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CORRELATION BETWEEN TERTIARY MAMMAL HORIZONS OF EUROPE AND AMERICA

An Introduction to the More Exact Investigation of Tertiary Zoögeography. Preliminary Study with Third Trial Sheet

Two Presidential Addresses before the New York Academy of Sciences; first address delivered February 27, 1899; second address delivered February 26, 1900.

By Henry Fairfield Osborn

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PART I.—ADDRESS, 1899–1900.

[1] An abstract of the second address was published in *Science*, April 13, 1900, pp. 561–574.

PART I. PARALLELS BETWEEN TERTIARY HORIZONS.

INTRODUCTION.

This address is designed to reconsider an old subject in the new spirit and methods of modern palæontology. It does not pretend to cover the whole subject, but rather certain parallels between the mammalian faunæ of America and Europe and between the later Tertiary faunæ of Europe; it is introductory to a more exhaustive treatment.

The work done hitherto in this field of commanding interest and importance serves mainly to pioneer the more exact comparisons between Europe and America which are now becoming possible.

I desire to enter an urgent plea for the establishment of uniform divisions of the Tertiary and for the international usage of common terms both as to life stages and life forms. As in military disarmament, this result is easier to propose than attain, because each is willing to disarm on his own basis, each is reluctant to part with either the language or perspective belonging to the historical development of the geology and palæontology of his own land. Yet in these matters patriotism and provincialism naturally should have no weight. Palæontology knows neither the divisions formed by the English channel, the Rhine, nor the Atlantic; it does not recognize the superiority of an English system, of a French or German system, or of an American system, but like all its sister branches of science in this time of absolute scientific good will it demands an international system. As during the Tertiary period animals migrated freely by land over the entire northern hemisphere, so our ideas and methods must enjoy a free migration and fall beneath the rigid operation of the law of the survival of the fittest. Since anatomical, descriptive, taxonomic and geologic terms are mere symbols for the expression of certain facts, ideas, hypotheses and theories, we should all employ the same symbols whatever our national sympathies. For my own part if an approximate synchronism can ever be established, I would go so far as to advocate the adoption of the standard European divisions for the American Tertiary as soon as the European stages and periods are finally determined upon. In the meantime no one can oppose the immediate adoption of the fundamental principle that the old and new world palæontology should be studied as a unit.

If we are eager to solve the great number and variety of most interesting questions still unsolved as to the source, origin, filiation, migration and extinction of the noble races of animals which passed across the stage of the Northern Hemisphere or *Ancient Holarctic Region*, during the Tertiary we must hasten to use more exact methods, to agree upon the synchronism of the Tertiary and the arbitrary limits which we shall assign to the Eocene, Oligocene, Miocene, Pliocene and Pleistocene periods and their subdivisions. The synchronism is a difficult subject, in fact it involves the main question ; the limits of the periods are largely arbitrary and are capable of being settled at once. Although the *lower* Tertiary of America from the base of the Eocene to the summit of the Oligocene is infinitely more complete, in fact an unbroken historic chapter, it will probably prove best that the beautiful series of Tertiary horizons of France should be adopted as the *basis of division*, partly because of their priority and completeness throughout, but chiefly because of the remarkable alternation of marine and freshwater deposits, whereby the vertebrate is checked by the invertebrate time scale. After we pass the summit of the Oligocene our country affords a series of vistas only while Europe offers a commanding view of the later Tertiary life periods. If France furnishes the initial basis, comparison with America will serve to check and amplify—thus the final basis for the division of the Tertiary will be comparative.

European Correlations :—In France Gervais, Gaudry, Filhol, Lemoine, Depéret, Boule, and others have drawn the demarcations of the typical horizons. The parallels with England have been especially set forth by Prestwich and Dawkins and with Germany by Schlosser, Depéret and v. Zittel, while the parallels between Europe and America, or the ancient Palæarctic and Nearctic Regions, have been discussed by Gervais, Leidy, Cope, Filhol, Scott, v. Zittel and Schlosser. Lydekker has broadly covered the whole field in his Geographical History of Mammals.

It may seem remarkable that a nearctic palæontologist should enter the palæarctic field, as the herald of a conference and agreement upon common usage of terms, but I make no apology because the matter arose from necessity rather than choice; several years ago the discovery of some new types of rhinoceroses in this country directed my attention afresh to the study of the Tertiary fauna of Europe as parallel with that of America, in the succession of European and American types it appeared that there were most interesting similarities between rhinoceroses as widely separated as the present regions of Colorado and southern France, but upon attempting more than a general comparison I was confronted by a lack of definite time scale between the levels in which these animals occur. The available correlations by Cope, Filhol, Scott, v. Zittel and others proved too indefinite at certain points. This difficulty became so obstructive that a more exact correlation of European and American horizons appeared to be an essential basis not only for the phylogeny of the rhinoceroses but for that of other types of mammals of Europe and North America. We need a unified old world system as a starting point for comparison. As a matter of fact there is even at the present moment no consensus of opinion or common usage among palæarctic palæontologists as to the larger divisions of the Tertiary.

The Trial Sheets:—As an initial step towards a more exact correlation I offer here a provisional classification of the Tertiary of Europe with critical discussion of the reasons for placing the larger division lines at certain points, also a comparison chiefly with the Eocene of America, both accomplished with as much aid from workers past and present as could be mustered. This classification probably contains many errors, some of them, perhaps, of a gross description. As I freely criticise and differ from some of my colleagues, I trust they will freely criticise, correct and expand this preliminary parallel and the methods of attack here advocated. Realizing that an acceptable working basis could only be secured by coöperation I drew up in 1897 a '*Trial Sheet of the Typical and Homotaxial Tertiary Horizons of Europe*' and circulated it abroad for criticism. This proved to be a rather faulty trial; extremely valuable corrections and additions were received, especially from my friends Professor GAUDRY, Professor V. ZITTEL, Professor DEPÉRET and Doctor SCHLOSSER, Madame PAVLOW, Doctor BOULE, and Mr. R. LYDEKKER. These criticisms were embodied in a '*Second Trial Sheet*' which was issued about April 15, 1898. This sheet was used as a basis for further personal discussion with the above palæontologists, also with Professor LEPSIUS of Darmstadt, Doctor FORSYTH MAJOR of the British Museum and others. In course of a tour in foreign museums, I was greatly aided by many other critics, and made also numerous observations of my own which bear upon the Holarctic parallels. A '*Third Trial Sheet*' is issued in connection with this address; it is probably more accurate than its predecessors but it is still lacking both in the desired exactness and fullness. The closer comparison of the post-Eocene divisions of the Tertiary fauna of Europe and North America must be deferred for a full report which is in preparation.

I. AVAILABLE EVIDENCES OF PARALLELISM

Among the tests of approximate synchronism of deposition in the Nearctic and Palæarctic regions are the following:

1. COMMON GENERA AND SPECIES: the presence of identical or closely allied genera and species. This time honored and obvious basis of comparison is now rendered most difficult by the diversity of usage in generic and specific definitions.

2. SIMILAR STAGES OF EVOLUTION: the similarity in the stage of development of allied phyla, as expressed in the pattern of the molar teeth, in the transformation of the premolar teeth, complication of the molar teeth, in the reduction of digits, etc. This test of synchronism is comparatively novel. For example, the remarkably definite transformation of the fourth

premolar of the *Plagiaulacidæ* or of the premolars of the *Perissodactyla* afford certain very exact data for correlation purposes.

3. SIMULTANEOUS INTRODUCTION OF NEW FORMS: the sudden appearances in both Nearctic and Palæarctic regions of types which have no known ancestors in lower horizons and have apparently originated elsewhere, either in Africa or in South America. The value in chronology of these immigrations has not been fully recognized.

4. PREDOMINANCE OF CERTAIN TYPES: the predominance or spread of certain types as of the *Perissodactyla* in the Middle Eocene, or of the Artiodactyla in the Upper Eocene and Oligocene are in the nature of supplementary evidence.

5. CONVERGENCE AND DIVERGENCE OF PALÆARCTIC AND NEARCTIC FAUNÆ: far closer than in any known Tertiary or Quaternary stage, were the relations existing in the Holarctic region during the Upper Jurassic period. The resemblances among these minute mammals, as found in the Purbeck of England and the Como beds of Wyoming are most astonishing, for of thirteen genera, six have their English counterparts, and the family characters are very close as regards the remainder. (See OSBORN, '88, pp. 186–7.) It would be rash to say whether or not continuous close geographical connections existed from the Jurassic throughout the Cretaceous, but in the next Nearctic and Palæarctic parallels which we can draw, namely in the Basal Eocene between the *Torrejon* of New Mexico and the *Cernaysien* of France, the resemblances are again very close. During the Upper Eocene the faunal parallels became decidedly less close, in fact the correlation can only be established by relatively few forms. In the lower Oligocene the faunal relations suddenly became again much closer between the old and new worlds and they remained close throughout the later Tertiary until the middle of the Pleistocene period.

II. CLASSIFICATION OF THE EUROPEAN TERTIARY

Invertebrate palæontologists have naturally taken the leadership in the classification of the old world Tertiary, their vertebrate confrères having followed, adapted and modified the system.

Without question the final classification will be by a synthesis of evidence derived from invertebrate and vertebrate remains, from the comparison of marine, fresh water and terrestrial forms of life with each other and with earth movements. In numerous instances the exclusive use of one class of evidence has led to serious errors.

The great faunal Periods or Systèmes, Eocene, Miocene, Pliocene, and Pleistocene we owe to LYELL. The Oligocene was proposed by BEYRICH ('**54**, pp. 640–666), chiefly on geological grounds, and although confirmed by the Berlin Geological Congress some doubts are entertained as to its ultimate utility and survival.

D'ORBIGNY, divided the Eocene into the lower (*I*) *Suessonien*, in which we find fossil mammals deposited chiefly north of Paris around the Suessonien gulf, and the upper (*II*) *Parisien* in which the deposits are chiefly around Paris and in the Helvetien canal of the south of France and Switzerland.

The stages and substages of the palæarctic Tertiary employed in the *Third Trial Sheet*, are chiefly the proposals of MAYER-EYMAR ('**89**), D'ORBIGNY, DUMÉRIL, SUESS, and LAPPARENT ('**85**)—all invertebrate palæontologists. The history or authorship and synonymy of the *Étages*, *Montien*, *Thanétien*, *Suessonien*, etc., may be found in the two palæogeographical essays by MAYER-EYMAR ('**89**, p. 26), and CANU ('**95**, pp. 53–56), in which a reclassification of the entire Tertiary is advocated upon the hypothesis of the relation between the perihelions of the globe and the sedimentary substages, as shown in the Tableau I, of CANU ('**95**, pp. 12–13). For the purposes of the mammalian palæontologist however, the Lyellian system is more convenient.

Valuable tables of European faunal parallels are given by V. ZITTEL ('**93**). The fullest lists of European mammals in different horizons are those collected by SCHLOSSER ('**87**–'**90**) and DEPÉRET ('**85**–'**95**) in his memoirs on the Miocene and Pliocene. A mine of wealth for an investigation of this kind is SCHLOSSER'S *Literaturbericht* ('**83**–'**97**); the writer has referred to it constantly and can hardly express his indebtedness.

Trouessart's ('97) *Catalogus* would have been far more valuable if localities had been cited as well as the geological divisions.

The first step is to ascertain how far the Periods or *Systèmes* can be paralleled in America and Europe and similar permanent limits placed between them. The second is to establish, as convenient divisions of each, *Upper, Middle, Lower,* or *Lower* and *Basal.* It is not too much to hope that the synchronism of these periods in the entire Holarctic region during the Tertiary can be established with considerable exactness. The Stages and Substages present much greater difficulty and may prove impossible owing to the absolute independence of the earth movements which caused them in the old and new worlds. It is perfectly evident that the overlapping of these deposition stages would be the rule and that exact synchronism would be largely coincidence and therefore highly improbable. All that we can reasonably hope to establish in the near future is an *approximate parallelism of the Stages;* ultimately the lines of overlap may be determined.

III. COMPARISON OF THE EOCENE IN EUROPE AND AMERICA

1. The Puerco without a Faunal Parallel

The base of the American Eocene is the *Puerco,* which has been observed by Cope and Wortman to immediately overlie the upper Cretaceous in northern New Mexico.

Contrary to the prevailing opinion and usage there is in Europe no known fossil mammal deposit parallel to the basal Eocene or Puerco of America. The Puerco fauna proper is older than the oldest in Europe.

We may therefore provisionally conclude that the fresh water Puerco deposits were approximately of the same age as the earliest marine and brackish limestones of the Suessonien Sea, namely, the *Montien* (Calcaire grossier de Mons, Belgium), or marls, *Heersien,* (*Marnes de Heers*), *Maudunien* (*Marnes de Meudon*), all resting unconformably on the Cretaceous.

2. The Torrejon and Thanétien (Cernaysien) nearly Parallel

The oldest fossil mammal beds of Europe are the fluvio-marine *Glauconie de la Fère* (Aisne, 6 metres), containing *Arctocyon primævus*, equivalent to the marine *Sables-de-Bracheux*, also resting upon the Cretaceous which is immediately overlaid by the lacustrine *Calcaires et sables de Rilly* (38 metres). These together constitute the *Thanétien* (LAPPARENT, '85), with which the purely fresh-water *Cernaysien* (LEMOINE) beds in the vicinity of Rheims are closely parallel.

