It is evident that in the Tonga Group, which is a very extensive area of elevation, the recent corals have played no part in the formation of the masses of land and of the plateaus of the Tonga Ridge, and that here again, as in the Society Islands and Cook Islands, both also in areas of elevation, they are a mere thin living shell or crust growing at their characteristic depths upon platforms which in the one case are volcanic, in the other calcareous, the formation of which has been independent of their growth.

We expect to leave for the Ellice, Gilbert, and Marshall islands as soon as we can coal and refit.

A. AGASSIZ.

THE OCCURRENCE OF APTOSOCHROMATISM IN PASSERINA CYANEA.*

THE following remarks upon the Aptosochromatism of *Passerina cyanea*, although of insufficient importance to establish the phenomenon of color change without moult as a constant occurrence in the species, are conclusive enough, I am convinced, to prove the possibility of such a change, and are merely offered as such for what they may be worth.

Individual error and dogmatism have greatly retarded honest effort in this most important branch of ornithological science. It is a singular fact that certain individuals have conceived the idea that a feather once having passed its premature condition is utterly disconnected with the vital system of the bird, and such individuals cling to this belief with a tenacity wonderful to behold. They do not tell us, by the way, how it is that certain species of birds lacking external sebaceous glands manage to present as bright plumage as their allies so provided. Doubtless they may attribute the presence of oily matters upon the surface of the feathers of those species in which these glands are wanting to osmotic action; but admitting this, why not admit Aptosochromatism?

In his article on alleged changes of color in feathers (Bull. Am. Museum Nat. Hist. 1896), Dr. Allen compares a feather to a green leaf, which when once formed, cannot extend its growth to repair any injuries which may arise from insects, etc. This simile might well be carried yet farther and to better advantage. When the later summer or early fall approaches, certain leaves undergo a complete change in color, resulting in the beautiful colors of our September and October woods. The history of the underlying phenomena of autumnal coloration in leaves is very obscure, yet no one doubts the occurrence of the change for an instant. So it is with Aptosochromatism—the individual feathers undergo in many cases complete color changes, and although the underlying processes of these changes may be obscure, the fact of their presence is to my mind undeniable.

At the present time Aptosochromatism has not progressed far enough to encourage one to take up in detail the systematic occurrence of the color change in our species of native birds. It seems evident that for the present, attention should rather be devoted to endeavoring to demonstrate its fundamental principles, without which no science is firm, plainly evident as may be its happening.

Passerina cyanea, apart from its seasonal fall moult by which the plumage acquired in the spring is changed for the duller garb of the fall, doubtless exhibts two forms of Dichromatism, a term whose proper place, I hope, is now recognized as the fundamental term for the complex phenomena of double coloration. As I shall direct my attention toward proving that Aptosochromatism is concurrent in the species, and Ptosochromatism in the present paper will play an inconspicuous part. Both are compre-

* Read before the Nuttall Ornithological Club of Cambridge, Mass., June 5, 1899, with exhibition of the bird worked upon.

hensive terms, by the way, coined by Dr. Coues. The latter term may be defined for convenience, as the occurrence of Dichromatism depending entirely upon the loss of old feathers which are replaced by others of a different color. Both processes subserve the same general purpose and result in a seasonal change of color, in the present example, from that of the fall to the nuptial of the spring. The Ptosochromatic change of the spring will not further be considered here—let it suffice to say that beyond doubt some indigo birds change color in the spring by completely, or nearly so, shedding their feathers. The change not due to such feather loss is what interests us at the present, and will necessarily be presented far from exhaustively. My remarks are based chiefly upon observations conducted during the fall, winter, and early spring of 1898–99, upon a captive male bird. In view of the color of the plumage of my bird, at the time I took possession of it, it must have been in the adult condition, and as such birds are commonly captured while in the adult state, the difficulty in adapting my bird to his captive condition and the heavy feather loss undoubtedly resulting from this may consequently, be explained. I secured it October 13th, while it was nearing the completion of its fall moult, which by October 28th was finished. From that date every cast-off feather was carefully collected and labelled. In order to be sure of obtaining all, a fender was placed about the cage and the room carefully swept at frequent intervals. In addition to this I made many examinations of the bird and secured such specimen feathers in a fresh state as I wished for microscopic examination.

