parent height of the cliffs, if blasting of the latter could be prevented.

Professor Dodge described the similar trap formations of Connecticut.

After a vote of thanks to both lecturers the meeting adjourned.

THEODORE G. WHITE,
Secretary of Section.

DISCUSSION AND CORRESPONDENCE.

THE PLUMAGES AND MOULTS OF THE INDIGO BUNTING (*Passerina cyanea*).

IT is no new idea that the Indigo Bunting changes color without moulting, but just as one swallow does not make a summer, neither does one bird make 'aptosochromatism' an assured fact. This, however, is what a recent writer (Birtwell, SCIENCE, N. S., Vol. XI., Feb. 23, 1900) would have us believe, and yet there is quite a different way of looking at his supposed facts which suffer from the very 'individual error and dogmatism' he deprecates in others. He says "It is a singular fact that certain individuals have conceived the idea that a feather once having passed its premature condition (what may this be, please?) is utterly disconnected with the vital system of the bird and such individuals cling to this belief with a tenacity wonderful to behold." Doubtless it does seem 'wonderful' to persons who would wave aside all the careful observations that have been made upon feather growth and feather wear, and plumage generally, but possibly it is not so wonderful as the strange things they see just as soon as they watch a bird of striking colors in a cage. It is well to understand some elementary and fundamental facts that are self evident before having recourse to theoretical explanations, and lest Mr. Birtwell's conclusions be taken too seriously, it is my present purpose to first explain the plumage changes which regularly occur in the wild Indigo Buntings and then show why observations upon caged ones are open to doubt.

The Indigo Bunting regularly moults twice every year, differing in no wise in this respect from many other species, and like some of them it is also peculiar in requiring several moults to reach the adult plumage. This is what usually takes place in highly-colored species, and another peculiarity, if such it may be called, is the retention at the time of one moult of the feathers of certain areas until a later period of moult, a mixture of older and newer feathers in juxtaposition being the result. The key to the whole matter lies in understanding the principle of *sequence of plumages* as I have called it (*Auk.*, XVI., 1899, pp. 218–220, pl. III. and XVII., 1900, pp. 34–43) which is adequate to explain all parti-colored plumages without recourse to theory. I regret, that owing to unfortunate delays another article which explains the principle and its application at more length is still in press, so that it is not at present available for reference.

To understand clearly the successive stages of plumage in the Indigo Bunting it is desirable to take them up in the order in which they occur.

Natal Down. — On hatching, the chick is sparingly clothed with long downy filaments, the precursors of the definitive feathers to the apices of which they are attached. The down varies very little among the many species of Passerine birds.

Juvenal Plumage.—This second stage succeeds to the downy, part of the feathers being acquired before the bird leaves the nest. Brown is the prevailing color, paler below with streaks most obvious on the breast. In females the remiges and rectrices are wholly brown also, but in males they usually have a greenish blue tint most marked in the tail and varying in intensity according to the individual. The body feathers are looser in texture than are those of the next stage, assumed by the postjuvenal moult which occurs in the latitude of New York during August and September.

First Winter Plumage.—The third stage of plumage, commonly known as the 'autumnal,' is similar to the previous one, the moult usually involving only the body feathers. In males, the feathers of the throat especially become basally more or less tinged with dull blue, the females remaining dull brown and gray. Some males, however, assume by a more complete moult a new tail and several, usually, five or six, distal primaries which are nearly black and distinctly edged with bright blue. Indisputable

proof of moult in the shape of such feathers still in their sheaths, is furnished by a couple of birds in the collection of Mr. Wm. Palmer (No. 3283, September 17th and No. 3655, October 2d, Washington, D. C.). I am of opinion that it is perhaps only southern breeding birds that moult so completely at this season, for no northern specimens show it. Immature birds from semi-tropical localities taken during the winter months have either brown edgings or blue edgings to the remiges and rectrices and should not be mistaken for adults which have dark, blue-edged primary coverts, instead of the wholly brown ones which are characteristic of the young bird. It is probable that young birds, when they acquire precociously new wings and tail at the postjuvenal moult, like adults, do not again moult then until the following autumn; but we do know that most brown winged birds acquire five or six distal primaries, a new tail and body feathers besides at a prenuptial moult. Two birds in the New York National Museum (Nos. 107844–45 Bahamas, W. I., March 11th) prove actual growth of all these feathers, the worn brown primary coverts being retained and many summer specimens furnish evidence of having passed through a moult before reaching their breeding grounds, the relative amount of wear the different feathers show proving them to be of different ages. Very little is known about the prenuptial moult in most species and it appears to be in many of them a somewhat irregular affair spread over a number of the winter months, but there is ample evidence of its occurrence, the time, however, being the only puzzling feature.