The *Cernaysien* has been almost universally paralleled with the *Puerco*, but many years ago, while studying the Cernaysien fauna of Rheims, with the kind aid of the late Doctor VICTOR LEMOINE, I reached the conclusion that it was more recent than Puerco (OSBORN, '90, pp. 51–62). This conclusion is now confirmed by the separation (WORTMAN and MATTHEW, '99, p. 28) of the true Puerco fauna underlying the Torrejon fauna. The Torrejon agrees closely with the Cernaysien, so far as we can judge from evidence which awaits a more exact study of the Cernaysien fauna than we have yet enjoyed.

a. MULTITUBERCULATES. It is especially interesting to compare the number of grooves and tubercles upon the *Neoplagiaulax* (Cernaysien) and *Ptilodus* (Torrejon) fourth premolars and first lower molars, as indicating a similar age.

b. Among the RODENTS or PRIMATES (for the systematic position of these animals is not definitely known, see SCHLOSSER and MATTHEW) compare *Protoadapis* (Cernaysien), dentition 2–1–3–3, and *Plesiadapis* with its reduced dentition, simple molar type and enlarged incisors, with *Indrodon* (Torrejon) (*? 1. 3. 3*).

c. CREODONTS. Of the *Mesonychidæ*, *Hyænodictis* (Cernaysien) is a little more modern than *Dissacus* (Torrejon) in its lower molars. Of the *Arctocyonidæ*, *Arctocyon gervaisii* (Cernaysien) and *Arctocyon* (Clænodon) *corrugatus* (Torrejon) are to be compared.

d. UNGULATES. As hypothetically ancestral to the Ancylopoda, *Pleuraspidotherium* (Cernaysien) is in an earlier stage than *Meniscotherium* (Wasatch) which it somewhat resembles in teeth, skull and skeleton.

The fact that neither primitive UNGULATES (*Condylarthra* and *Amblypoda*) nor EDENTATA have been found in the *Thanétien* or Cernaysien beds, together with their absence in the Suessonien and later periods in the *Palæarctic* region, lends some *probability* to the hypothesis that Condylarthra, Amblypoda and Edentata were exclusively Nearctic during the lower Eocene. On the other hand the Cernaysien beds may present a very imperfect picture of life in France during this period.

3. Egerkingen Beds more recent than Puerco, Torrejon or Wasatch

Nor is the above probability lessened by the testimony of *Egerkingen* which has been widely accepted as proving the existence of the Condylarthra in Europe and as in part a very old fauna.

The suppositions of Rütimeyer ('88), already questioned by SCHLOSSER ('95), that the older portion of the famous fissure fauna of Egerkingen is of Puerco age and that it contains Condylarthra are rendered improbable by the following considerations.

FIRST: by my examination of the teeth referred to *Euprotogonia*, *Periptychus* and *Phenacodus* in the Egerkingen collection, which fails to sustain Professor RÜTIMEYER'S identifications. Egerkingen is rich in small Eocene Primates; it is possible that the types of the supposed Condylarthra correspond with the larger Bridger or Middle Eocene American monkeys such as *Notharctus*, *Tomitherium* (COPE) *Telmatolestes*, *Limnotherium* (MARSH) which are astonishingly ungulate in appearance.

SECOND: I have certainly seen similar primate teeth in Professor DEPÉRET'S collection from *Lissieu*; this is also a fissure fauna and of similar age to Egerkingen.

THIRD: because of the absence in Egerkingen of many typical lower Eocene or Suessonien types and the abundant presence of typical middle and upper Eocene types. It is improbable that a Jurassic fissure would accumulate basal Eocene types, omit lower Eocene types such as *Coryphodon*, and again collect middle and upper Eocene types.

FOURTH: the Tæniodonta, or ancestral Edentata with enameled teeth, are apparently truly represented in Egerkingen by the *Calamodon europæus* of RÜTIMEYER, but this tooth is quite as probably in a *Stylinodon*, or Middle Eocene (Bridger), stage of development as in an older stage.

4. Lower Eocene, Wasatch and Suessonien (Sparnacien, Yprésien) truly parallel

The *Sparnacien* of LAPPARENT is the middle substage of the more comprehensive stage *Soissonien* (MAYER-EYMAR); it marks a continuation of the north France depression or Suessonien Sea (Heersien, Thanétien or Suessonien) and is characterized by marine and fluvio-marine deposits bordered to the west and south by purely fresh water fluviatile or lacustrine deposits.

Of the latter the lacustrine *Lignites du Soissonais* (5 metres) contain *Coryphodon owenii*, *Palæonictis gigantea* (Muirancourt, Oise) and *Lophiodon larteti*. The *Argile plastique* (50 metres) is considered by some mainly aërial (fide CANU), by others lacustrine (GARDNER, LAPPARENT); it commences with the *Conglomerat de Meudon*, certainly fluviatile, which contains *Coryphodon anthracoideus*.

In the London basin are the *Lower Bagshot Sands*, a marine formation, and below these the *London Clay* (166 metres), see CANU ('**95**, p. 54), an estuarine formation; these together constitute the *Londinien* of MAYER-EYMAR. The London Clay contains a primitive species of *Hyracotherium*, *H. leporinum*, a primitive *Coryphodon*, *C. cocænus*. These fossil mammals would cause us to consider the London Clay as parallel with the Sparnacien, but LAPPARENT and CANU, from the invertebrate standpoint, place the London Clay in the higher level of the Yprésien or Londinien.

In the Paris Basin a fresh return of the sea deposited the *Sables Nummulitiques du Soissonais* (50 metres, Aisne) embracing the overlying estuarine and littoral *Sables de Cuise la Motte*; here FILHOL ('**88**, p. 155) records a small *Lophiodon de Cuis*, this would correspond with *Heptodon*, the first of the American *Lophiodontidæ*. GAUDRY ('98, p. 302) parallels with these beds the freshwater *Sables Agéiens* (D'EPERNAY), *Étage Agéien*, LEMOINE, the mammalian fauna of which has been described by LEMOINE as containing *Lophiodon* and *Pachynolophus;* but this fauna belongs on a higher level, as in fact GAUDRY himself intimates.

The parallel between the Wasatch and the Suessonien of France was first recognized by MARSH in describing *Coryphodon*. In the meantime vast additions have been made to our knowledge of the Wasatch fauna and practically nothing to that of the Suessonien. Although we know only a fraction of the life of the period, there certainly existed at this time in Europe the successors to certain Cernaysien genera which are represented by descendants in the Upper Eocene.

The three known genera common to both countries, namely, *Coryphodon*, *Hyracotherium* and *Palæonictis* present close structural parallels.

Filhol records *Lophiodon larteti* of the *Lignites du Soissonais* as an ancestor of the true heavy bodied Lophiodontinæ, whereas in the Wasatch we find *Heptodon* belonging to the light bodied Lophiodonts of the "Helaletes-Colodon" line which subsequently appears in Europe. *Platychærops*, mistakenly compared with *Esthonyx* by LYDEKKER has no parallel in America unless among the *Arctocyonidæ*. GERVAIS ('59) mentions a rodent-like type of incisor from the Suessonien, but this has not to my knowledge been subsequently described.

5. Fissure Formations, Egerkingen and Lissieu, younger than the Wasatch

These formations both represent the remains of animals slowly accumulated in fissures of Jurassic age. The Lissieu fauna is of approximately the same Middle and Upper Eocene duration. As above stated the Egerkingen composite fauna almost certainly does not contain types as old as those of the Wasatch. There is one important exception: the *Proviverra typica* of Egerkingen is in the same stage of development as the *Sinopa* (*Sty-*

polophus) *viverrina* of the Wasatch, while RÜTIMEYER's supposed *Stypolophus* does agree with the *Sinopa brevicalcarata* of the Bridger. Notwithstanding these facts, in the absence of *Coryphodon*, *Palæonictis* and other typical Wasatch and Suessonien forms, the greatest age which can be positively assigned to the beginning of these fissure formations is the lower portion of the Middle Eocene.

6. Middle Eocene, Lutétien, apparently parallel with the Wind River Fauna

Constituting the base of the greater *Parisien* stage, the *Lutétien* substage, first, marks the advance of the sea beyond its Suessonien limits southward around Paris, and to the west and north into Belgium ; second, it marks the appearance of fossil mammal deposits in the south of France, in Switzerland (Helvetien Canal), and in Alsace.

The *Calcaire grossier* beds (45 metres) are entirely marine in their lower strata (*Calc. gros. moyen. et infér.*) but become freshwater or fluviatile at the summit (*Calc. gros. supér.*) where they contain Lophiodon and many other ungulates.

Parallel with these beds are those of the *Gres d'Issel* (Aude, 24 metres) fully studied by FILHOL ('88) ; of *Argenton* (Indre) ; of the *Argiles à lignites*, or *Agéin* (Rheims) explored by Dr. Lemoine, of *Bracklesham* (England). Certain types of *Buchsweiler*, Alsace, seem to be somewhat more recent. Finally our knowledge of the mammals of this stage is greatly enriched by the older portions of the fissure deposits of Egerkingen (Vaud) and of Lissieu, near Lyons.

This fauna has been hitherto paralleled with that of our great Middle Eocene deposits of the Bridger ; we shall see that *it only corresponds with a section of the upper Wind River or the Lower Bridger Lake deposits* of the Rocky Mountains.

Characteristics : FILHOL ('88, p. 1, 75), in his conclusion upon the Issel fauna, speaks doubtfully of the presence of a large Creodont, as *Palæonictis gigantea*.

This is the continuation of the reign of Lophiodon, a type predominant in number and variety.

Three perissodactyl phyla occur, namely the Hyracotheriinæ, Lophiodontinæ and Helaletinæ, whereas at the same period in America we find the *Hyracotheriinæ*, *Tapiridæ*, and *Helaletinæ*.

Without exception in the Lutétien representatives of the perissodactyl families *Lophiodontinæ* and *Hyracotheriinæ the premolars are simpler than the molars and these animals are therefore in a stage of evolution corresponding with that which we find in the Wind River beds.* The horses so far as I can judge from personal study, from FILHOL'S descriptions and from figures, (GERVAIS, '59) *P. Suillus*, *P. parvulus*, *P. duvalii*, all belong to the primitive stage, namely, *premolars simpler than molars, no mesostyle*, and are therefore in a *Wind River* (*Protorohippus*) rather than *Bridger* (*Orohippus*) stage of development. FILHOL ('88, p. 182) lays great emphasis upon the fact that all the so-called 'Pachynolophus' of Issel, Pépieux and Lautrec have the premolars simpler than the molars. Furthermore in beds of undoubted *Issel*, *Argenton* or *Buchsweiler* age, no complete *Anchilophus* types of premolars (pm = m) occur. As for the oldest *Artiodactyla* in either country, COPE ('82, p. 71) has compared Lemoine's *Lophiodochærus peroni* of the *Argiles-à-lignites* with his *Trigonolestes brachystomus*, from the Wind River. Among the primates the little known *Heterohyus armatus* GERVAIS, distantly resembles *Microsyops* of the Bridger in its molar teeth only, the premolars being simpler than in the Bridger species.

These are significant facts. So far as they go they indicate that the known beds of Lutétien formation (having a thickness of 45–24 metres) are by no means equivalent to the Bridger Beds (having a thickness of 800 metres), as heretofore stated, but they merely correspond to a section of the Lower Bridger or more probably of the Upper Wind River formation.

It is true that in the *Helaletinæ*, or cursorial Lophiodonts, in the fauna of *Egerkingen* and *Lissieu*, namely *H. cartieri*, *H. annectens* (and perhaps *Helaletes* (Hyrachyus) *intermedius* of *Selles-sur-Cher*), the third and fourth premolars have double internal lobes like those of *H.* (*Desmatotherium*) *guyotii* of the Bridger. But it must be remembered as regards both Egerkingen and Lissieu that they are composite faunæ, containing *upper* Eocene forms mingled with the *middle* Eocene forms, therefore, they cannot be cited at all as proofs of synchronism. Similar Helaletes-like teeth are described by FILHOL from Buchsweiler, Alsace, namely the type 3d and 4th premolars of his *Palæotapirus buxovillanus* ('88, p. 179, pl. XIX, fig. 4), which certainly belong not to the *Tapiridæ* but to the *Helaletinæ*, a sub-family of *Lophiodontidæ*. On the other hand, the upper molar and the lower jaw assigned to *Hyrachyus intermedius* (FILHOL '88, p. 114, pl. XXX, figs. 8 and 6) from *Argenton* resemble the *Helaletinæ* in a Wasatch or *Heptodon* stage of development because they are small and simple.

7. Middle Eocene, Bartonien, apparently Equivalent to the Lower Bridger

This substage receives its name from the *Barton Clays* of England (100 metres). The *Sables de Beauchamp*, marine (15 metres) is succeeded by the partly lacustrine *Calcaire de Saint Ouen* with which the fresh water *Grès de Cèsseras* (Hérault) are considered parallel.

From the *Grès de Cèsseras* a few mammals are recorded. The *Cesserasictis antiquus* (FILHOL '88, p. 182, pl. XIX, fig. 3) type is a small lophiodont jaw with molar teeth which resemble those of *Helaletes* of the Bridger except in the extreme simplicity of the supposed 4th premolar.

If FILHOL's identification and description is correct no comparison can be made with our Bridger Helaletes which has a partly compound fourth premolar. The *Lophiodon cesserassicum* FILHOL (*L. occitanicum*, GERVAIS) is judging by GERVAIS' figures (pl. 18, fig. 7), one of the *Equidæ* in a Bridger stage of development.

The American parallel of the Bartonien is probably Lower Bridger but it cannot be determined until we secure a more exact knowledge of the state of molar and premolar evolution of the few ungulate fossils which it contains.