Briefly, the bird was fed mostly upon millet and canary seed, appeared healthy, bathed regularly, and during bright days sang frequently. On March 26th, however, he died after an illness of three days, before which he was as lively as ever. Examination showed constipation to be the probable cause of his untimely death. The color change had progressed excellently however, and but little additional information could have been gained had he lived, excepting the period of time occupied by the entire change. Data is present in sufficient quantity, nevertheless, to enable me to state the time occupied by the change in certain portions of the plumage.

The appearance of my bird as regards color, October 28th, was as follows: Feathers of the head and breast slightly tinged with cobalt, the chief color of the feathers being dull rusty. The breast thus was somewhat mottled in appearance. Back rusty, the concealed centers bluish. Primaries and rectrices blackish with blue edges. Secondaries and coverts broadly edged with rust color. Lower abdomen buffy, ventral area whitish.

From October 28th till January 28th I observed no marked color change, but from February until the bird's death, it was very noticeable. A curious and undoubtedly unnormal process intervened however, and in order to understand this comprehensively I will tabulate the feather loss beginning with the first feather shed after October 28th, when it will be recollected that the bird had completed its moult.

Nov. 1,	1	contour	
" 7,	1	"	
" 12,	1	"	
" 21,	2	contours	
" 22,	1	contour	
" 25,	2	contours	
" 29,	1	contour	
Nov. 30–Dec. 5,	4	contours	
Dec. 5–11,	4	"	
" 11–24,	20	"	
" 24–31,	12	"	
Dec. 31–Jan. 7,	11	"	
Jan. 7–23,	3–5	"	daily
" 24,	12	"	
" 25,	16	"	
" 26,	13	"	
" 27 and 28,	61	"	
Jan. 28–Feb. 11,	34	"	

From February 11th to February 28th an average of 50 contours was lost daily. By March 5th the loss had abruptly ceased, and until his death on March 29th the bird lost but one or two feathers daily. The loss of down feathers was very small, not exceeding twenty specimens—a fact of possible importance to be dwelt upon later on. The total summary of the contour feathers lost, carefully estimated at 1350 feathers, appeared to comprise about three-fifths of my bird's entire plumage. They were shed from all parts of the plumage, and in view of the heavy loss I was quite prepared to ultimately conclude that any color change resulting in my bird would ensue from extensive feather loss. I was thus quite unprepared for what eventually followed. Microscopically, the cast-off feathers were broken, abraded and apparently in the worst condition. The barbules were broken or wanting, the barbs in many places worn down, and the rhachis of the larger feathers was split. This is also of importance as will directly be seen. To many observers my bird by March 5th would have been pronounced to be completely moulting. Immature feathers were in prominence especially upon the head and were scattered all about the remaining feathers of the plumage, which, as has been before remarked, amounted to about two-fifths of the entire plumage. The color of a discarded feather, compared with a freshly plucked one from the body, showed in most cases a decided contrast. Not only were the blue portions dull but their superstructures were gone in many cases, the feathers then being dull brownish. A probable, and, as I am convinced, the truthful source of my bird's extensive loss is found indirectly in the temperament of the bird. From the very first it was fretful and timid, fluttering wildly when uncovered in the morning or when the cage was cleaned out. Even an approach in his direction while hanging in the room caused a wild fluttering. Upon such occasions many feathers would be shed, and those remaining were more or less injured. Thus when such a vital process as Aptosochromatism begins to work, these decrepit feathers necessarily would have to be renewed in order to take part in the general plan. The head upon which many pin feathers appeared, naturally received a considerable share of the injury as regards its feathers, and the tail was in a very bad state.

