as the recent remarkable displays have been attributed to the volcanic dusts of Krakatoa. The peculiar phenomena in the skies, like those described, were not noticed at Tientsin in the spring. This may be accounted for by atmospheric conditions being changed, and the air at this season of the year being overcharged with too much fine material derived from the dust-storms which form, during March and April, so marked a feature of the climate of northern China. I think it quite probable, however, that red skies, similar to those recently observed in various parts of the world, may at times be seen throughout the winter by foreign residents at Peking and Tientsin.

A few more words about loess-dust. During the winter referred to I was much interested in the question of the loess that was annually being removed from the land and carried out to sea, and not only was impressed with the amount transported by streams, but was led to believe that a not inconsiderable quantity was borne eastward by the prevailing winds, and finally precipitated upon the ocean. Inquiries brought out the fact, that, in the China seas, ships many hundred miles from land frequently report showers of fine material falling upon the decks, which in many cases have been wrongly regarded as deposits of volcanic dust. In conversation with the captain of the steamship China, on the passage from Yokohama to Hong Kong in the autumn of 1879, he narrated his experience in a dust-storm, while passing over the same route in the preceding spring. The storm occurred April 25, in latitude 29°, longitude 128°. It lasted twelve hours, with a heavy wind blowing steadily from the north-west. Every thing on board was coated with an excessively fine dust, which, as the captain expressed it, "was so thick that it could be taken up with the fingers like so much snuff." From the rigging, one of the sailors, under orders from the captain, collected with a knife-blade a large amount of the dust, samples of which he forwarded to London for examination. Now, I very well remember that in April the whole plain of northern China was enveloped in several severe dust-storms; two of them, at least, having a duration of three days each, and filling the air at times with dust, so as to completely obscure the sun. There is no question in my mind but that the material which fell upon the steamship came from the loess of China; and I believe that a great deal of the so-called volcanic dusts which are often reported as observed at sea are, at least in Chinese waters, derived from loess-deposits. Arnold Hague.

THE EVOLUTION OF THE CEPHALOPODA.—I.

Cephalopods, or cuttlefishes, have structural peculiarities which make them the most favorable subjects now known for the special study of the problems and laws of the evolution of forms in time. In two of the orders the animals were shell-covered; and the shell in these is so built that it preserves, even in the fossils, the embryo, the young shell, and all its stages to the full grown. Then, passing on into old age, it shows in the senile period a series of retrograde transformations, often reversing its adult condition and aspect. This record of the entire life is fuller than any one who has not minutely studied this type can imagine from his experience in other branches of the animal kingdom. It is not only in itself a complete cycle of changes, and these of no slight or doubtful character, but the external records of the shell-structure, apertures, and other parts, are supplemented by the hard portions of two internal structures, which are preserved, and also change in accordance with the age of the shell. We have, therefore, in every well-preserved specimen, the unique advantage of being able to study the complete cycle of its individual life in three distinct sets of organic parts. We can therefore compare the changes which we observe in the individual with the modifications which the group has undergone in its progression or retrogression in geologic times with a certain completeness of the evidences, at present unattainable in any other class of animals. In the Belemnites, the third order, the shell and its parts are much less instructive; and finally, in the fourth, the Sepioidea, it is so much reduced, and so frequently absent, as to lose very largely in this respect.

The class has two sub-classes, Tetrabranchiata and Dibranchiata. These were established by Richard Owen as orders,—a purely technical difference, which does not change in any way the value of the structural distinctions as given by this eminent naturalist. The Tetrabranchiata are shell-covered; and they are represented by the modern Nautilus, the only existing genus. The Dibranchiata are descendants of the former, but enclosed the shell, and resorbed it in many forms, so that they appear as naked animals. The cuttlefishes, squid, devil-fishes, etc., are existing types. In studying these types, the author has been led to adopt a new method of characterizing the divisions, and besides the old structural distinctions, which are still available, to apply the

correlations of habit and structure to the elucidation of ordinal differences.