The writer is chiefly indebted to Professor ALBERT GAUDRY for the arrangement of the lower Eocene in the accompanying 'Third Trial Sheet.'

8. Upper Eocene, Ligurien

The summit of the French Eocene is characterized geographically by the recession of the northern gulf on its western borders and by numerous small freshwater lake and river deposits in the south and southwest of France, in Switzerland, and on the German border (CANU, '95, Plate 44).

In the Paris Basin, made famous by the classic researches of Cuvier and Brogniart, is the *Gypse de Montmartre* (55 metres) partly marine, partly lacustrine ; at its summit are 20 metres of gypsum which contain most of the mammals described by CUVIER. Above are the lacustrine *Marnes de Pantin.*

Parallel with the *Gypse* are the rich *Lignites de la Débruge* (Vaucluse, 2 metres).

Parallel with the *Gypse* in the South are the beds of *St. Hippolyte de Caton* (Gard) recently described by DEPÉRET ; of *Castlenaudry* (Aude) ; of *Lautrec* (Tarn) described by NOULET ('63) also by GERVAIS ('69).

There are also the lacustrine limestones of Carcassonne, near the Pyrenees, and the localities *Mas-Saintes-Puelles* and *Villeneuve-la-Comptal*, Castres. To the west in Germany are the fissure deposits or *Bohnerzen* of *Heidenheim* (Mittelfranken) *Ulm*, *Pappenheim*, *Fronstetten*[1] (Swabian Alps), *Sigmaringen ;* to the south the older fissure deposits of the *Phosphorites du Quercy*, and the fissures of *Egerkingen* and *Lissieu.*

This period contrasts with all its predecessors by the superbly full fauna which it contains ; we feel for the first time that the fossil record is approximately representative of the living fauna. It is greatly enriched by the composite parallel faunæ of the *Sidérolithique de Mauremont* and the newer portions of the composite faunæ of Egerkingen and Lissieu.

Lautrec, undoubtedly Upper Eocene, contains a very large *Lophiodon*, *L. lautricense* of especial interest, because it is apparently the last of its race. It is probable that the large Lophiodon of *Heidenheim*, with complex premolars, is related to the Lautrec type. In the Heidenheim specimen the second and

[1] Fronstetten fauna described by Jäger, Fraas, Quenstedt and v. Meyer.

third superior premolars have double internal cusps. *Lissieu* as studied by Depéret is mainly middle Eocene but it contains some important Upper Eocene forms, while *Egerkingen* has a rich representation of Upper Eocene types.

The large *L. rhinocerodes* Rütimeyer, of Egerkingen is, however, not of the Heidenheim type because it has simple upper premolars associated with it ; it is an older representative of the large race of *Lophiodontidæ*.

Mauremont is considered mainly, if not exclusively, of Upper Eocene age.

General Characters.

(1). This fauna is much more modern than that of the *Grès de Césseras*, or of the *Calcaire Grossier* and *Issel ;* the great advance in the structure of the teeth especially seen in a comparison of *Propalæotherium* and *Palæotherium* is proof of modernization. Palæotherium is now the predominating type of Perissodactyl, although a large form of *Lophiodon* survives.

(2). Secondly, the composite beds of *Egerkingen* and *Lissieu* furnish the ancestry of certain types of *Gypse* Artiodactyla and in these beds we also find certain other forms transitional between the *Issel* stage and the *Gypse* stage.

(3). Thirdly, the *Gypse*, is a very highly specialized and differentiated fauna including many artiodactyls and other types the ancestry of which is known neither in Europe or America and has not thus far been found in Egerkingen or Lissieu.

(4). Fourth, the Ligurien is widely distinct faunally from the American Upper Eocene or Uinta with which it has been heretofore paralleled. At no period of the Tertiary were the Nearctic and Palæarctic faunæ so widely separated. In fact a much wider gap exists between Western America and Europe in the Upper Eocene than in the preceding Lower and Middle Eocene or in the succeeding lower Oliogocene.

The resemblances or parallels with America are mostly limited to one genus of horses (*Pachynolophus*), which occur in both countries, to one Creodont *Hyænodon*, and to the ancestors of the *Canidæ* and *Viverridæ* which occur in both countries.

(5). Contrasts. The *Cheiroptera* and *Insectivora* of these two regions cannot be compared until the American forms named by Marsh are adequately studied. The *Primates* have no direct parallels. Among the *Perissodactyla*, *Palæotherium*, *Palaplotherium*, and *Anchilophus* have no parallels in America. The *Selenodont Artiodactyla* of the two continents are widely distinct; the *Gypse* selenodont Artiodactyla have no parallels in America. The bunodont Artiodactyla have not yet been carefully compared.

(6). There are therefore comparatively few *direct* reasons for considering the *Gypse* and *Uinta* as nearly contemporaneous but there is a substantial indirect reason namely that they both closely underly Oligocene Beds in which there suddenly reappears a marked community of fauna in the Nearctic and Palæarctic regions. In other words the *Gypse* bears a relation to the Ronzon similar to that which the Upper Bridger bears to the Upper Uinta and White River.

The most significant fact is the apparent invasion of the Palæarctic region in the Upper Eocene by a great variety of Artiodactyla which mingled with the older phyla of France and Germany. Where did these animals come from? Not from Asia, certainly, because some of them would have found their way also into the Nearctic, probably therefore from Africa or the *Ethiopian Region.*

9. Composite, Imperfectly Stratified Fissure Deposits of Middle Eocene to Middle Oligocene Age

The most famous of these fissure deposits are those of Quercy, Egerkingen, Mauremont, Fronstetten.

In the Swiss Jura are the *Bohnerzen*, mainly non-calcareous reddish clay nodules with pisolithic iron grains. The siderolithic earths, *Sidérolithiques*, typically at *Mauremont*, found in Jurassic limestone fissures are so called because they contain grains of iron, imbedded in concretions probably of mineral spring origin, associated with travertines. A special type of fissure deposits, analogous to the above in certain respects are the *Phosphorites*, typically represented in *Quercy* but characteristic also of other periods.

The age of these various deposits is a very important matter. For reasons given above and below certain of these deposits appear to have overlapped or extended through one or more periods of regular stratigraphic deposition as follows:

Egerkingen (Canton Vaud) Middle to Upper Eocene inclusive.

Lissieu, Middle to Upper Eocene inclusive.

Fronstetten (Swabian Alps), Mainly Upper Eocene.

Heidenheim (Mittelfranken), " "

Mauremont (Canton Vaud) " "

Oerlinger Thal. u. Eselsberg, Ulm, Upper Eocene.

Quercy, Caylux, Mouillac, Phosphorites, Upper Eocene to Middle Oligocene.

The PHOSPHORITES DU QUERCY, the most extensive and famous fissure deposits of this kind, occur in Jurassic calcareous fissures of 3 to 6 metres in width and 35 metres in length. The matrix is a phosphate of lime probably of mineral spring origin (FILHOL, '77, p. 1–27). The fauna enjoyed a warm and moist climate. FILHOL believes that death was caused by asphyxiation, due to poisonous vapors arising from hot springs, many skeletons being found complete and showing no marks of teeth. In contrast with Quercy, which contains a fauna of extraordinary richness, beauty and completeness, EGERKINGEN and LISSIEU have yielded merely isolated teeth.

The Quercy fauna according to FILHOL predominates in Upper Eocene or *Gypse* types. The Phosphorite rhinoceroses have by some authors and in many museums been referred to *A. lemanense* and *A. minutum*, both of which are Upper Oligocene or Aquitanean species—*this is an error;* the two rhinoceroses which this formation contains are probably the *Ronzotherium velaunum* AYMARD, found also in Ronzon, and another species much simpler than the Aquitanean *Diceratherium minutum* CUV. (*R. pleuroceros* DUVERNOY), of Moissac. This small species has simple upper premolars; it either belongs to *A. gaudryi* RAMES, or represents a distinct species. These facts with the tables published by FILHOL ('77) show that the Quercy deposition probably terminated in the lower or Middle Oligocene.

Characteristic of the region of the Alps during elevation are the marine, brackish and freshwater *molasses*, that is, calcareous or argillaceous rocks easy to work, mingled with conglomerates called *nagelfluh* a littoral formation. These were produced in Switzerland on the shores of islands during oscillation periods.

IV. OLIGOCENE OF EUROPE

This Period is actually well defined in its geographical features, as well as in its fauna and flora; in France it begins typically with the *Ronzon* fauna which *contains a number of entirely new types*, and it terminates with that of *St. Gérand le Puy*. Some authors, however, LYDEKKER (**'96**, p. 191), LEPSIUS (**'92**, p. 550), include within the lower Oligocene the Ligurien or *Gypse;* this is a cause of great confusion in the literature.

The duration of the Oligocene may be estimated by deposits in Italy of 2900 metres in thickness.

Earth Movements.—According to LAPPARENT (**'85**, p. 1164) the Oligocene of Europe begins with the main elevation of the Pyrenees and is marked toward the close by the initial elevation of the Alps. Its first or early earth movements (*Étages Infra Tongrien* and *Stampien*) caused a recession of the sea at the south, and an invasion of the sea from the north—this invasion reached the centre of France; in the Rhine valley it extended as far south as Basle. The climate during this period was moderate. The second or *Étage Aquitanien* was one of elevation and strongly contrasted with the preceding by a general recession of the sea; it instituted a period of great freshwater lakes in France and Southern Europe, varied by lagoons with lignitic deposits. Under more temperate climatic conditions, with considerable moisture, the flora was of Indian and Australian type, the deciduous trees increased in number, but palms still flourished as far north as the Baltic; the bird life of central France (Allier, MILNE-EDWARDS) was similar to that of the lakes of Southern Africa. Along certain lake borders however, in Southern France (Aix and Gargas, SAPPORTA), the heat and drought during the latter part of the summer were extreme.

The Oligocene terminated by the deepening of valleys, drying of the lakes and substitution of the fluviatile régime of the Lower Miocene.

Upper Oligocene 3.		Aquitanien.	Extensive freshwater lakes and lagoons. Recession of sea.
Middle Oligocene 2.	Tongrien.	Stampien.	Advance of sea in Paris Basin.
Lower Oligocene 1.		Infra Tongrien.	Marine and brackish deposits, lacustrine and marine Marls.

1. Infra Tongrien, Lower Oligocene

Ronzon was considered of Stampien age by Lapparent (**'85**, p. 1176); it is true the beds overlie the *Calcaire de la Brie*, which is undoubtedly lower Oligocene; Gaudry accordingly places it in the Infra Tongrien, and its fauna certainly succeeds closely that of the *Gypse*.

In 1881, M. Filhol (**'81**, pp. 256–263) concluded that *Ronzon*, even after 30 years of exploration, could not be considered a locality typical of the French fauna of the period. Since 1881, however, considerable additions have been made to the Ronzon, fauna, so that now it must be considered fairly typical (see Schlosser, **'90**).

The animals which make their first appearance here are the anthracotheres (*Anthracotherium* said to be absent in Ronzon), the elotheres, *Entelodon* (Elotherium) and the rhinoceroses, *Ronzotherium* (Aceratherium), two new genera of dogs, *Amphicynodon* and *Cynodon*. Otherwise the fauna continues an evolution of that of the *Gypse*, being especially distinguished as the last stage in which the *Palæotheriidæ* and the creodont *Hyænodontidæ* occur.

The marsupials are represented by *Peratherium*. Insectivores are represented by *Tetracus*. Among rodents we find representatives of the *Anomaluridæ* and *Muridæ*.

The European parallels with the *Marnes et Calcaires de Ronzon* (100 metres) fauna are mainly the newer portion of the Phosphorites. If M. Filhol's identification is correct in establishing the three genera, *Leptomanis*, *Necromanis* and *Palæorycteropus*, Filhol (**'93**, p. 129), it is possible that during this early Oligocene stage, the earliest edentates, pangolins and aard varks occur. Here also occurs the earliest of the European *Ancylopoda*, *Schizotherium priscum*.

The lignites of *Cadibona* (Piedmont) were considered Upper Oligocene (Aquitanien) by LAPPARENT ('85) and WEITHOFER, but they contain a little rhinoceros with simple premolars of lower Oligocene type. A portion of the fauna of *Lobsann* (Alsace) is parallel (ANDREÆ, '84) containing *Anthracotherium*, *Hyopotamus velaunus* and a species of rhinoceros wrongly attributed to *Aceratherium incisivum*.

2. Stampien

The Mid Oligocene stage is according to all authorities chiefly represented by the marine phase *Sables de Fontainebleu et d' Étampes* (41 metres); freshwater parallels are as follows: the *Argiles de St. Henri* (Rhone) are placed in the Stampien by Gaudry because they contain *Anthracotherium* and (?) *Diceratherium minutum.* In the Paris basin are *Ferté-Alais* (Seine et Oise), lacustrine sands, also placed by Gaudry at this level; *Selles-sur-Cher* (lacustrine limestones), also in the Paris'Basin; *Villebramar* (Molasse, Lot et Garonne).

3. Aquitanien, Upper Oligocene

The typical mammal deposits of this stage are the famous lacustrine beds of *St. Gérand-le-Puy* (Allier), calcareous, with a rich fauna (FILHOL, '79). This directly underlies lower Miocene beds containing Anchitherium and Mastodon.

Distinctive types of this stage are:

Palæoerinaceus,
Palæogale (and other mustelines),
Progenetta (and other viverrines),
Amphicyon lemanensis,
Protapirus douvillei (not certainly a tapir),
Diceratherium minutum,
Aceratherium lemanense,
Anthracotherium magnum. (Lignites de Volx.)
Anthracotherium hippoideum. (Lignites de Volx.)

