mediterranean ancestors, is not denied. Differences, however slight, may in the end establish themselves, though it be quite possible that the Suez Canal may do something towards the equalization of the character of the water of the two seas as well as in introducing fresh batches of the parent stock. It seems no unreasonable assumption that species which were the first to migrate in Postpliocene times will be the first to migrate now; at any rate, they are at least as likely to migrate as any others. At the same time I fully anticipate that, as the Red Sea becomes better explored, forms will be discovered which will connect species hitherto regarded as distinct, and thus the list that I have here presented will become gradually increased.

It only remains to mention in this last connexion a very interesting and remarkable paper by Dr. Conrad Heller ‡, which shows that the opening of the Suez Canal has, apparently, already induced several species of Mollusca to start on their travels, not only from the Mediterranean to the Red Sea, but in the reverse direction as well. Indeed, while at least two undoubted Red-Sea species (*Mactra olorina*, Phil., and *Mytilus variabilis*, Krauss) had, in 1882, established themselves at Port Said, only one Mediterranean species (*Cardium edule*, L.) had reached even the large Bitter Lakes, and it might possibly have been living there before, as *C. isthmicum*,

* The sea-water at Suez contains a very small fraction over 4 per cent. of saline matter. Maury, 'Phys. Geogr. of the Sea,' p. 190; Trans. Bomb. Geogr. Soc. vol. ix. 1849–50.

† "Recent experiments have shown that the water of the Mediterranean contains full 4 per cent. of salt. M. Bouillon la Grange investigated the subject with great perseverance, and his conclusion is, assuming the proportion of saline matter in the water of the Atlantic Ocean to be 38, that of the English Channel will be 36, and that of the Mediterranean 41."—*Smyth, 'Mediterranean,'* p. 127.

‡ "Die Fauna im Suez-Canal und die Diffusion der mediterraneen und erythräischen Thierwelt." Dated Zurich, Sept. 1882.

Issel. Two other species (*Pholas dactylus*, L., and *Solen vagina*, L.) had reached Ismailia. One could wish it were not so proverbially difficult to prove a negative; for, if *Mactra olorina* and *Mytilus variabilis* did not exist at Port Said, or in any part of the Mediterranean, prior to the opening of the Suez Canal (and in the total absence of evidence the other way, one may fairly assume this to have been the case), their passage from one sea to the other in the short space of thirteen years is an event remarkable in the history of distribution. It will be interesting, too, to notice whether the species in question have undergone, or are undergoing variations as a result of their change of locality.

XXXIX.—*Note on the Structure of* Crotalocrinus. By P. Herbert Carpenter, D.Sc., F.R.S., F.L.S., Assistant Master at Eton College.

The third part of Messrs. Wachsmuth and Springer's "Revision of the Palæocrinoidea," the second section of which has recently appeared *, contains the following statement respecting the suborder "Articulata," which, as defined by the authors, includes the family Ichthyocrinidæ, together with the three genera *Crotalocrinus*, *Enallocrinus*, and *Cleiocrinus*:—

"We maintain, however, that the outer test of the ventral side in this group was a continuous integument, composed of calcareous plates, united by ligament and not by a close suture, and that by reason of this structure and the articulation among the plates of the dorsal side it must have been pliant or flexible. . . . . That there was an inner integument roofed in and covered by the flexible vault we have mentioned, and that it contained the summit-plates and 'covering pieces,' we know to be true in the Crotalocrinidæ, and we think it altogether probable that the general plan of the ventral structure for the Articulata generally is expressed in that of *Crotalocrinus*."

This last paragraph contains a somewhat positive and emphatic statement. The authors "know it to be true" that *Crotalocrinus* had a flexible vault above the summit-plates, which, be it remembered, themselves covered in the disk on which the peristome and ambulacra were situated. It has generally been considered hitherto that the summit-plates of

* Proc. Acad. Nat. Sci. Philad., March 30, 1886, p. 64. The paging of the separate copy is 140, and in future references the pagination of the entire work will be quoted, not that of the Philadelphia "Proceedings."