It will be noticed in the table how gradually the loss began, due doubtless to the gradual approach of activity towards color change in the feathers. It must be admitted that this explanation is purely hypothetical, but such a hypothesis, although not of fundamental importance, ofttimes prepares the way for a clearer understanding of the problem under consideration. The small loss of down feathers points in two ways to the truth of this assumption. Firstly, being more or less under the contour feathers they received less of the wear caused to the others, and secondly, having no color change in themselves, their part in the color-changing process was inconspicuous. It is not probable that the bird could have swallowed many down feathers without it being observed in the excrement.

As I frequently examined the bird closely I noticed at once that the developing feathers which were supplying the places of the cast-off ones, far from appearing to change the color of the bird to blue, were actually coming true to the colors in which they were shed, *i. e.*, in the colors of the fall plumage. To be positive I collected and examined extensively and in every case verified this most interesting principle. It will be recollected that in my observations upon the Aptosochromatism of *Chrysotis Levaillanti* (see *Osprey*, III., No. 8, April, '99), similar results were noticed. In later dates a few parti-changed feathers were found in the embryonic condition, but these may be readily accounted for in two ways, for in no cases were fully changed feathers so detected. (1) Where a partially changed feather had been pulled out or shed and was being renewed, and (2) where a feather had begun to change before it was matured (this being noticed in my parrot investigation). Many of the contradictory and confusing remarks of dealers in birds may perhaps be explained by these most important observations, and it may readily be true that more than a few instances of so-called color changes depending upon spring moults in cage birds, may be due to extensive feather losses precedent to an Aptosochromatic change.

It seems unnecessary to dwell upon the fact that no vital process can readily take place in a greatly injured organic structure, and the renewal of my bird's feathers concurrent with the approach of the macroscopic activity of the color change is, I think, an incident of no little value.

The first appearances of a color change were noticed in some of the old feathers of the crown during the first week of February. Here a brightening of the blue area of the feather was noticed but no perceptible change of color at the tips where the russet was. From this date till the death of the bird a slow but constant change occurred, chiefly noticeable on the rump, throat, and breast. The first indication of the approach of the change externally was the brightening of the blue portion of the feather, beginning evenly on each vane from the bottom. When the band of tawny was reached, it appeared slowly to be absorbed until but faint tips of this color could be seen upon the ends of the larger barbs. In no cases were the barbs or barbules broken off sufficiently to account for the change. A loss of one-third of the length of the feathers in many cases would have been the result, and close observation did not sustain this in the least. I was enabled to notice the change in certain breast feathers, which was much more rapid than that of the parrot before referred to. Yet in the latter case the change which gradually causes the yellow plumage is a slow one of life duration, and but few feathers are involved at a time. That of *Passerina cyanea* is one of comparatively short duration and involves the greater part of the entire plumage.

Upon his death the bird presented the following appearance as regards color. An irregular area of brilliant cobalt blue extended from the throat to the belly down the center of the breast, the feathers upon each side graduating gradually to the sides, where but little change had occurred. Head partially changed in parts, inter-scapulars not perceptibly changed at all (a place where many pin feathers formed). Back altered slightly, rump and scapulars $\frac{2}{3}$ changed to bright greenish blue, the long russet tips almost entirely changed in some feathers, wings and tail unaltered with the exception of the secondaries and coverts, which had slightly changed on the edges. Throat slightly blackish, lower ventral region as with the rump. Assuming, as we safely may, that the first of February marked the beginning of the macroscopic change, we may attribute the total length of time occupied in the change of some of the breast feathers, from the fall to the spring colors, to a period of about fifty days, which for some of the feathers is an over-estimate.

It is not a little curious that the feathers should act so independently and especially so when it is considered that each feather comes true in color.