The rhinoceroses show a very marked progression. The large *A. lemanense*, with complicated premolars represents one line; the small *Diceratherium* (*? croizeti*) *minutum* represents the Dicerathere line. Boule has reported a third line, *Cadurcotherium* (Moissac) representing the Amynodontidæ.

Parallel with St. Gérand-le-Puy are: *Moissac* (Molasse) containing the oft quoted *D. minutum* Cuvier; *Gannat* (lacustrine) containing the type of *A. gannatense* which is identical with *A. lemanense*; also *Randan* (lacustrine). Lignitic deposits of this stage are the *Lignites de Volx* (700 meters, Bas Alpes) and of *Manosque* (600 meters, Aix).

The former contains the large anthracotheres, *A. magnum*, *A. hippoideum*, highly characteristic of the upper Oligocene stage.

Beds paralleled with these by v. Zittel (**'93**, p. 66), in Germany are those of Ulm (Eselsberg and Eckingen); the complete faunal list of Ulm (Lepsius, **'92**, p. 570) shows these beds to be transitional between upper Oligocene and lower Miocene age; v. Zittel however places St. Gérand-le-Puy in the lower Miocene.

V. MIOCENE OF EUROPE

The lower Miocene of Europe is sharply separated from the Oligocene both geologically and faunally. Its duration may be judged from the thickness, 2700 metres, of marine deposits in Italy.

Divisions.—The Miocene is clearly divided in some regions into two stages, at others into three, as follows:

2d Mediterranean. (Suess.)	3. *Tortonien* (Oeningien, Grepp)	Recession of sea. Mainly fresh water, brackish and lacustrine deposits.
	2. *Helvétien*, M. E. 1857. (Falunien, d'Orb.)	Maximum of sea, mainly marine and brackish deposits. Local fluviatile and lacustrine deposits in the south.
1st Mediterranean. (Suess.)	1. *Langhien.* M. E. 1857. (Burdigalien, Lapp. Depér.)	Mainly fluviatile deposits. Invasion of sea on the south, partly marine and brackish deposits.

European geologists and invertebrate palæontologists are practically unanimous as to these divisions (Depéret, '92). Certain vertebrate palæontologists, however, still include in the uppermost Miocene the Pikermi and Eppelsheim beds which clearly belong in the base of the Pliocene. Faunally (mammals) the Miocene is now divided into upper and lower but it is apparent that it is capable of division into three life-stages typified in France as follows:

3. Upper, typified by *Grive-St-Alban.*

2. Middle, typified by *Sansan* and *Simorre.*

1. Lower, typified by *Sables de l'Orléanais.*

The separation of these life stages we owe chiefly to Depéret.

Physical Geography.—The Miocene is in general distinguished by a relative *elevation* of Northern Europe and *depression* of Southern Europe; accompanied by great volcanic eruptions in central France and Hungary; and ending in the completion of the great chains of Alps and Himalayas.

1. *Langhien.* In France the Oligocene Lake Basins were drained off and replaced by great river valleys, as attested by the fluviatile deposits or *Sables de l'Orléanais.* 2. *Helvétien.* This stage has a thickness of 495 metres in the basin of Crest (Fontannes.) The sea invaded the west coast of France up the valley of the Loire, also upon the south, isolating Spain and extending up the Rhone Valley, surrounding the northern slope of the Alps and extending northward to the Mayence Basin, to the east and south into the Vienna Basin, submerging large parts of Austria and Italy and converting parts of Europe into an archipelago. 3. *Tortonien.* A general recession of the sea accompanied by a marked increase in the number of freshwater deposits characterize this stage. Among these deposits perhaps the most typical or complete at the present time is that of *Grive-St-Alban* (Isère), monographed by Depéret ('92). The lesser part of this fauna is equivalent to that of Sansan; the greater part is somewhat newer. To the southeast, Austria was still partly submerged forming the *Leithakalk* or marine summit of the Tortonien in the Vienna Basin.

Climate.—If we can judge by the very gradual evolution of the fauna, the physical and biological conditions changed slowly.

The climate was extremely mild, subtropical but becoming more temperate, with a persistence of Sequoias and Palms (Sabal), even far north, a gradual increase in the number of deciduous trees which include a large proportion of North American types, and a marked increase in the grasses, stimulating the evolution of deer in the north and antelope in the south, especially towards the close of the period.

1. Langhien or Burdigalien, Lower Miocene

The *Sables de l'Orléanais* (Paris Basin, max. 20 metres) at Neuville-aux-Bois, Chevilly, Avaray, Chitenay (Loire-et-Cher), with a rich typical fauna, consitute the base of the Langhien, overlying the Aquitanien (Calcaire de Beauce) and underlying the *Marnes de l'Orléanais*, and the *Calcaire-de-Montabuzard*, beds which are parallel with the *Sables-de-Salogne* (40 meters).
The *Calcaire-de-Montabuzard* has a mammal fauna which Douvillé compared with that of Simorre, while the *Sables de l'Orléanais* fauna was formerly compared with that of Sansan. But French palæontologists (Gaudry, Depéret, **'92**, p. 155) now consider the *Sables de l'Orléanais* fauna somewhat older than that of Sansan, especially because it contains successors of certain Upper Oligocene types such as *Brachyodus onoideus*, the last of the anthracotheres in Europe, *Palæochœrus typus* also a survival, and *Procervulus* or *Dicroceras* (Depéret, **'92**, p. 155). On the other hand the *Sables de l' Orléanais* mark a faunal change from the Oligocene of the sharpest kind in the presence of the Proboscidia, *Dinotherium bavaricum* and *Mastodon angustidens*, both typically and exclusively Miocene species, which possibly had recently migrated into Europe from Africa by means of a favorable land connection. The *Sables de l'Orléanais* therefore constitute the *typical lower Miocene of Europe*. Freshwater equivalents (Depéret, **'95**, p. 397) of these beds are the *Grauen Süsswasser Molasse* (Lausanne) containing a rhinoceros ; *Engelhalde* (Bern) ; *Rappenfluh* (Aarburg). The *Brackische Schichten* (Ulm) are transitional ; partly calcareous deposits near *Ulm* (Eckingen, Eselsberg, Hockheim), contain *Anchitherium* and a fauna which is partly Oligocene, partly

Miocene (LEPSIUS, '92, p. 570). Among the marine equivalents (Lepsius, '92, p. 546) are the *Obere Meeres Molasse* (Switz.), *Muschelsandstein* (Baden). The marine molasse of *Eggenburg* is a noteworthy parallel as containing *Brachyodus onoideus* (DEPÉRET, '95, p. 397) and *Metaxytherium*, a Sirenian. *Brüttelen* (Studer, '95) also contains this true lower Miocene fauna including *Brachyodus onoideus* (SCHLOSSER, Lit'b., '95, p. 183) and *Hyopotamus helveticus*. The marine Cetacean of the period is *Squalodon barriense*.

Of exceptional importance is the presence of a similar fauna (*Amphicyon*, *Mastodon angustidens*, *Dinotherium*, *Anthracotherium*, *Hyotherium* and *Listriodon*), in southwestern India, in the *Bugti Beds* of Sind. These beds (BLANFORD, '84, p. 37) are far below the horizon of the Siwalik (Pliocene) fauna and contain all the typical older Miocene forms mingled with many of newer type. We find here especially *Hyopotamus giganteus* which Depéret regards as merely distinguished by its greater size from *Brachyodus onoideus*. LYDEKKER ('96, p. 201) and Blanford both consider the Bugti beds as "not improbably of Upper Miocene Age," and as indicating a survival in this area of archaic types which at that time had completely disappeared in Europe; the same author refers also to *Tetraconodon*, a large elothere, and to *Hyopotamus*; associated with the Miocene types therefore are true Oligocene types. The Bugti Beds are rich in Proboscidia and taken all together should be considered Lower and Middle Miocene rather than Upper Miocene.

Especially significant is this community of fauna between southern Asia and Europe at this time.

The lower, middle and upper Miocene faunas may therefore be contrasted as follows:

LOWER MIOCENE. *Typ.: Sables de l'Orléanais.*	MIDDLE MIOCENE. *Typ.: Sansan & Simorre.*	UPPER MIOCENE. *Typ.: Grive-St.-Alban.*
Brachyodus	o	o
Elotherium	o	o
Rhinoceros aurelianensis	R. Sansaniensis	R. brachypus ×
Anchitherium aurelianense		×
Dinotherium bavaricum		×
Mastodon angustidens	×	×

Macrotherium	×	×
Amphicyon		Hyænarctos.
Lutra		Ursavus (Ursus) primævus.
	Pliopithecus (Sansan)	Pliopithecus.
	Dryopithecus (St. Gaudens)	Oreopithecus (Mt. Bamboli)

o = extinct, or not recorded.
× = present, or recorded.

2. Helvétien, Middle Miocene

Fortunately for the mammalian palæontologist a large fresh water basin (termed '*Lac de l'Armagnac*' by Canu) was formed in southwestern France. Here were deposited the *Calcaires de l'Armagnac* (300 metres); in the lower levels are the famous *Calcaires de Sansan*, discovered in 1834; these were placed in the Langhien by LAPPARENT ('**85**, p. 1198) but are considered at the base of the Helvétien by Depéret; the rich Sansan fauna, containing both large and small animals and many skeletons, was first made known by LARTET ('**51**), and more recently has been monographed by FILHOL ('**91**).

Upon a higher level than Sansan, separated by conglomerates (LAPPARENT, '**85**, p. 1189), are the *Calcaires de Simorre* (originally compared with the *Calcaire de Montabuzard* by Douvillé) FILHOL ('**91**, p. 9) treated the Sansan and Simorre fossils as of the same age; he did not for example separate *Rhinoceros simorrensis* from *R. sansaniensis;* the writer finds that the former is specifically different from the latter and is of slightly more recent type. Simorre is thus geologically on a higher level and faunally somewhat younger than Sansan although still within the stage Helvétien, as arranged by Depéret. Parallel with Simorre is *Saint Gaudens* (Haute Garonne), according to Gaudry and Depéret. At the extreme base of the Helvétien and therefore parallel with Sansan or the 2d Mediterranean (Suess, DEPÉRET, '**92**, p. 156), are the *Lignites de Styrie* or the *Steiermark Braunkohle* (Eibiswald, Wies, Göriach, Voitsberg); the fauna of these outlying lignites of the Mediterranean sea invasion has been fully described by Suess, Peters, Hoernes, Hoffman, Toula. *Leiding*, in Southern Austria, is said to be of the same age.

The lignites of *Monte Bamboli* (Tuscany) are placed by LEPSIUS in the Langhien; their position is doubtful; they are here placed in the Tortonien.

3. Tortonien, Upper Miocene

This is the 'middle miocene' of Gaudry, Depéret, Gaillard and others who include Pikermi in the Upper Miocene; it is the 'upper miocene' of those who place Pikermi in the Pliocene.

Grive-Saint-Alban (Isère), explored by JOURDAN between 1845 and 1861, should now be regarded as typical upper miocene. That the mammalian fauna of this stage is distinctly more recent than that of Sansan and Simorre was maintained by DEPÉRET ('**87**, p. 22; '**92**, p. clvi) who showed that of 34 species 14 occur in Sansan; GAILLARD ('**99**, p. 75) has increased the faunal list of *LaGrive* to 63 species and the new types he records all tend to emphasize the more recent age [1] of this remarkably rich and typical fauna; many of the forms, however, such as *Felis*, *Ursus*, *Sus*, recorded by Gaillard are Pliocene genera, which probably should receive different names.

The best known parallel of *La Grive* are the sands of *Steinheim*, Württemberg, in which upwards of 30 species have been recorded (fauna, see LEPSIUS, '**92**, p. 586); twenty of these species are common with those of *La Grive*. In Bavaria are the deposits of *Günzburg*, *Ries* (Nordlingen) and *Georgensgemünd*. In Switzerland are the *Œningen* beds (Obere süsswassermolasse, Molasse d'eau douce supérieure), famous not only for its fauna but for its remarkable flora. This flora, as monographed by Heer, indicates a climate similar to that of Madeira and Japan; other localities of the upper *molasse* are *Elgg* and *Käpfnach*. In the Paris basin is the *Molasse de l' Anjou* (DEPÉRET, '**92**, p. 155); the *St. Jean de Bournay*; in the Rhone basin the *Cucuron* (Molasse) and *Cabrières* (Marnes).

[1] *Op. cit.*, "Les nouveaux mammifères rencontrés à la Grive tendent à donner à la faune de ce gisement une physionomie toute particulière et à la rapprocher davantage de la faune actuelle."

VI. PLIOCENE OF EUROPE

The mammalian faunal base of the Pliocene is defined in its northern facies by the Eppelsheim beds, in its southern facies by the very rich Pikermi deposits—the differences being entirely explainable by climate and latitude. Lepsius, the chief authority upon the geology of the Mayence Basin, holds (in opposition to Schlosser) to the unmixed character of the Eppelsheim fauna and to their unquestionable Pliocene age. The early identifications of Eppelsheim rhinoceroses, etc., with those of Sansan by Kaup and others were erroneous; according to the writer's recent observations they are very distinct. In both the German and Greek beds as maintained also by Eymar, Blanford, Lapparent and Schlosser the Pliocene age is unquestionable.

A new type of horse *Hipparion*, with very complex teeth and apparently a new comer to Europe, is common to both horizons, so are certain rhinoceroses and Ancylopoda but among the ruminants the hardy deer of Eppelsheim are replaced by antelopes and giraffes in Pikermi. Thus fortunately the beginning of the Pliocene is as sharply determinable by its mammalian fauna as the beginning of the Miocene.