The class Cephalopoda is composed of exclusively aquatic and marine animals, and consequently they breathe with gills. The structures of the two sub-classes coincide with two distinct habitats which they respectively occupy. The Tetrabranchiata, like the Nautilus, were essentially littoral crawlers, though possessing organs suitable for swimming, and doubtless using them more or less for leaping and swimming.

The animal of the Nautilus has a large mantle or fleshy sac enclosing the internal organs, which can be opened around the margin, or closed, at the will of the animal. Admitting the water around the margin, they fill their mantle-cavities with water, and then, closing and compressing the mantle-sac, force it out with violence through a fleshy pipe, which is exclusively used for that purpose, and always situated on the ventral side. The reaction of the stream is sufficiently powerful to drive the body of the animal with varying degrees of swiftness backwards. The fleshy pipe is therefore an ambulatory pipe or hyponome; and we propose, in place of the old and confusing terms, to call it by this name.

The Dibranchiata change the external shell, which they inherit from the Tetrabranchiata, into an internal organ, and taking advantage of the powerful hydraulic apparatus of the Tetrabranchiata, which they also inherit, and increasing its efficiency, become, as is well known, exclusively swimmers.

The ambulatory pipe of the Nautilus causes a corresponding depression or sinus to occur in the aperture of the shell on the outer or ventral side, and its effect is also to be seen in the striae of growth throughout the entire length of the shell on the ventral side; so that we know, from these indications in any fossil, what was the comparative size of the pipe, and whether the animal was more or less powerful as a swimmer. Other indications, such as the openness or contracted form of the various apertures of different genera, exhibit with equal clearness what they could do in the way of crawling. The wide-open apertures indicate powerful arms, capable of carrying and easily balancing the large spire of the shell above: the narrow contracted aperture shows that the arms were small, and that the animal could not so efficiently balance or carry the shell in an upright position, and was therefore, according to the amount and style of the contraction, more or less inefficient as a crawler.

In studying the different types of the Tetrabranchiata, we find that there are two orders as first defined by Professor Louis Agassiz, — the Nautiloidea and the Ammonoidea, — and, further, that these divisions coincide with differences in the outlines of the ambulatory sinuses which indicate distinctions of habit general throughout each order.

The extinct Nautiloidea have large ambulatory sinuses, and were evidently capable, like the modern Nautilus, of rising to the surface, and swimming with a jerky motion; though their open apertures, as a rule, show their normal condition to have been crepitant, or bottom-crawling. The exceptional shells, which depart from the typical form in the sinus and apertures, exhibit their peculiarities in the adults, but not, as a rule, in the young, except in cases where direct inheritance can be proven to have occasioned the exception. The exceptions, then, are, in fact, the most conclusive of our proofs, since they show the power of the habitat to produce permanent changes in the apertures.

The orthoceratitic shells of this order are straight cones, with internal septa dividing them into air-chambers, connected by a tube uniting all the air-chambers, and opening into the body of the animal itself, which occupied a small part only of the whole length of the cone. This is the simplest form: and others are, the bent or arcuate, cyrtoceratitic; the loosely coiled, but with whorls not in contact, gyroceratitic; the closely coiled, with whorls in contact, nautilian; and the still more closely coiled or involute shells, the involute nautilian, in which the outer whorls may simply overlap the inner, or entirely conceal them by their excessive growth, as in Nautilus pompilius.

The Ammonoidea in their earlier forms, the Goniatites, have apertures, with a less strongly marked ambulatory sinus, but still sufficient to show that they must have had considerable powers of rising or leaping in the water, if not of swimming, like the Nautilus. In their later forms, the Ammonitinae, however, the ambulatory sinus is absent; and in its place projecting beaks or rostra are developed, indicating reduction in the size and use of the ambulatory pipe. This and the generally open apertures enable us to see that they were more exclusively bottom-crawlers than the Nautiloidea. The most interesting of the facts in this order lies among the exceptional shells, some of which must have been sedentary, and neither have crawled nor moved about with any ease; but none of these, so far as we know, seems to have exhibited a type of aperture which in-

dicated transition to an exclusively swimming habit. These shells appear in our subsequent remarks among the geratologous and pathological types.