First Nuptial Plumage.—The fourth stage of plumage in the Indigo Bunting results from the prenuptial moult which, as in most young birds, is more or less incomplete. Consequently we find breeding males almost wholly bright blue or with only a scattering of blue feathers mixed with the brown, gray or dull blue worn ones belonging to the first winter plumage. The individual variation is great, but all young birds may be differentiated by the ragged brown primary coverts. Females undergo very little moult and often none.

Second or Adult Winter Plumage.—In August, after the breeding season and relatively earlier than the time of the postjuvenal moult, the first postnuptial moult takes place. At this time all feathers are renewed in both sexes and the identity of young and old is lost in most cases, the former now acquiring for the first time blue-edged primary coverts like those of the latter. It is probable that a few year-old birds do not assume primaries and coverts as deeply blue as older birds, for in some winter specimens these are dull, but the majority do, as proved by birds taken in the midst of the moult. Specimens of adults in winter or 'autumnal' plumage, as it is commonly called, are scarce in collections chiefly because the adults migrate southward as soon as the moult is completed. The remiges, their coverts and the rectrices now acquired are, unlike those of the juvenal stage, worn for a twelvemonth; the body feathers, largely blue with rusty-brown tips which conceal much of the blue, are, on the other hand, like those of the juvenal stage, renewed by a prenuptial moult, the second. I have examined birds in the U. S. National Museum, and in the American Museum of Natural History, taken in Mexico, Yucatan and elsewhere which show new growing blue feathers at various points on the body, such specimens bearing dates of February and March. It is of interest to note in passing that the bright blue feathers assumed either in young or old show a different structure from those of the winter plumage when examined under the microscope and cannot be mistaken for them. The barbs are much more lanceolate than those of the winter dress.

Second or Adult Nuptial Plumage.—As just indicated the adult breeding dress is acquired by a partial moult which does not include the wings nor the tail which are renewed in the young bird. Before the prenuptial moult takes place the blue of the body feathers is exposed more or less by the wearing away of the feather tips, and birds often appear brighter than they do in the fall, but the moult itself is more complete upon the body than in young birds and fewer old worn feathers will be found upon adult summer specimens.

It is not necessary to trace the moults and plumages further for later ones are but repetitions of those already explained, and the few birds which show immaturity during their sec-

ond breeding season are certain to acquire fully adult colors at the second postnuptial moult, if they failed to do so at the first.

Here then we have the facts about the Indigo Bunting, and any specimen taken at the proper time of year will verify them. Nevertheless, Mr. Birtwell thinks that "for good results in investigations upon color change one should operate rather upon live birds in confinement." Well, perhaps so, for the 'proof' of color change without moult certainly does rest chiefly upon caged birds. The fact that they moult irregularly and often at long intervals and, as for instance in the case of the Purple Finch (*Carpodacus purpureus*), having once lost their bright colors may never again regain them does not seem to impair belief in a theory fifty years and more old. It began when most people were ignorant of the fact that birds could and did moult twice in the year. This was sagely declared to be too great a drain upon their vitality, but when it was found that some species did moult twice, theory had to be reserved for others that did not appear to be guilty of draining their vitality. When these in turn were proved to moult twice, refuge was taken in the assumption that only certain individuals of certain species changed color without moult. Later came red-handed proof of guilt in feathers found growing upon these individuals and the believers in theory fell back upon the claim that although one feather did seem to be renewed by moult, the one next to it underwent a color change, concerning the nature of which no two believers were agreed. Some of them have gone so far as to assert rejuvenation of frayed feather edges by some sort of exudative processes which only need to be carried a step farther to elimate altogether the necessity of moult. This is no fancy picture and I only paint it that my readers may know what 'aptosochromatism' represents.

Now, Mr. Birtwell comes forward with evidence convincing him of the growth of new feathers which expand of the wrong color and then undergo a change to blue, at the same time that the balance of old feathers also change. He kept an Indigo Bunting in a cage and, wiser than his predecessors, who have seen caged birds change color without loss of a feather, placed a 'fender' about it, resulting in the capture of over 1300 cast-off or moulted feathers! He tells us that the change to the blue in the new dull feathers had progressed 'excellently' when the bird died so that to this event he evidently attaches no importance. I do, and my opinion is that the dull feathers were deficient in color as is frequently the case in caged birds and never would have changed to blue had the bird lived. The blue he saw was either exposed by the wearing away of old feathers originally blue, or it belonged to new feathers the growth of which he failed to observe until the feather sheaths were lost. It is extremely easy to overlook growing body feathers which may be small and take but a few days to develop. The temptation is to make actual examinations of a struggling bird at long intervals and see the rest of the changes we want to through the bars of the cage, and I speak from experience with several birds. An adult male Indigo Bunting that I kept through the winter and up to July lost practically no feathers and yet members of my household were confident he was changing to blue and so he was by imperceptible loss of feather edgings. His cage was in a bag of mosquito netting such as I would commend to observers who cannot find feathers while a bird 'changes color.'