In time and geographical history the Pliocene period extends between the completion of the Alps and the establishment of the main coast lines of modern Europe, the last touches to these lines being given in the Pleistocene and establishing their modern aspect. Marked throughout by continuous volcanic disturbances the period included a prolonged land depression in southern Europe and extensive invasions of the sea as shown in the following table:

4. SICILIEN. (ARNUSIEN)	A marine phase in Sicily. Fresh water lacustrine deposits in the Val d'Arno. Marine, brackish and lacustrine deposits.	Mammalian fauna of *Val d'Arno supérieure.*
3. ASTIEN.	Recession of the sea from southern river valleys, followed by fluviatile and lacustrine conditions (Sables jaunes astiens).	Mammalian fauna of *Rousillon.*

2. PLAISANCIEN.	Maximum marine *subapennine* invasion, long arms of the sea up the Po and Rhone valleys. Mediterranean extends to the East. (Argiles bleues subapennines). Chiefly marine deposits.	Mammalian fauna unknown, except that of *Casino* at the base of this stage.
1. MESSINIEN.	Renewed advance of the sea, brackish and freshwater conditions. Mediterranean bounded by Sardinia on the east; great Caspian seas and lakes beyond.	Fauna of *Pikermi* and *Eppelsheim*.

Climate.—Owing to the warm Mediterranean invasion the climate was mild. DEPÉRET, our chief authority ('**93**, p. 529), shows that there was no decided change of flora; nevertheless the period was marked by the very gradual advance of northern forest types and by the recession of the more delicate southern types, the palms for example being driven 10 degrees further south. The decisive lowering of temperature came during the early Pleistocene period.

1. Messinien, Lower Pliocene

During the first or Messinien stage the fauna of the lake-bound Ægean region (Pikermi), altogether similar to that of Southern France (Mt. Léberon), indicates abundant if not highly watered vegetation and extensive grazing pasturages of central African type. This fauna was widely distributed and highly distinctive; the parallels are numerous and well known.

Orient.	*Pikermi*—typical southern fauna.
	Samos (Ægean Sea), *Maragha* (Persia).
France.	*Mt. Léberon* (Vaucluse).
	Molasse d'eau douce supérieure du Rhône (higher than beds of same name in Switzerland).
	Cucuron (Couches saumâtres). *Puy Courny* (Cantal).
Austro-Hungary.	*Belvédère Schotter*, fluviatile gravels (Pontique, Depéret, '92. p. 156, Congeria Beds, Vienna Basin).
Spain.	*C. ncud* (Èbre Valley, near Madrid, a very extensive lacustrine formation), *Alcoi*.
Germany.	*Eppelsheim* gravels (4–7 metres), near Darmstadt.
	Upper Dinotherium sands, of Augsburg, Neuburg, Delsberg.

Distinctive types of this stage are *Pliohylobates* (Eppelsheim), *Hystrix* (Pikermi), *Pliohyrax* (Samos) *Hipparion gracile. Accra-*

therium incisivum of Eppelsheim succeeds the *A. tetradactylum* of Sansan ; the above are dolichocephalic rhinoceroses, possibly ancestral to Elasmotherium ; *R. schleiermacheri* possibly is a very large successor of *R. sansaniensis ; R. goldfussi* (Eppelsheim), a successor of *R. brachypus* of la Grive-Saint-Alban ; *R. blanfordi* (Maragha) also represents the short skulled or brachycephalic race ; *R. pachygnathus* is probably an African immigrant. *Dinotherium giganteum* replaces *D. bavaricum.* So throughout the Mammalia, besides numerous newly introduced forms, such as *Pliohyrax* and *Orycteropus*, there is a marked evolution beyond the upper Miocene types.

2. Plaisancien, Lower Pliocene

As this is chiefly a marine phase the terrestrial mammalian fauna is unknown except in the lignites of *Casino* (Tuscany) at its base ; these are equivalent to the *Couches saumâtres à congéries,* according to Depéret, and Lapparent. Here are found *Hipparion gracile, Sus erymanthius, Antilope massoni, Tapirus priscus, Semnopithecus monspessulanus* and other lower Pliocene types. This is the 'pliocène inférieure' of Gaudry, Depéret and others who have maintained the upper Miocene age of Pikermi. Upon a somewhat higher level than Casino are the following marine formations of England in which many cetacean and a few terrestrial types occur ; the parallels are :

Coralline Crag (Suffolk), marine, containing Mastodon, Rhinoceros. Red Crag, inferior or Nodule Beds, Marine, containing a fauna equivalent to that of the Astien stage in part.

3. Astien, Middle Pliocene

This stage contains the 'faune pliocène ancienne' of Depéret, or the 'older pleiocene fauna' of certain English authors who have not recognized Pikermi as the typical older Pliocene. Typical localities are the following :

Rousillon.	Sables sillicieux gris (25 metres), fluvio-lacustrine, fauna very similar to that of Montpelier.
Montpelier infér.	Sables jaunes marins (50 metres), described by Gaudry and representing the Plaisancien faunal stage in part.

Perpignan. Fluviatile.
Meximieux (Ain) tufas, famous for its characteristic Pleistocene flora : Bamboo, Sassafras, Magnolia, Laurel.
Sables de Trévoux (Saône)

DEPÉRET'S fine memoir upon *Rousillon* ('90, p. 538, 539) tends to make this locality typical. Characteristic species not found in Pikermi are *R. leptorhinus*, *Mastodon arvernensis*, *Tapirus arvernensis*, *Ursus arvernensis*.

Types with Messinien or Pikermi affinities are *Hipparion*, *Palæoryx*, *Hyænarctos*, *Dolichopithecus*. The Asiatic apes are *Dolichopithecus* and *Semnopithecus*. The African antelopes are *Palæoryx cordieri* and *P. boodon*.

4. Sicilien, Upper Pliocene

This embraces the 'newer pleiocene fauna' of English authors, the '*faune pleiocène récente*' of Depéret. *Hipparion* disappears, being replaced by *Equus stenonis ; Rhinocerus etruscus* succeeds *R. leptorhinus*. *Macacus florentinus* appears, related to the living Gibraltar form. The Proboscidia are represented by the last of the European mastodons, *Mastodon arvernensis* and *M. borsoni ; Elephas meridionalis*, the great southern elephant and precursor of the mammoth, is found in Italy and the Saône Valley. This species is absent locally (Depéret) in the *Sables à Mastodontes* of Puy, Coupet, Vialette. The typical locality is in the classic valley of the Arno in Italy, the so-called *Val d'Arno supérieure ;* its richness contrasts with the general poverty of Italy in middle and lower Pliocene types.

Italy. *Olivola*, a little higher than Val. d'Arno. Summit of Pliocene.
Val d'Arno supér. Thick fluvio-lacustrine beds (60 metres). Fauna fully listed by Stefani.
Astésan, *Villafranca* (San Paola), Tossano.
France. *Sainzelles* (Puy) a little higher than Perrier.
Perrier (Issoire) fluviatile gravels.
Montpellier supér. (Rhône), fluvio-lacustrine.
Coupet supér., volcanic deposits.
Vialette (Haute Loire, near Puy).
Chagny (Saône) fluviatile clays and sands.
Sables à Mastodontes du Puy.
England. Red Crag (Suffolk) Marine.
Norwich Crag (Norfolk) Fluvio-marine.

This arrangement is mainly upon the authority of Depéret.

It is important to note that Boule, another eminent French authority, differs in the arrangement of the Pliocene in particulars which will be discussed later.

To the north, in the Red and Norwich Crags of England, are said to appear the earliest arctic types of shells, the prophets of the glacial period. Also here (Norwich Crag) occurs the earliest giant beaver *Trogontherium minus*. The roe and stag deer become varied in southern France.

VII. PLEISTOCENE

In the Pleistocene period the fullness of European investigation is in strongest contrast with the indecisive results of American work and in no other period can we anticipate more weighty inductions from Holarctic correlation. The period is distinguished as the Ice Age and by the first recorded traces of man in beds which have been claimed as Tertiary but are properly Quarternary.

The Pleistocene history of Europe is still in a formative stage but it is absolutely evident that a final and positive time scale and subdivision of the early Age of Man is not far distant and that the vast labors of European geologists, botanists, zoölogists, palæontologists and anthropologists will be rewarded with a harmonious theory of all the phenomena of the Pleistocene.

Combined attack by geological and biological methods has nowhere produced more brilliant results. The unaided testimony of the rocks and soils fails to tell us of the successive advances and retreats of the ice but where, owing to the obliteration of surface deposits, geology is in confusion, plant and animal life serves both biology and meteorology like a vast thermometer actually recording within a few degrees the repeated rise and fall of temperature. This record consists of the invading and retreating life waves of river, forest, field, barren ground, steppe, tundre and arctic types with increasing cold, or the reversed order with diminishing cold, in the same localities or geographical areas. There seems to be sufficient evidence for a subdivision of the Pleistocene as shown in the Table below.

UPPER PLEISTOCENE: Post Glacial.

MIDDLE PLEISTOCENE: Glacial.

LOWER PLEISTOCENE: Preglacial.

Briefly, the glacial story presented in the second column of our Table is as follows: (1) The preglacial stage presents a mingling of south temperate, temperate and northern forms. (2) The long first glacial advance was followed (POHLIG) by the Rixdorf stage, intermorainal, colder than the succeeding Mosbach and Thuringian stages which have a more temperate facies in the recurrence of some of the Forest Bed fauna. (3) The faunal evidence for a colder mid-glacial period is conclusive; the evidence for a second or mid-glacial advance, between the first and last great glacial stages, is mainly biological, that is subarctic are followed by more temperate life forms, as we gather largely from studies of the rodent fauna by NEHRING, STUDER and others. The hypothesis of three distinct glacial advances and of two interglacial retreats rests therefore upon a combination of geological and biological evidence which is not as yet conclusive. We shall consider it more fully after discussing the fauna. It is supported geologically by observations of Penck and Böhm in the Bavarian Alps. Upon this theory the Pleistocene history with its fluctuations of temperature is epitomized in the following Table. This Table is an attempt to combine the chief results of the masterly work of DAWKINS, POHLIG, BOULE, NEHRING, STUDER, WOLDRICH, SCHLOSSER, and others. None of these authors has treated the whole period; yet there is an evident harmony and synthetic trend in their work.

Deposits.—Geologically we have to do with the characteristic glacial deposits, boulders, boulder clay or drift, gravels and till. The origin of the fine calcareous loam termed "Loess" distinguishing the upper middle Pleistocene is still under debate; it is partly glacial mud; partly subærial, it is also subsequent to the second glacial stage, and in part postglacial. We find also the river deposits of the lower and mid-Pleistocene (Forest Bed, and Mosbach) as well as of all higher divisions. The mid-Pleistocene was distinguished by volcanic disturbance, as attested in Thuringia by the volcanic travertines and tufas. There are also

Partly Theoretical Divisions of European Pleistocene, after Pohlig, Depéret, Nehring and Others

I. Main Stages.	II. Partly Theoretical Relations of Glacial Oscillations.	III. Characteristic Geological Deposits.	Faunal Div. (Pohlig.) Localities. Climate. Gen. Fauna. IV. Stratigraph., Faunal and Geol. Succes.	V. Human Remains and Characteristic Mammals.
Neolithic implements. UPPER PLEISTOCENE. Post-Glacial or Alluvial.	Recession of Glaciers.	Humus, Lake Terraces. Post-Glac. Löss.	**Prehistoric Stage.** N. temperate. Forest, Upland, River and Field Fauna.	**Forest and Lake Dwellers.** Recently exterminated types.
(Moustiéren Human type.)	3d Glacial. 2d Interglacial.	Löss, Valley Gravels, Cave Clays, Diluvium, Sands.	**Elephas primigenius stage.** N. temperate and Boreal, Steppe and Forest Fauna. Up. Rodent. Steppe Fauna, Yellow Culture Layer; Lower Rodent Tundre Fauna. Subarctic Tundre Fauna.	Felis, Hyæna, Ursus spelæus, Cyon alpinus, Capra ibex, Ovibos, Rangifer, Bison priscus, Equus, R. tichorhinus, Elasmotherium, Elephas primigenius. **Neanderthal and Spy, human types. Steppe and Cave Dwellers.**
Palæolithic implements. MIDDLE PLEISTOCENE. Glacial or Diluvial. (Cheléen Human type.)	2d Glacial. Interglacial. 1st Interglacial.		RHINOCEROS MERCKII. **Elephas antiquus stage.** N. Temperate Thuringian tufa, Taubach (Weimar).	**Oldest human remains known, Molar teeth** (Nehring). Saiga prisca, Alces machlis, Capreolus, Lemmus, Alactaga saliens, Lepus, Elephas antiquus, E. primigenius, Rhinoceros merckii.
		Fluviatile, River Sands, and Gravels. Gravels, Conglomerates, Sands.	**Elephas trogontherii stage.** Temperate. B. Mosbach Sands (Lower Terraces). A. Rixdorf Beds, Subarctic. (Higher Terraces.)	Felis spelæa, F. lynx, Bison, Sus scrofa, Cervus elaphus, Equus caballus, Rangifer, Hippopotamus, Arctomys. Megaceros, Ovibos, R. tichorhinus, R. merckii, Elephas trogontherii.
	1st Glacial.	Boulders, Erratics, Clays, Drifts, Sea-terraces, Moraines.	Arctic.	Fauna unknown.
LOWER PLEISTOCENE. Preglacial or Transitional to Pliocene.	Advance of Glaciers.	Estuarine and Fluviatile, Marls and Sands.	**Elephas meridionalis stage.** Forest Beds (Norfolk). St. Prest. Durfort. Malbattu (Auvergne Puy-de-Dôme). Chalon - St. - Cosme (Bresse).	**Earliest palæoliths.** Machærodus, Hyæna spelæa, Ursus spelæus, Lutra, Ovibos, Hippopotamus, Bos primigenius, Equus stenonis, Rhinoceros etruscus, Elephas meridionalis, E. antiquus, Trogontherium.

lake and sea-beach deposits constituting the lacustrine and marine terraces. The very characteristic cave deposits, breccias and earths belong to the upper mid-Pleistocene. Then there are the younger river alluvia, lake bottoms, aëolian sands, peats and mosses.