The shells of this order have no such variety of form in the paleozoic formations as we have described in the Nautiloidea. They are close coiled, and even involute, in some of the first forms found in the Cambrian.

The Belemnoidea of the Jura had a solid cylindrical body, called the guard, attached to the cone-like internal shell, and partly enclosing it. Aulacoceras of the trias, as described by Branco, is a transitional form with an imperfect guard, which frequently contains fragments of other shells and foreign matter. This demonstrates an important link in our evidence, that this guard could only have been built by some external flap or enclosing sac, independent of the true mantle. This false mantle must have enclosed both the shell and the guard, and must have been at the same time open, so as to admit the foreign materials which Branco found built into the substance of the guard. One of the straight shells of the Silurian Nautiloidea, Orthoceratites truncatus, regularly breaks off the cone of its shell, and then mends the mutilated apex with a plug. This plug, we are able to say, is the precise homologue, in position and in structure, of the guard of the Belemnite. Barrande showed this plug to have been secreted by external organs, as he supposed, — two arms stretching back from the aperture like those of Argonauta, and reaching beyond the broken apex. The dorsal fold of Nautilus is, however, a secreting-organ stretching back over the shell; and, as the probable homologue of the plug-secreting organ of the Orthoceratites and the guard-building organ of the Belemnoidea, it enables us at once to explain how the Belemnoidea arose from the Orthoceratites, and why Aulacoceras had an imperfect mantle. This fold, which was far larger among the ancient Orthoceratites, would have been necessarily open on the ventral side, then more but not completely closed in Aulacoceras, and finally completely closed in the later Belemnoidea, and able to construct a guard as perfect as that which they carry.

The solid guard of these animals in a compact cylindrical body, such as they were known to possess, could have been only a heavy burden to a swimming animal. The Belemnoidea, therefore, were not purely natatory; but for these and other reasons, which we cannot here discuss, they were evidently ground-swimmers, probably boring into the mud for shelter, or as a means of concealing themselves while lying in wait for their prey.

The old view, that the guard could have been in any sense a 'guard' against collisions with rocks, etc., in their wild leaps backwards, is inadmissible for many reasons. The most obvious are its position as an internal organ, its solid structure, and its weight. We think it more reasonable to suppose that it might have increased the liability to injury from collisions. In tracing the Belemnoidea to the Orthoceratites we have simply continued the labors, and carried out more fully the sagacious inferences, of Quenstedt and Von Ihering.

The modern Sepioidea are known to be almost exclusively swimming types; and the more ancient, normal, flattened forms, and their descendants the existing cuttlefishes, have flattened internal shells, in which the striae of growth are remarkable for their forward inflection on the dorsal aspect, due to the immense comparative length of this side of the aperture. Gonioceras, a well-known Silurian type of the orthoceratitic Nautiloidea, has the same contours in the striae of growth on the dorsum; and if, as we think, it had a corresponding depression in the aperture on the ventral side, in similar proportion to that of other forms, the aperture must have been transitional to the internal shell of Paleoteuthis Dunensis of the Devonian, and to the more modern forms. The septa, also, of Gonioceras, have similar curves to the layers of calcareous matter in the interior of the cuttlefish bone, which we look upon as aborted and retrogade homologues of the septa of other forms. Gonioceras connects directly with a series of less compressed, straight, orthoceratitic shells; and thus the independent derivation of the Sepioidea from the Orthoceratites, among the shell-covered, coniform Tetrabranchiata, is probable. The enclosure and suppression of the shell have already been predicted, with a sagacity which commands our highest admiration, by Lankester, from studies of the embryo of Loligo; and these facts carry out his conclusions, substituting, however, the more ancient Sepioidea for the Belemnoidea, with which Lankester made his comparisons, and the hood for the two mantle-flaps which were imaged by him as the organs which enclosed the shell and formed the shell-sac. Most paleontologists have considered the Sepioidea and Belemnoidea as more closely allied; but they appear to us as two orders, certainly as distinct as, and perhaps even more widely divergent than, the Nautiloidea and Ammonoidea.