While skins of birds may serve highly important purposes, it appears essential that for good results in investigations upon color change, one should operate rather upon live birds in confinement. It is quite absurd to suppose that a single generation in confinement would so alter the natural laws of the organism as to obscure Aptosochromatism or Ptosochromatism, if one process or the other be a natural tendency. It is objectively certain that the phenomenon of Aptosochromatism occurs widely, but whether of individual or specific occurrence is not yet clearly shown. While my bird threw out no hint whatever as to the constant occurrence of the color change, it did prove that the 'impossibility' is possible.* It is certain that the heavy feather loss of my bird but indirectly helped the change; 1st, we have seen that many feathers changed which were not renewed by moult; 2d, we saw that those feathers which were renewed by direct gain and loss were colored similarly to those which preceded them, but that later on they changed Aptosochromatically, and 3d, no purely blue, *i. e.*, changed feathers, were found in an embryonic condition at any time, although frequent careful examinations of the bird were made.

Although it is of no positive certainty whether, in the new feathers, the vascular connection with the body was severed, it was found that their complete form was attained in most cases a week or more before a change set in; and in those unshed feathers carried over from the fall, it is quite reasonable to suppose that all connections with the body of the bird were as normal as in other feathers of a similar age. Before the change of color had begun, in December or January, in specimens examined carefully under the microscope, I could detect no presence of carrier pigment cells and found the calamus of each feather to be in the expected dried up condition. The change would thus seem to be confined to activity in the feathers alone.

In a brief summary of the principal points already discussed in connection with my bird we may conclude (1) that Aptosochromatism in my *Passerina cyanea* occurred beyond doubt, (2) that although present with severe feather loss it does not follow that the gain of color was directly responsible to it, as proved by careful examination of the newly acquired feathers, and (3) that although the feather loss was objectively independent of the Aptosochromatic change, it might subjectively be so, inasmuch as old and imperfect feathers were renewed for active and healthy ones, in which such a color change subsequently occurred.

The results quoted of Dr. Chadbourne and Mr. Maynard appear to me to be conclusive in themselves and require no further comment. Microscopically, the color change was not of as much prominence as might have been expected at first thought, but it will be recollected that blue and violet colored feathers depend, in a large measure, for their effects, upon involved objective superstructures, which act in combination with some underlying pigment or pigments. These pigments produce chemical objective effects, due to the absorption of all light rays not depending upon the characteristic color of the pigments.

Chemically and microscopically, the feathers of my *Passerina cyanea* appeared to contain two pigments, one, a diffused non-granular tawny colored stain, the other,

* Dr. Chadbourne has informed me, since the above was written, that of three confined male indigo birds observed by him, two changed color ptosochromatically and the third 'without any feather loss to speak of,' *i. e.*, aptosochromatically; and still later on, I was delighted to learn during a conversation with Mr. C. J. Maynard that he too had followed a male *Passerina* through its entire spring change of color. The bird involved, belonged to a friend of Mr. Maynard, who informed him that the bird had changed its colors during the season just passed without moulting its feathers. Determined to follow out the change exactly, Mr. Maynard examined the bird frequently the next season, throughout the entire time occupied by the change, and perfectly satisfied himself that it was totally unassisted by a moult or any considerable loss of feathers.

a granular blackish substance. The yellowish stain was confined to the transparent sheath of the barbs and to the barbules, while the granular matter varied in placement with the color of the feathers.

An unchanged, *i. e.*, fall-colored feather, examined in a fresh state, exhibited the following appearance under the microscope. The rhachis appeared, centrally, to be cellular in construction with an enveloping sheath thickly supplied with the black pigment matter, the granules arranged in an order suggestive of a streaming movement toward the tip of the feather. At the junction with each barb a small portion of the main system curved upward into the central portion of that member. Proximally this column ended in the modification of the rachis into barbs. The center of each barb of the colored parts of the feathers contained a prismatic column, resembling to my eye, a number of bodies set together so as to resemble the nodes and internodes of a bamboo cane. At the distal end of each barb these bodies tapered, and in many cases the extreme joints were separated from the main column. About the blue portions of the feathers, these columns were massed thickly with black matter, the portions giving the rusty effects being much less plentifully supplied, and surrounding this central column a transparent envelope of the yellowish stain was present. The barbules of the non-blue area were the color of this sheath but became well supplied with the dark pigment when the blue-producing area was met with, completely obscuring the presence of the stain. The tips of the prismatic columns showed a pale brownish orange color, but gradually as the microscope slide was passed across the stage the color became deeper until when one-half of the length of the barbs had passed before the objective, it appeared deep black.