Geographic Changes.—The beginning of the Pleistocene is remarkable for its broad land connections and it represents the last stage of that community of fauna which during the Pliocene distinguished the entire region of Europe, Asia and Africa. The mid-Pleistocene period in Europe is mainly one of continental depression; (1) at the climax of the first glacial advance extensive portions of northern Europe were submerged beneath the sea; (2) at the close of the first interglacial or temperate period (Elephas antiquus stage) occurred the volcanic disturbances in Central Europe and the hot spring formations of Thuringia (Taubach, Weimar); at this time *all the old continental connections characteristic of the Tertiary and serving as land bridges for free Holarctic, Oriental and Ethiopian migration began to break up in the following manner*: during the early mid-Pleistocene or *Elephas antiquus* stage (Pohlig) the English Channel broke through the long preëxisting land-bridge between England and France; Great Britain was faunally isolated; similarly the Irish Channel was depressed and Ireland lost its land connection with Wales in the early Pleistocene and with Scotland in the newer Pleistocene.[1] In the Mediterranean region, also, at the close of the first interglacial period (Pohlig) the land bridge across Gibraltar, also that between Italy, Sicily and Africa was broken; Malta[2] was isolated as an Island and the great *Elephas antiquus* dwindled into the small insular type *E. melitensis.* To the eastward the Mediterranean extended into the Ægean plateau, which had previously been terra firma, and the Ægean sea cut off the land connection between Greece and Asia Minor. It is important to note as observed by Wallace and Lydekker, that the arid and desert land connection still existing between Europe and Africa at the Isthmus of Suez constitutes practically a faunal barrier as impassable for most mam-

[1] According to Scharff, Ireland has yielded only ten Pleistocene species, including the Northern *Lepus variabilis* and Reindeer and the great *Megaceros hiberniæ*, which is found in the post-glacial peat moors.

[2] Malta shows evidences of two periods of elevation and depression. See Pohlig, also Leith Adams, "The Nile Valley and Malta," London, 1870.

mals as water. The Sahara desert although elevated during the Tertiary was another faunal barrier and northern Africa was zoölogically a part of Europe. In the far northeast the Behring Straits were formed and after a complete community of arctic, boreal and north temperate faunas had been established, the Nearctic region or North America was completely isolated from the Palæarctic or Europe and Asia. (See Fig. III.)

Stratigraphy.—Faunally the strata record is far less exact than in the preceding Tertiary periods owing to the wide spread removal of easily eroded materials. Yet definite stratigraphic succession occurs in many places and upon the whole the faunal succession as shown in column V of the Table, p. 36, is as fully and definitely known as in any previous division of the Tertiary. In the sands of St. Acheul, near Paris, *Elephas antiquus* occurs at 7 metres, *Hippopotamus amphibius* at or below 5 metres, *Elephas primigenius* never below 3 metres. The most exact stratigraphic records are those of the caves near Schaffhausen for example; here a general succession of types is positively ascertained.

1. Preglacial, Elephas meridionalis Period

The typical preglacial deposits are the *Forest Beds* of Norfolk. The weight of opinion and of fact is all upon the side of considering these beds as Pleistocene. Depéret ('**93**, p. 538), is strongly of opinion that they are transitional between Pliocene and Pleistocene with prevailing affinities on the latter side. He places with them as of the same age *St. Prest* (Eure et Loire), *Durfort* (Gard) where a magnificent skeleton of *Elephas meridionalis* was obtained for the Paris Museum; *Malbattu, Peyrolles* (Auvergne, Puy-de-Dôme).

From the list given by Dawkins ('**80**, '**94**), Schlosser and other writers the Preglacial period is found to contain:

12 Pliocene species;
32 Pleistocene species and races, now extinct;
17 Living species, of which 7 are Insectivora and 1 Cheiroptera.

Some of the determinations are questionable. Pohlig states that the true *Cervus megaceros hiberniæ* is post-glacial, the preglacial type being more primitive ; also that the straight tusked *Elephas antiquus* first appears in the north in the Mosbach interglacial bed ; elsewhere he refers to it as occurring in the south of France (St. Prest) preglacial beds.

The remarkable feature of this fauna is the mixture of African and North Asiatic forms. The great *Elephas meridionalis*, a precursor of the Mammoth, is the most characteristic type.

The first traces of man in the palæolithic flints of the Cheléen type occur upon this level.

The climate, judging by the flora and Conchylien fauna, was somewhat cooler than that of the Upper Pliocene. The first arctic flora in England is in a layer which separates the *Forest Bed* from the glacial Boulder Clays.

2. Glacial and Interglacial, or Mid-Pleistocene

a. Lower Mid-Pleistocene. First Interglacial Period (*Elephas trogontherii*) Lower Stage, Pohlig.

In climate the early part of this period, immediately during and succeeding the first ice advance, was very extreme. None of the first ice advance fauna is known unless we except *Elephas* (*primigenius*) *trogontherii* or *intermedius* and *Cervus elaphus*, the latter being doubtfully recorded from the Boulder Clay of England. Here we find the first arctic and sub-arctic types in central Europe. Geologically, these post-glacial deposits consist (Rixdorf Beds) of gravels, conglomerates and sands, constituting (Pohlig) the highest post-glacial terraces, or *Higher Terraces*. It is marked by the first appearance of *Elephas trogontherii*, *Rhinoceros merckii*, *R. tichorhinus*, and the following species of *northern* type : *Ovibos moschatus*, *Cervus* (Megaceros) *germaniæ*. Among the new forms we note the megarhine rhinoceros, *R. merckii*, as most distinctive. The mammoth *Elephas* (*primigenius*) *trogontherii* succeeded the *Elephas meridionalis* of the preglacial beds.

b. Lower Mid-Pleistocene. First Interglacial Period (*Elephas trogontherii*) Middle Stage, Pohlig.

This stage marks the recurrence of a *more temperate climate*, first observed by Lyell and Evans in England and abundantly known in Germany and France. Two only of the characteristic Pliocene species recur, *Hippopotamus amphibius*, and *Elephas antiquus*. These alone have been universally cited as evidence of a south temperate climate but the more numerous northern types still living which are found in this stage constitute still stronger proofs of a *north temperate climate*.

Geologically the deposits are of fluviatile origin, consisting of river sands and gravels containing *Hippopotamus*, *Rhinoceros merckii* and *Elephas trogontherii*. *Trogontherium cuvieri* makes its last appearance here.

Geographically the southern continental depression has not begun and the Lower Pleistocene land bridges persisted. Parallel faunæ are those of Essex (Ilford, Grays Thurrock, Clacton) and Kent (Erith and Crayford) fully listed by Dawkins (**'80,** p. 397 ; **'94,** p. 243) and Woodward (**'83**). In Germany the typical fauna is that of Mosbach (Lepsius, **'92,** p. 652).

The Mosbach and Essex faunæ give the following results :

4 Pliocene species, (including two living types) ;
7 Pleistocene species, now extinct ;
16 Living species (including 2 Pliocene species).

The characteristic Pleistocene species which are first recorded in Mosbach are *Cervus megaceros*, *Cervus* (*Alces*) *latifrons*, *C. elaphus typus*, *C. Capreolus typus*, *Felis spelæa*, *Ursus spelæus*, *Bos taurus*, *Bison priscus ;* in Essex, Cervus (Megaceros) *belgrandi*, *Hyæna spelæa*. Among the living species recorded for the first time or making their first appearance at this stage are *Rangifer tarandus*, *Sus scrofa*, *Equus caballus*, *Felis lynx*, *Meles taxus*, *Arctomys marmotta*. The Essex Fauna is fuller but although of more southern latitude is not of more southern type, including the northern and north temperate forms *Felis catus*, *Canis* (*Vulpes*) *alopex*, *Canis lupus*, *Ursus ferox*, *Ursus arctos*, *Lutra lutra*.

c. Mid-Pleistocene. Elephas antiquus stage, First Interglacial Period Upper Stage, Pohlig.

According to Pohlig the Mid-Pleistocene proper, or succeeding stage, was characterized by volcanic disturbances in central Europe and by the deposition of gypsum and tufas. Probably these earth movements were connected with the marked geographical changes brought about by wide-spread depression of the continental borders and isolation, which the same author assigns to this period. The fauna, typically represented in the Thuringian tufas, indicates a cooler or north temperate climate. *Elephas antiquus* is very abundant, making its last appearance north of Italy. The typical locality is the Thuringian Tufa in which Pohlig records 61 species. Parallel with this is the Taubach Weimar fauna.

In 1895, NEHRING ('**95**, p. 369) reported from this level what he regarded as the oldest human remains thus far found in Europe, consisting of two very large molar teeth resembling in some respects those of the chimpanzee; this he considered of Cheléen type. In the same year Newton described a human skeleton of Esquimaux type in the still older 'higher terraces' or Hippopotamus level; the antiquity of this skeleton is, however, rendered somewhat doubtful by the fact that the skull is of much newer type than those of Néanderthal and Spy, and the evidence for its extreme palæolithic age is not considered absolutely conclusive.

In this fauna Hippopotamus no longer appears—an indication perhaps of a decidedly colder climate. *Elephas antiquus* however persists and is most abundant. Among the other characteristic Pleistocene forms are *Rhinoceros merckii* which disappears soon after this stage; *E. primigenius typus; Cervus gastaldi.* The faunal list is provisionally analysed as follows:

3 Pliocene species still living (Castor, Hyæna, Arvicola);
7 Pleistocene species, now extinct;
23 Living species (including living pleistocene Northern types).

The number of recorded living species increases, there being a marked increase especially in the number of reindeer. The most important new living types are: the steppe antelope *Saiga prisca* (*tartarica*), the moose *Alces machlis*, the lemming, *Myodes lemmus*, the Siberian jerboa *Alactaga saliens*, *Hystrix*, *Lepus timidus*. These constitute a distinct invasion of north Asiatic forms into the southern steppes.

Theory of a Mid or Second Glacial Advance

In all the preceding summary a certain faunal succession is noted consisting chiefly of elimination of southern types and introduction of northern.

Woldrich ('**96**) maintains that all the loess and cave types are of postglacial age—the tundre and steppe types alone representing the last great glacial advance—after which came the meadow or field (Weide-fauna) and the forest fauna (Wald-fauna); he considers the alleged ice periods as mere local oscillations.

The possibility must also be freely admitted, as discussed by Bulman ('**93**, p. 261), of the existence of south temperate types remote from the Ice Sheet; we find, for example, in southern Alaska, a very mild climate in proximity to great glaciers; similar conditions may have existed in southwestern Ireland and southern Europe.

Other authors such as Boule, have maintained the glacial age of the Tundre and Steppe fauna and the post-glacial age of the Forest fauna. If they are correct the theory of an interglacial or second glacial advance would lose its strongest support. It is evident, however, that such a succession of faunas might recur more than once. Nehring has observed in different localities (Westeregeln, Thiede), the *unquestionable interglacial age of the steppe fauna* and he considers Schweizerbild as interglacial.

d. Upper Mid-Pleistocene. Elephas primigenius Stage, Pohlig

As we enter the next succeeding life stage, namely, the Loess and Cave Fauna of Central Europe, the stage of *Elephas primigenius*, *Rhinoceros antiquitatis* or *tichorhinus* and *Rangifer tarandus* we note the decline of *Rhinoceros merckii* and the absence of *Elephas antiquus* in geological deposits which are chiefly diluvial valley gravels and sand clays. These facts alone indicate a prolonged colder period, *a northern* or boreal climate. The fauna presents a great variety adapted to different degrees of temperature but decidedly of northern type. Other facts indicate that this colder period was initiated by a distinct second advance of the ice followed by a gradual recession, namely the occurrence of arctic and subarctic types succeeded by north temperate types, in a number of localities, typically near Schaffhausen (Schweizerbild, STEINMANN, **'93**, p. 117) (Franken, SCHLOSSER, **'95**, p. 211).

These successive northern faunas in single localities are typically as follows:

1. TUNDRE FAUNA. (Frozen subsoil, arctic and subarctic.)	2. STEPPE FAUNA.
Myodes torquatus,	Alactaga,
" obensis,	Spermophilus,
Lepus glacialis,	Lagomys pusillus,
Rangifer tarandus,	Arvicola,
Ovibos moschatus,	Cricetus phæus,
Lagopus mutus,	Equus,
" albus,	Antilope saiga.

The prevailing types of this stage are the typical *Elephas primigenius* which succeeded *Elephas trogontherii*, *Rhinoceros tichorhinus* and *Rangifer tarandus*. The reindeer, first the barren ground then the woodland variety, increased rapidly in number during this period and constitute its most distinctive form; hence this is known as the Reindeer period.