Among these two orders we recognize many

exceptional forms, — such as the Spirula among Belemnoidea, and among Sepioidea the octopods; and we think they all prove our position, that the habitat so closely accords with the structural changes of the type that its purely physical agency must be regarded as the efficient and direct cause of the correlated changes of structure which distinguish the different orders and sub-orders, and often of the exceptional genera and species. We will mention but one of these exceptional cases, in some respects the most pertinent, — the existing Argonauta, or paper nautilus. Here a thin shell secreted by the mantle, by the edge of the mantle, and by the two pairs of long dorsal arms, encloses completely the animal of the female alone, the male being naked. As a sexual organ for the protection of the eggs; as an adolescent and adult structure, originating at a late stage in the life of the individual, and not in the shell-gland of the embryo; and in its microscopical structure, — it is not a true shell, or similar to any true shell among Cephalopoda. Still, in form and position, and as built in part by the mantle, it is a homologue of a true shell, and has in part, also, the functions of a true external shell, and ought therefore to support or refute our hypothesis. It belongs to a swimming animal, and should therefore have the sinus and aperture and striae of growth as in Nautiloidea; and these it certainly has. We can appeal to this example as a most convincing exception to prove the rule that the shell is a true index of the most remarkable adaptive structures, and, among the fossils, can give us exact information of important differences in structure and habits.

The *efforts* of the Orthoceratite to adapt itself fully to the requirements of a mixed habitat gave the world the Nautiloidea: the *efforts* of the same type to become completely a littoral crawler developed the Ammonoidea. The successive forms of the Belemnoidea arose in the same way; but here the ground-swimming habitat and complete fitness for that was the object, whereas the Sepioidea represent the highest aims as well as the highest attainments of the Orthoceratites, in their surface-swimming and rapacious forms.

We cannot seriously imagine these changes to have resulted from intelligent effort; but we can fully join Lamarck,[1] Cope, and Ryder, in imagining them as due to efforts induced by the physical requirements of the habitat, and think this position to be better supported by facts than any other hypothesis.[1]

Confining ourselves to the Tetrabranchiata, which we think the most favorable for our purposes, the next problem presenting itself is whether the two orders, Nautiloidea and Ammonoidea, have had a common origin, or whether they bear internal evidence of having had a distinct origin. The embryo of all Ammonoidea, as shown by the author in his 'Embryology of the fossil cephalopods of the Museum of comparative zoölogy,' and since confirmed by the more extensive researches of Dr. Branco, is the little bag-like shell first discovered by Saemann. This is attached to the apex of the secondary shell. The embryonic bag is called the protoconch by Professor Owen; and the secondary or true shell, the conch.

There is no protoconch in Nautiloidea, as first shown by Saemann, then by Barrande, and subsequently by the author and Branco; but where it ought to have been attached on the apex of the conch, or true secondary shell, there is a scar, first demonstrated by Barrande. The view brought forward by the author, that this scar indicated the former existence of a protoconch in the Nautiloidea, has been opposed by Barrande, Branco, and several authors, on the ground that the cicatrix demonstrated the existence of a distinct embryonic form. Therefore, according to Barrande, the Nautiloidea were not similar to the Ammonoidea in their earliest stages of growth, and must have been equally distinct in origin.