Now, of course, all the theorizing and microscopic evidence offered in Mr. Birtwell's article is not of the slightest importance if his bird did not do exactly what he claims it did, and I have already indicated some of the possible sources of error in observation. An observer who did not know the plumage differences between the adult and the young bird, nor discover the structural differences between autumnal and nuptial feathers, nor hesitate to look for 'carrier pigment cells' under the microscope, may well have his accuracy of observation questioned. These are some of the things that do not tend to inspire us with confidence in Mr. Birtwell's well-meaning and painstaking article for the narrowness of his horizon prevents facts being seen in their true light. It is so easy to be mistaken, and a mountain of theory resting upon a tiny and insecure base of alleged fact has ere now brought the *Chromatist* to grief. When the well-established laws of feather growth and

feather loss fail to account for plumages, it will be time enough to adopt theories demanding new life in epidermal structures, that for many months have been histologically dead. The existence of such a thing as 'aptosochromatism' will hardly be proved by those who have no grasp upon fundamental principles, and as long as such observers expect to be taken seriously, they must not be surprised if they are called sharply to account.

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INDIAN PICTOGRAPHS ON THE DAKOTA SANDSTONE.

The Dakota cretaceous formation which extends from northeastern Nebraska to southwestern Kansas is composed of massive ledges of sandstone alternating with beds of shale and clay. These ledges weather out and in many places form precipitous walls from ten to fifty feet high.

It is upon these walls that the Indians have written their history in pictographs. Traces of the drawings may be seen on dozens of cliffs in the two states. Old hunters and cattlemen tell us that twenty years ago or more the chalk cliffs of the Niobrara cretaceous in western Kansas were also covered with these inscriptions. But they have already disappeared because of the soft material composing the wall upon which they were carved. The Dakota sandstone being somewhat harder is consequently not so easily worn away and many of the drawings are still legible.

Not infrequently the sandstone wall in the immediate vicinity of one of the springs which abound in the Dakota will be covered with these hieroglyphics. This is the case at the Santee caves on the Platte river opposite Ashland, Nebraska, and at the noted cave section in Ellsworth county, Kansas. Again some prominent cliff or land-mark has evidently been selected. Pawnee rock on the old Santa Fé trail, the spot forever wedded to a tale of terror, was formerly covered with pictographs. The face of the rock has since been blasted away for building stone. A cliff of yellow sandstone standing boldly out on the north bank of the Smoky Hill river near the mouth of Alum creek contains some of the finest pictographs in the region.

In 1867 Dr. F. V. Hayden, United States Geologist described some pictographs near the Blackbird mission on the Missouri river some twenty miles south of Sioux City, Ia., as follows:

"About two miles above the mission the hills are cut by the river so as to reveal vertical bluffs, the rocks of which in the distance have a yellowish-white appearance and from this fact are usually called chalk bluffs. * * * This is perhaps the finest and largest exposure of the rocks of this group along the river. The mural exposures of soft sandstone present good surfaces for the Indian to make use of on which to write his rude history. And on the chalk bluffs there are many of these hieroglyphics in positions totally inaccessible to the Indian of the present time. None of them now living know anything about them and it is supposed that they must be very ancient, and that, since they were made, great changes must have been made in these bluffs by the waters of the Missouri. These markings are at least fifty feet above the water and fifty feet or more below the summit of the bluff, so that they must have been made before the lower portion of the bluff was washed away by the Missouri. It seems strange that none of these hieroglyphic writings which occur quite often on the chalk-rocks of the Niobrara group higher up the Missouri are known to any Indians now living. The creek near by is called in Dakota language the creek where the dead have worked on accounts of the markings on the rocks."

The pictographs referred to by Dr. Hayden may still be seen, although many of them are now practically obliterated.

Not infrequently these inscriptions occur in obscure cañons or lonely cliffs. The sandstone was easily scratched and the artist was evidently not seeking notoriety. Examples may be cited in a cañon five miles east of Kanapolis and in Cameron's draw near Belvidere, Kansas.

The writer has neither the ability nor inclination to discuss these picture writings from an ethnological standpoint. Doubtless the figures had a meaning, not only to those who drew them, but also to their contemporaries. Such writings are found in many, perhaps all parts