It includes the most remarkable diversity of life of Asiatic both Siberian and Oriental, and of African origin. The persistence of the following southern forms: *Felis* (*leo*) *spelæa*: *Felis pardus*, *Hyæna* (*crocuta*) *spelæa*, *Equus caballus*, *Equus* (*asinus*) *hemiones*, *Rhinoceros tichorhinus* (with affinities to *R. simus*), *Elephas primigenius*. All these types, excepting possibly the Mammoth, now inhabit warm, dry, semi-arid regions. There is therefore an Ethiopian and Oriental fauna, in certain localities succeeding a steppe and tundre fauna. At no period either before or since was Europe so thoroughly cosmopolitan, a fact which has not been sufficiently emphasized previously. The climate was cold and relatively dry.

The close of this period is also the close of the Palæolithic human period which after a long interval was succeeded by the Neolithic period.

3. Upper Pleistocene, Postglacial

As above observed there is a difference of opinion as to the interglacial or postglacial age of the loess. All the North Siberian, Oriental and African types gradually disappear, the modern European forest and field fauna alone survives. There is some evidence that both the mammoth and reindeer lived for a time in this period, the latter being now confined to more northern Europe. The Irish deer, *Megaceros hiberniæ*, the reindeer, the bovidæ *Bos taurus*, *Bos longifrons*, *Bos brachyceros*, are the characteristic ruminants. *Alces palmatus* is a postglacial Russian moose. The horse, *E. caballus*, of larger and smaller varieties is now domesticated and used for food. The carnivora, rodentia and insectivora are all of modern type.

The detailed comparison of the Pleistocene of Europe, America, and Asia is still under way, and very important results may be expected from it. It will be equally serviceable to American anthropologists and palæontologists, for our own Pleistocene is far from being understood. The stages represented by our horse or *Equus Beds*, which are usually considered Lower Pleistocene, as well as of the Megalonyx and Cave Fauna of the East remain to be exactly fixed. Interest in this problem is greatly enhanced by the fact that we may at any moment discover the remains of man or of his ancestors associated with *Equus* and positively demonstrate the existence of man upon this continent at a period contemporaneous with the first proofs of his appearance in Europe in the existence of preglacial palæolithic flints.

PART II. FAUNAL RELATIONS OF EUROPE AND AMERICA DURING THE TERTIARY PERIOD AND THEORY OF THE SUCCESSIVE INVASIONS OF AN AFRICAN FAUNA INTO EUROPE

In an address before the Academy last year the various steps which have been taken to secure correlation were described. The work proves to be a very difficult one and is by no means complete. The kind co-operation of the leading palæontologists of Europe was enlisted and as a result an approximate correlation sheet was prepared. This was virtually a report of progress in this investigation, main emphasis being laid upon geological succession. In continuing the subject this year, main emphasis will be laid upon *faunal succession* or the distribution of the different orders and families of mammals, concluding with the latest views as to the succession of life during the Pleistocene period in Europe.[1]

I. STRATIGRAPHICAL CORRELATION: PRELIMINARY

LYELL'S SYSTEM.			Approximate American Parallels.
PLEISTOCENE.	UPPER.	Post Glacial	
	MIDDLE.	Glacial & Interglacial	
	LOWER.	PREGLACIAL	? EQUUS BEDS
PLIOCENE.	UPPER.	SICILIEN	? BLANCO
	MIDDLE.	ASTIEN PLAISANCIEN	
	LOWER.	MESSINIEN	Upper Loup Fork
MIOCENE.	UPPER.	TORTONIEN	LOUP FORK
	MIDDLE.	HELVETIEN	Lower Loup Fork and
	LOWER.	LANGHIEN	Upper John Day

[1] This portion of the second address is placed in its proper order above after Pliocene.

OLIGOCENE.	UPPER.	AQUITANIEN	Lower John Day (Diceratherium Layer)
	LOWER.	STAMPIEN	WHITE RIVER
		INFRA TONGRIEN	
EOCENE.	UPPER.	LIGURIEN	BRIDGER & UINTA
	MIDDLE.	BARTONIEN	LOWER BRIDGER
		LUTETIEN	WIND RIVER
	LOWER.	SUESSONIEN	WASATCH
	BASAL.	THANETIEN	TORREJON
		MONTIEN	PUERCO

Preliminary Correlation Table of European and American Tertiary Horizons. On all the levels above the Stampien the parallels are imperfectly established.

The preliminary correlation sheet abbreviated in this table sets forth the results of the geological succession and correlation so far as it has been carried at present and illustrates the rapid progress of the knowledge of our own horizons. It includes the latest results of the American Museum explorations in the Miocene of Colorado and Kansas, as roughly studied by MATTHEW, but these correlations are not to be understood as final. SCOTT has already transferred our John Day of Oregon, from the Miocene, where it was formerly placed, to the Upper Oligocene. The lower part at least of these beds belongs in the Oligocene, while the Upper John Day may prove to correspond with the Lower Miocene of Europe. Our Pliocene record as compared with the magnificent Pliocene of Europe is extremely meagre, and our Miocene succession rich as it is, is not as fully understood as the Miocene of France ; we look for more exact results from the American Museum explorations which are now being collated. It is only when we pass into the great time period from the Oligocene downwards that the American record becomes a superbly complete time standard for the whole Northern Hemisphere or Holarctic Region.

II. TERTIARY GEOGRAPHICAL DISTRIBUTION

The importance of Geographical distribution was first recognized by HUMBOLDT, and set forth by DARWIN in the 'Origin of Species,' in 1858. In the same year SCLATER divided the world into six great regions and into eastern and western divisions or Palæogæa and Neogæa, to embrace the Old and New Worlds respectively, a division which has proved to be illogical. This led DARWIN'S distinguished colleague, ALFRED WALLACE, to his great work upon the 'Geographical Distribution of Animals' and the division of the world into life regions; in which Sclater's scheme was adopted and developed.[1] In 1868 Huxley divided the world into a northern division, Arctogæa, and a southern division Notogæa to include the Northern and Southern Hemispheres respectively; this division was a little nearer the truth than Sclater's. Between 1868 and 1890, SCLATER, ALLEN, NEWTON and BLANFORD, working upon living birds and mammals, continued this investigation, but it remained for BLANFORD, in 1890, to prove that the world zoölogically should be divided into three great divisions; an Australian, a South American and a third region, Arctogæa, comprising North America, Europe, Asia and Africa.[2]

Now it is clear that exactly as our understanding of the relations of living animals and plants to each other depends upon their fossil ancestors or upon their palæontology, so the final test of a scheme of zoölogical distribution must be a palæontological test. The animals of various families and orders have either originated in or migrated into their present habitat in past time, so that the geological record as to their order of appearance becomes of first importance. Here again the necessity of an *absolutely reliable correlation time scale* such as we are now establishing becomes evident, for the very first step toward an exact solution of the problem of past migration is to establish, as far as possible, the faunal parallels upon different continents; we can then determine where certain types of animals first appeared, and distinguish between the autocthonous endemic or native types and the migrant or new types.

[1] The history of opinion upon this subject is fully set forth by LYDEKKER'S valuable work the "Geographical Distribution of Mammals," published in 1896.

[2] Dr. Theodore Gill has kindly called attention (*Science*, June 8, 1900) to my oversight of an important paper of his ("On the Geographical Distribution of Fishes," *Ann. Mag. Nat. Hist.*, 1875, pp. 251–255). He unites South America, Australia and Africa into a single division EOGÆA, in contrast with CÆNOGÆA, which includes North America, Eurasia and India.

This then is our problem, to connect living distribution with distribution in past time and to propose a system which will be in harmony with both sets of facts.

The tests of synchronism between European and American depositions are four-fold : *First*, the presence of a number of identical or closely allied genera and species. *Second*, similarity in the steps of evolution in related animals. *Third*, the predominance and spread of certain animals, as of the odd-toed Ungulates in the middle Eocene and of the even-toed Ungulates in the Upper Eocene. *Fourth*, the sudden appearance of new types which have apparently originated elsewhere and have enjoyed an extensive migration, so that they appear simultaneously in different regions of the earth. An instance of this kind is afforded by the unheralded appearance of new types in the base of the Oligocene (Rhinoceroses) and of the Miocene (Proboscidia) in Europe and America. (See Part I, pp. 22 and 26.)

Unfortunately there is still no agreement among zoölogists as to the faunal geographical divisions. LYDEKKER well versed in both palæontology and zoölogy, has for the first time brought together both classes of evidence in his recent valuable work upon the "Geographical Distribution of Mammals," he shows conclusively that zoö-palæontology favors the division of the world into three great realms as proposed by BLANFORD ; to these may be applied the terms ARCTOGÆA, NOTOGÆA and NEOGÆA, as proposed anonymously (SCLATER) in 1893.[1] (Fig. 1.)

Geographically, these realms are connected by low lying portions of the earth, which, during long periods of submergence beneath the sea, have completely isolated them. At the same time we are forced to conclude that there were shorter intervals of elevation or land continuity at various times during the Tertiary period.

Now it is a well-known principle of zoölogical evolution that an isolated region, if large and sufficiently varied in its topography, soil, climate and vegetation, will give rise to a diversified

[1] In a review of papers by Merriam and Allen (The Nearctic Region and its Mammals, *Natural Science*, 1893, p. 289), P. L. Sclater observes "Thus we have a very obvious threefold division of the earth's surface, taking mammals as our text, into what may be called *Notogaea*, *Neogaea*, and *Arctogaea*."

fauna according to the *law of adaptive radiation*[1] from primitive and central types. Branches will spring off in all directions to take advantage of every possible opportunity of securing food. The modifications which animals undergo in this adaptive radi-

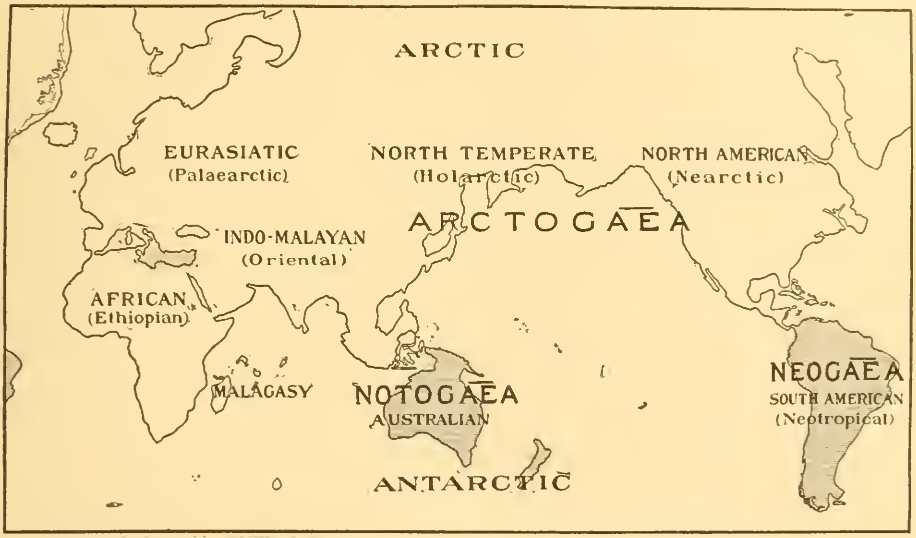

FIG. I.—Division of the World into three Realms and nine main Geographical Regions. The continental platform is raised to the 200 metre line showing the main Tertiary land connections.

ation are largely of mechanical nature, they are limited in number and kind by hereditary, stirp or germinal influences, and thus result in the independent evolution of similar types in widely separated regions under the *law of parallelism or homoplasy*.

Adaptive Radiation of Orders and Families

This law causes the independent origin not only of similar genera but of similar families and even of similar orders. Nature thus repeats herself upon a vast scale, but the similarity is never complete and exact. When migrations are favored by over-population or geographical changes, a new and severe test of fitness arises by the mingling and competition of the parallel types.

[1] So termed by the writer (OSBORN, '93 and '99).

Under the operation of these laws a most interesting generalization or hypothesis can be made as to the three realms: geographical isolation has been so continuous and prolonged that great orders of mammals have been evolved (Fig. III) in each. Thus *Arctogæa*, containing the broadest and most highly diversified land area, appears hypothetically as the center in which fourteen primitive and specialized orders radiated from each other. In the southern portion of *Neogæa* at least four orders sprang from primitive members of the above orders, and the Hystricomorph rodents enjoyed their chief radiation. In *Notogæa* two orders were cut off by the sea; one of them a rapidly declining type, the Monotremes, the other, the Marsupials, enjoying a very highly diversified radiation. This hypothesis is expressed in Fig. III. Two other orders of mammals, the Sirenia (probably a branch of the hoofed tribe) took the rivers and coasts of America, Europe and probably Africa as their radiating center, while the Cetacea occupied the fourth or oceanic realm.