Our present contribution to this discussion is simple and straightforward. We have found the protoconch in several forms of Orthoceratites, of some of which we give figures; and, further, it can probably be found on the apex of the so-called perfect shells, which have no scar or cicatrix. These were discovered by DeKoninck, and supposed by him, in his 'Calcaire carbonifère' (*Ann. du mus. roy. de Belgique*), to be fatal to our conclusion. Having no scar, they could not possibly, according to DeKoninck, have had a protoconch. When the so-called perfect apex is broken off, the observer will probably find that this apex was the shrivelled remains of a protoconch which concealed the cicatrix underneath, as in Fig. 2. There is therefore no essential difference between the embryos of the Ammonoidea and those of the Nautiloidea. There are some of

[1] A noted French writer well known to embryologists, Lacaze-Duthier, has lately asked, "Who, at the present time, supports Lamarck?" The author can answer, that some of our leading scientific men consider Lamarck's hypothesis to contain more fundamental truths than Darwin's or any other.

[1] We can also confidently appeal to Dohrn's hypothesis of change of function in support of this view, in which he shows with many convincing examples that organs have latent functions which can be developed by any change of habits, and then become predominant over the older functions, and by their reactions occasion an entire change in the structure of the organs themselves.

minor importance which we cannot discuss here. These, however, do not interfere with the facts of general agreement; and there is great probability that the shell-covered forms of all kinds which have the protoconch — namely, the ancient and modern Gastropoda, Tentaculites, and the ancient Pteropoda, and all the radical forms of Cephalopoda — had a common origin, probably in some chamberless and septaless form similar to the protoconch. Von Ihering has already designated this prototype as probably Tentaculites. No exact correspondent to the protoconch is yet known to us; but certainly Tentaculites is nearer to the protoconch of both Cephalopoda and Gastropoda than any other known ancient form.

The young of the simplest and earliest of Ammonoidea, the Nautilini, have in varieties of two species, as shown by Barrande, a straight apex, like the adult shell of Orthoceras, the radical of the Nautiloidea. We have already claimed that this fact was sufficient to prove the high probability of a common origin from a straight shell like Orthoceras for both of these orders; and we are now able to reiterate this conclusion, and to meet the objections of the great paleontologist Barrande, and his supporters, more effectually than ever before.

Goniatites compressus, sp. Beyrich (*Sand. verst. Nassau*, pl. 11, fig. 4), is a shell which differs from all other Ammonoidea in an essential and highly important character. The septa have no inner lobe. The v-shaped annular lobe which occurs in all the Ammonoidea except the Nautilini is also absent in this species. What is more to the point, this shell has the sutures of a true nautiloid, since it has the dorsal saddle, in place of the dorsal lobe, of the sutures of its nearest allies, the Nautilini, and all of the remaining Ammonoidea. Goniatites ambigena Barr., of the Silurian, is a close ally of this Devonian species, and the two are the only Ammonoidea which are not truly nautilian in form. The whorls are in contact; but there is no impressed zone, and no sutural lobes on the dorsum, as in true nautilian shells. On the contrary, they are purely gyroceran forms, with rounded dorsum and sutural saddles in place of lobes. All of the Nautilini and G. compressus also have the septa concave, as in the Nautiloidea, in place of the convex character of the septa in later Ammonoidea. As doubts may disturb the mind as to whether G. compressus is an ammonoid at all, we recommend a comparison of this shell with the young of Goniatites fecundus of Barrande, which is a miniature copy made by heredity.

Bactrites is a perfectly straight form, similar to these Goniatites in very important characteristics, especially the siphon and septa.