The blue area of such a feather gave a good reaction for Zoomelanin (black), for by boiling the feather in KOH, 0.5% and then heating with chlorine, the dark matter was completely broken up, and the feather appeared colored as with the rusty-colored tip which was apparently unaltered by the test.

When compared to a feather wholly changed to blue by the Aptosochromatic process, a valuable suggestion is at once thrown out, as to the nature of the change of color. In a microscopic examination of such a feather it is noticed that the lower parts of the central barb colums were as in the bicolored-fall feathers excepting that the massing of the black appeared to be denser. The upper parts however which were deep orange brown before, varying to lighter tints as the tips of the barbs were approached, now appear thickly massed with the black also, and the yellowish barbules are likewise colored. The streaming movement of the color granules is now especially prominent in an actively changing feather, and it readily appears that the rhachis gives up a part of its matter to the barbs, which in turn supply it to the barbules. A positive change of pigment is manifested macroscopically, for a fall feather held to the light or crushed, remains yellowish in its yellow-colored parts, while a spring feather, appearing entirely blue, so treated, shows darkly, due to the addition of black pigment.

Undoubtedly the blue effects are produced by the prismatic column in coöperation with the dark involved pigment, the sheath enveloping these parts playing its part with the barbules in producing the fall-colored feather. A cross section of the blue-producing barb sustains this view. When placed under the microscope with all light obstructed, but that descending to the stage from above, the sheath became invisible but the central column showed up like phosphorus as a pale glimmering blue which became opalescent with the varying quantities of light admitted. Unsectioned feathers so treated acted quite similarly, but the parts of the column appearing in the tips of the fall feathers, instead of betraying blue, showed gleaming white effects. Under transmitted light, as in ordinary examinations, the effects of the pigments alone were seen.

The massing of the granules of pigment begins evenly upon each vane, from the bottom of each barb and works towards the tips, the barbules being filled, from the tips first, as they are passed. The tips of the distal barbs usually were the last to completely undergo this change.

In both fall and spring feathers, the objective superstructure occupied the same relative position, being confined to the center of the barbs alone for almost their entire lengths.

Dr. Gadow, who has published results of his investigations upon the nature of the blue-producing structures in feathers, concludes that the production of blue is, in a measure, caused by the fine ridges of the prismatic columns, and thinks that the bodies of the columns and the transparent sheaths of the barbs may exert an appreciable influence. He adds in consequence "the production of blue therefore in a feather would be the result of a very complicated process."

As shown in my feathers, however, the blue appeared to be largely independent of the envelope of the barbs, yet this might concentrate light rays or so modify them that the consequent would be helpful. One thing appears certain, that to the presence of quantities of granular black-like matter is due no small share of the ultimate production of blue.

The causes of the differences in the shade of the blue feathers from violet to greenish, according to their position on the bird, appeared to be very slight microscopically, and I could detect no constant characters with the facilities at my disposal.

As to the causes of the activity necessary to produce a color change, we may only infer. As proved by dissection my bird was not undergoing any prominent sexual change, and the theory that the temperature of the atmosphere might be responsible would not be applicable to most cage birds which are kept in warm rooms. There can be no doubt, however, but that the fall change of plumage is one of protective tendency, and it is highly possible that until changed in the spring, the feathers, in a certain sense, are immature. In the case of the double yellow-headed parrot before mentioned, the color change was of a retrograde nature, but in the present example the process is synthetic rather than otherwise.