This same genus includes straight cones like

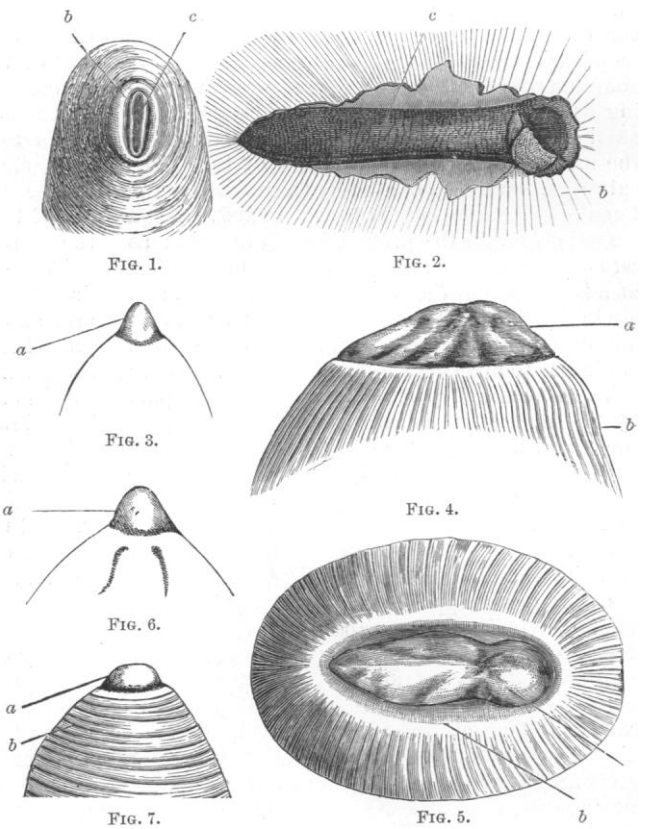

FIG. 1. FIG. 2. FIG. 3. FIG. 4. FIG. 6. FIG. 7. FIG. 5.

FIG. 1. — Aspect of the apex of the conch in Orth. unguis Phill., after the protoconch has been shed in the usual manner. *b*, conch or shell of the apex; *c*, cicatrix.

FIG. 2. — Aspect of the apex, after the protoconch has been accidentally broken off, fracturing the outer shell, and exposing the cicatrix. *b c*, as before.

FIGS. 3-5. — Apex and protoconch of Orth. elegans Munst. from the front, side, and above. *a*, protoconch; *b*, shell of apex.

FIGS. 6, 7. — Another individual, said to be of the same species, less magnified. *a b*, as before. The author has also, in other species, traced the striae of the outer shell on the protoconch itself, showing the continuity of the shell over this part (*a*), and completing the evidence that it must have been the shell which enclosed the embryo, and could not have been a mere plug, as asserted by Barrande (*Syst. sil.*, pl. 488).

Orthoceras pleurotomum Barr. (*Syst. sil.*, pl. 296), which are undeniably transitions to true Orthoceras in their striae of growth and position of siphon. There is therefore convincing evidence in the structures of these Cambrian shells that the Ammonoidea, with their distinct embryos, arose from the orthoceran stock, and passed through a series of forms, in times, perhaps, preceding the Cambrian, which were parallel to those characteristic of genetic series among Nautiloidea; viz., straight, arcuate, gyroceran, and nautilian.

The researches of Emmons and Marcou in this country, and the discovery of ten thousand feet or more of stratified rocks under the Cambrian by the U. S. geological survey, and the inferences of Bigsby from the extended study of Silurian and Devonian fossils, are beginning to place the probable existence of a prepaleozoic period beyond question, in spite of the really grand opposition and world-wide researches of Barrande. The study of the tetrabranchs teaches us, that, when we first meet with reliable records of their existence, they are already a highly organized and very varied type with many genera, and that the name 'paleozoic,' as applied to these first records, is a misnomer. There was a protozoic period; and the tetrabranchs, like their successors, certainly must have had ancestors which preceded and generated them in this period, but of which we are at present necessarily ignorant. Whatever the future may have in store for us we cannot now predict; but at present the search for the actual ancestral form, though necessary, is nevertheless not hopeful. We can, however, rely upon the facts of embryology, and predict without fear of failure, that, when our k owledge makes this prototypical form known, it will have a decided resemblance in structure and in aspect to the earlier stages of the shell as observed in the fossil cephalopods.

(To be continued.)

SCALES OF COLEOPTERA.

SOME of the more interesting forms of scales of Coleoptera described in the paper by Dr. George Dimmock, noticed in *Science*, i. **455**, are shown in the annexed figures. The scales of the carpet-beetle, Anthrenus scrophulariae, and of the museum pest, A. varius (fig. 1), resemble in general form those of many Lepidoptera, as do also the scales of Valgus squamiger (fig. 3). The scales of V. squamiger are, however, hairy, in fact, almost shaggy. The scales of Hoplia coerulea (fig. 2) vary from round to lanceolate, those of the dorsal surface being transparent yellow when viewed by transmitted light, and blue by reflected light. Those of the ventral surface are purplish, purplish red, red, bluish, and colorless by transmitted light, while by reflected light they are silvery white, with at times a tendency to metallic green. The scales of the dorsum are smooth, filled with fine reticulations (fig. 2, *d*), but those of the ventral portions and of the tip of the abdomen are covered with fine hairs representing the branches of the ordinary hairs of scarabaeidous beetles. The scales of Chalcolepidius rubripennis, an elaterid, are transparent brown when seen by transmitted light, but by reflected light appear bronzed blue, green, or red. Their form is seen in fig. 4. The black and white scales of Alaus oculatus (fig. 5), which give rise to the entire figuration of that curiously marked elaterid, although not of especially pe-

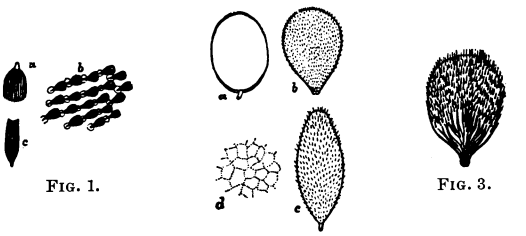

FIG. 1. FIG. 2. FIG. 3.

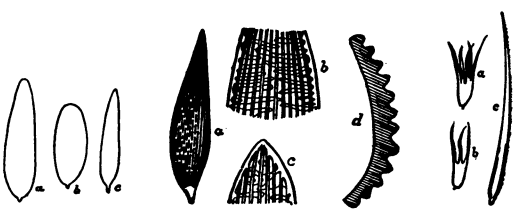

FIG. 4 FIG. 5. FIG. 6.

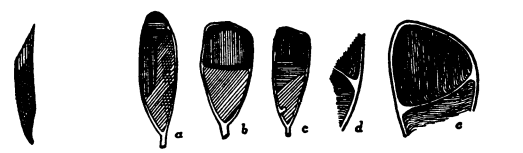

FIG. 7. FIG. 8.

FIG. 1. — Scales of Anthrenus: *a*, of A. scrophulariae; *b*, arrangement of same on portion of an elytron; *c*, scales of A. varius. Enlargement: *a* and *c*, 100 diam.; *b*, 50 diam.

FIG. 2. — Scales of Hoplia coerulea; *a*, from elytron; *b*, from under side of thorax; *c*, from femur; *d*, fine structure to be seen in *a*, with high powers. Enlargement: *a*, *b*, and *c*, 100 diam.; *d*, 500 diam.

FIG. 3. — Scale of Valgus squamiger. Enlarged 100 diam.

FIG. 4. — Different forms of scales from Chalcolepidius rubripennis. Enlarged 100 diam.

FIG. 5. — Scales of Alaus oculatus: *a*, brown scale; *b* and *c*, portions of white scales to show cross-bands; *d*, transverse section of a brown scale. Enlargement: *a*, 100 diam.; *b* and *c*, 300 diam.; *d*, 500 diam.

FIG. 6. — Scales and hair of Ptinus? rutilus: *a* and *b*, scales from elytron; *c*, hair from elytron. Enlarged 100 diam.

FIG. 7. — Scale of Clytus robiniae. Enlarged 100 diam.

FIG. 8. — Scales of Entimus imperialis: on *a*, *b*, and *c*, vertical lines indicate blue, horizontal lines indicate carmine red, and oblique lines yellow; where two kinds of lines cross, one color is tinged with the other; on *d* and *e* the fine lines represent the finer striation of the inner layer of the scales. Enlargement: *a*, *b*, and *c*, 100 diam.; *d* and *e*, 300 diam.