Numerous theories have been published which endeavor to account for the dichromatic fall change of many birds, but it would be irrelevant to discuss them here. One thing appears certain, that the process is deeply involved in the vital system of the organism. Professor Beddard cites an example noticed by Professor Weber of a chaffinch which was so colored that one-half of the bird was in the male plumage and the other portion in the female. Dissection proved the bird to be a Hermaphrodite, *i. e.*, the side sustaining the male plumage was found to contain a testicle, while the opposite portion of the body possessed an ovary, and Professor Beddard writes that this curious abnormality had been noticed before.

As no vascular connection appeared to be present in the perfect feathers of my bird, the change appears to be one of internal activity in the feathers themselves, and the simile before mentioned, of the autumn leaf, appears to be still more strongly consistent. The change is none the less vital, however, and ceases with the death of the organism. No tests delicate enough were applied to determine if new matter was formed directly in the feather. It appeared probable that none was, but that the striking change depended upon the massing of the dark granular matter from the rhachis to the barbs and their appendages. The absence of definite data upon the chemistry of animal pigments makes remarks in a qualitative direction wholly undesirable.

To conclude our microscopic study, however, we may affirm: (1) that microscopically as well as macroscopically an appreciable Aptosochromatic change took place in the individual feathers of my *Passerina cyanea;* (2) that this change far from being analytical or retrograde was inclined to the nature of constructive synthesis, probably passive in nature; (3) that the change was definite as shown by comparison with the blue areas of unchanged feathers; (4) that it depended chiefly upon the gain of dark pigment in the vicinity of the prismatic column, and (5) that there was an appreciable difference in the amounts of blackish pigment supplied to the barbs and barbules, before and after the change.

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THE SOCIETY FOR PLANT MORPHOLOGY AND PHYSIOLOGY.

THE Society for Plant Morphology and Physiology held its third meeting, with the American Society of Naturalists and the Affiliated Scientific Societies, at Yale University, New Haven Conn., December 27th and 28th, with President J. M. Macfarlane in the chair. For the ensuing year the following officers were elected: *President,* D. P. Penhallow; *Vice-Presidents,* Roland Thaxter and Erwin F. Smith; *Secretary,* W. F. Ganong. The following new members were elected: Oakes Ames, J. M. Coulter, Carrie M. Derick, B. M. Duggar, A. W. Evans, M. A. Howe, L. R. Jones, Henry Kraemer, F. E. Lloyd, D. T. MacDougal, Conway MacMillan, G. T. Moore, Adeline F. Schively, Hermann von Schrenk, Julia W. Snow. The business transacted of most general interest was the appointment of a committee, consisting of W. G. Farlow, D. T. MacDougal and H. von Schrenk to consider ways of securing better reviews of current botanical literature. It was voted to communicate the views of the Society upon this subject to the editors of the *Botanisches Centralblatt.* The following papers were presented. The abstracts are furnished by the authors.

Geotropic Experiments: DR. G. E. STONE, Massachusetts Agricultural College.

This paper dealt with the question at which angle gravity acts most strongly on a geotropically sensitive organism. The results were obtained by the use of grass nodes and in one or two instances the roots of *Vicia faba* were used. Three methods of experimenting touching upon the solution of this problem were described.

The first series give the results of dynamometer experiments in which the power of growth shown by different nodes placed at different angles was illustrated.

The second method consisted of taking the average of a large number of cut plants grown in moist sand and placed at different angles.

The third method showed the results of experiments due to the after effect of stimulation.

The results of all these experiments were similar and may be partly summarized as follows:

The horizontal position is the position of greatest geotropic excitability. This is shown by the increased amount of weight nodes will lift in this position, the amount of growth they display and the after effect reactions.

The relationship existing between nodes at oblique angles and those in a horizontal position is one which is proportional to the cosines of their angles. This also holds