We mean to express by this hypothesis that REALMS *were the main centers of adaptive radiation of orders of mammals*, but by no means the exclusive areas of distribution, for during the periods of land contact certain members of these orders found their way into adjacent realms. Each realm, therefore, contains its pure autocthonous types and its migrant or derived types. REGIONS, on the other hand, may be distinguished from realms as geographical and zoölogical areas, which have been isolated from each other for shorter periods, either by climatic barriers, as in the case of the Arctic or circumpolar region or by great physical barriers, such as masses of water and of desert sands. In certain cases these regions, such as Africa, appear to have been so large, distinct and isolated as to have become important centers of the radiation of certain *orders* of mammals and almost attain the rank of realms, but regions in general are chiefly and permanently distinguished by the *adaptive radiation of families of mammals.*

Arctogæa may thus be still divided on the old lines into five or six regions, the *Arctic* or Circumpolar; the *Ethiopian* or African, south of the Sahara; the *Indo-Malayan* or Oriental, including southern Asia and the Malayan islands ; the *Malagasy*, including Madagascar ; the *Nearctic* and the *Palæarctic*. There is no question, as suggested by Professor Newton in his term "Holarctic," and by Professor Allen in 1892, in his term "North temperate," that the North American (Nearctic) and Eurasiatic (Palæarctic) regions are now so closely similar that they might be united into one. When, however, the zoölogical or existing characteristics of these regions are put to a palæontological test it is found necessary to separate them, because throughout the Tertiary period North America and Eurasia were so remote that, to a certain extent, they constituted centers, not only of independent family, but to a limited degree of ordinal radiation. At the same time they were unified, both by frequent intermigrations and by a simultaneous evolution of allied animals.

The Continent Antarctica

We now come to one of the greatest triumphs of recent biological investigation, namely, the concurrence of botanical, zoölogical and palæontological testimony in the reconstruction of a great southern continent to which the name Antarctica has been given. Following BLANFORD ('90), FORBES ('93) made the first strong plea for this continent. The flood of evidence for the Antarctica theory has now become so strong that only a few details can be mentioned: FORBES ('93) and MILNE-EDWARDS from the consideration of the birds ; BEDDARD from the study of worms and other invertebrates ; MOORE from the study of the flora of South Africa ; SPENCER from the study of the fauna of Australia ; AMEGHINO, HATCHER and ORTMANN from studies and collections of vertebrate and invertebrate fossils in Patagonia not yet fully published ; MORENO, from the discovery of Miolania, an Australian fossil reptile recently found in South America ; from these and many other sources has been brought fourth the body of testimony which draws us almost irresistibly [1] to the conclusion that there was an antarctic continent at various times connecting South America, South Africa, Aus-

[1] After discussing the evidence with great fairness LYDEKKER ('96), takes a more conservative position.

tralia and New Zealand. Such a connection strengthens the conception announced by HUXLEY in 1868, that the zoölogical regions were mainly upon lines of latitude, rather than as suggested by the present configuration of the earth, upon lines of longitude. With the theoretical elevation of this submerged continent (Fig. II), which may be called the "Ant-

FIG. II.—Restoration of Antarctica by elevation to the 3040 sounding line, showing old continental lines and greater depth between Africa and Antarctica.

arctic Region," so as to connect the southern land masses at various times, all present and past geographical distribution of mammals may be theoretically accounted for. Elevation to the 10,000 foot (3040 meter) line still leaves a broad channel south of Africa. Without such elevation we are still met by many insuperable difficulties.

Among other problems, a land connection between Africa and South America across the South Atlantic enables us to explain the remarkable distribution of the Sirenia, sea-cows, dugongs and manatees, now found exclusively in the tropical belt of Africa and the Americas. (See Sirenia, Fig. III.) These animals first appear in the Oligocene of Germany. It is also, of course, possible that they may have taken a northern route, as indicated by the remains of *Rhytina* in the North Pacific.

Before confining our attention to ARCTOGÆA, let us further consider the mesozoic relations of the three realms. (Fig. I and Fig. III.)

In the Jurassic period stem forms of insectivores, marsupials and possibly of monotremes[1] are found in Arctogæa and seem to establish the theory of the northward origin of the mammalia as a class.

DOLLO ('99), has recently endeavored to demonstrate that all *Marsupials* have been evolved from arboreal forms like the Opossum. If we can draw a parallel with the adaptive radiation of the placentals during the 3,000,000 years, more or less, of the Tertiary, we may safely conclude that such a primitive family, entering the Australian region during the Cretaceous period either by way of Antarctica (SPENCER) or by way of the Oriental region (WALLACE and LYDEKKER), might have peopled Australia with all its wonderfully diversified forms of Marsupial life. The Didelphyidæ are to the Marsupials what the Creodonta are to the Placentals in point of potential evolution. The *Monotremes* also may have entered NOTOGÆA by either of these routes.

North America is the only part of the globe where Cretaceous mammals are known at present. In the late Cretaceous we appear to discover evidence of the existence of the following orders: Insectivora, Creodonta or ancestral carnivores, hoofed animals or Amblypoda and perhaps the earliest monkeys or Mesodonta. In the basal Eocene we certainly find primitive

[1] The writer's view (OSBORN, '88) that the Jurassic mammals of England and Wyoming embrace primitive placentals or insectivores as well as marsupials and multituberculates (? monotremes) is now generally accepted.

monkeys or Mesodonta, Rodentia and Tæniodonta or ancestral Edentata. A land connection with South America in the early Eocene would therefore have supplied *Neogæa* with the edentates as well as the stem forms from which might have been derived its wonderful radiation of hoofed animals, the Litopterna, Typotheria and Toxodontia; together with the remarkable radiation of the hystricomorph or porcupine-like rodents and of two families of monkeys.

The exact zoölogical affinities of the oldest mammalian or *Pyrotherium* fauna of South America remain to be determined.

Fig. III.—Orders of Mammals placed in their hypothetical chief centers of adaptive radiation during the Tertiary Period.

Pyrotherium itself is considered by AMEGHINO as the source of the order PROBOSCIDIA while other ungulates are believed to be related to the HYRACOIDEA; upon the affinities of these forms turns the problem whether South America derived the sources of its great radiation from Africa or from North America. (See Fig. III).

Four streams of migration to and from NEOGÆA appear to have occurred; the first established its autochthonous fauna or distinctive radiation of peculiar ungulates and edentates. The second related this region with Africa, via Antarctica; this contact, in addition to the problematical Proboscidia and Hyracoidea above alluded to, apparently introduced stem forms of Edentates into the Ethiopian region from which were derived the pangolins and aard varks ; these peculiar edentates together with armadillos all occur in southern France in the lower Oligocene (FILHOL, '94); this land bridge also distributed the Cape golden moles, *Chrysochloridæ ;* these facts and others too numerous to mention serve to show the vast importance of the explorations in Patagonia and make us impatient for the exact conclusions which are forthcoming from the materials brought together by Ameghino and Hatcher.

The third migration into Neogæa established its links with Australia, bringing in Marsupials, both polyprotodont and diprotodont. The fourth was from the north, Arctogæa, and is positively known ; it occurred at the end of the Miocene, and brought in the northern Carnivora, bears, wolves, cats, and sabre-tooth tigers, raccoons and mustelines, the Artiodactyla, deer and camels, the Perissodactyla, horses and tapirs, three types of rodents, the squirrels, mice and hares or rabbits and the mastodon. The Notogæic types, as well as the animals of the first invasion, in the meantime had largely died out, and the introduction of more vigorous Arctogæic types, especially the carnivores, together with a change of climate, exterminated a further portion of the autochthonous Neogæic fauna. At the same time, that is of this second invasion, many of the South American forms entered North America ; they seemed to have reached this continent in the upper Pliocene.

We now turn to ARCTOGÆA. In the Eocene period we find in Europe and North America what may be considered the pure or autochthonous fauna of the Holarctic region, in the absence of all knowledge of Asia. Southern Asia is an absolute *terra incognita* the earliest known deposits in this region being in the Upper Oligocene in which the fauna is remarkably similar to that of Europe. Northern Asia is unknown palæontologically until the Pleistocene—here is a region for explorers. However, we may consider it as part of a broad Eurasiatic land area—extending from the Rocky Mountain region to Great Britain. The faunal relations are astonishingly close, between the new and old worlds at this time. Every year's discovery increases the resemblance and diminishes the differences between Europe and the Rocky Mountain region. Distinguishing North America, however, are the Tylopoda ; this sub-order includes the peculiar Artiodactyla of the camel-llama tribe ; these Professor Scott in a recent paper considers as including all the early types of American ruminants which we have been vainly endeavoring to compare with European types. The radiation of the tylopod phylum into a great variety of types is quite conceivable and it is thoroughly consistent with the fundamental law of adaptive radiation which we find operating over and over again.

III. THEORY OF SUCCESSIVE INVASIONS OF AN AFRICAN FAUNA INTO EUROPE

In Europe there are in the upper Eocene two classes of animals, first, those which have their ancestors in the older rocks ; second, the class including certain highly specialized animals which have no ancestors in the older rocks—among these, perhaps, are the peculiar flying rodents or *Anomaluridæ*, now confined to Africa, and secondly the highly specialized even-toed ruminant types—the anoplotheres, xiphodonts and others, the discovery of which in the *Gypse* near Paris Cuvier has made famous. It is tempting to imagine that these animals did not evolve in Europe but that they represent what may be called the first invasion of Europe by African types from the Ethiopian region.

It is a curious fact that the African continent as a great theater of adaptive radiation of Mammalia has not been sufficiently considered. It is true that it is the dark continent of palæontology for it has practically no fossil mammal history ; but it by no means follows that the Mammalia did not enjoy there an extensive evolution.

Although it is quite probable that this idea has been advanced before, most writers speak mainly or exclusively of *the invasion of Africa by European types.* Blanford and Allen it is true have especially dwelt upon the likeness of the Oriental and Ethiopian fauna but not in connection with its antecedent cause. This cause I believe to have been mainly an invasion from south to north correlated with the northern extension of Ethiopian climate and flora during the Middle Tertiary. It is in a less measure due to a migration from north to south. Let us therefore clearly set forth the hypothesis of *the Ethiopian region or South Africa as a great center of independent evolution* and as the source of successive northward migrations of animals, some of which ultimately reached even the extremity of South America—I refer to the Mastodons. This hypothesis is clearly implied if not stated by BLANFORD in 1876 in his paper upon the African element in the fauna of India.

The first of these migrations we may suppose brought in certain highly specialized ruminants of the upper Eocene, the anomalures or peculiar flying rodents of Africa; with this invasion may have come the pangolins and aard varks, and possibly certain armadillos, *Dasypodidæ*, if M. FILHOL'S identification of *Necrodasypus* is correct. A second invasion of great distinctness may be that which marks the beginning of the Miocene when the mastodons and dinotheres first appear in Europe, also the earliest of the antelopes. A third invasion may be represented in the base of the Pliocene by the increasing number of antelopes, the great giraffes of the Ægean plateau, and in the upper Pliocene by the hippopotami. With these forms came the rhinoceroses with no incisor or cutting teeth, similar to the smaller African rhinoceros, *R. bicornis*. Another recently discovered African immigrant upon the Island of Samos in the Ægean plateau is *Pliohyrax* or *Leptodon*, a very large member of the Hyracoidea, probably aquatic in its habits, indicating that this order enjoyed an extensive adaptive radiation in Tertiary times.

It thus appears that the Proboscidia, Hyracoidea, certain edentata, the antelopes, the giraffes, the hippopotami, the most specialized ruminants, and among the rodents, the anomalures, dormice, and jerboas, among monkeys the baboons, may all have enjoyed their original adaptative radiation in Africa; that they survived after the glacial period, only in the Oriental or Indo-Malayan region, and that this accounts for the marked community of fauna between this region and the Ethiopian as observed by BLANFORD and ALLEN.

Against the prevalent theory of Oriental origin of these animals are: first, the fact observed by BLANFORD and LYDEKKER in the Bugti Beds (Sind) that the Oligocene or lower Miocene fauna of the Orient is markedly European in type; second, that if these animals had originated in Asia some of them would have found their way to North America; third, the fact that all these animals appear suddenly and without any known ancestors in older geological formations. These are the main facts in favor of the Ethiopian migration hypothesis.

In the meantime the unification of the North American and Eurasiatic regions was proceeding by intermigration. In the lower Oligocene the giant pigs or elotheres, the tapirs and peculiar amphibious rhinoceroses known as amynodons, found their way from America to Europe, while Europe supplied us with a few anthracotheres, both Anthracotherium and Hyopotamus. In the Miocene Europe sent us the true cats and we supplied Europe with the destructive sabre tooth tigers; in the upper Miocene Europe sent us our first deer and cattle or *Cervidæ* and *Bovidæ*, also probably the mastodons *en route* from Africa. In the Pliocene we supplied Europe with the rabbits and hares, and possibly with the raccoons, if the Panda belongs to this family. In the Pleistocene the camels wandered into Asia from America, while the bears passed them *en route* to America. These are a few instances out of many which are already well known.

On the other hand certain families had an exclusively Eurasiatic history, so far as we know. These are, among animals related to the horse and tapir, the palæotheres and Lophiodon; among ruminants the traguline deer and muntjacs; among insectivores the hedgehogs; among primates, the anthropoid apes and the lemurs. The latter are peculiar to the Malagasy and Ethiopian regions. At the same time America exclusively raised the titanotheres, the *Hyracodontidæ* or cursorial rhinoceroses, the pouched rodents or *Geomyidæ*, all the early families of Tylopoda, the peccaries. It is paradoxial that so many animals which we are wont to consider typically American came from the Eurasiatic region, while so many others which we always associate with Asia and Africa came from this country. Herein lies the necessity of a palæontological basis for zoö-geography.

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New York Academy of Sciences, Vice-President 1894–1898, President, 1898–1900.
DaCosta Professor of Zoölogy Columbia University, Curator of Vertebrate Palæontology American Museum of Natural History, Chairman Executive Committee New York Zoölogical Society.

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[ANNALS N. Y. ACAD. SCI., VOL. XIII, No. 1, pp. 73 to 360, Oct. 19, 1900.]

THE SEQUENCE OF PLUMAGES AND MOULTS OF THE PASSERINE BIRDS OF NEW YORK

JONATHAN DWIGHT, JR.

(Read March 13, 1899)

[Plates I to VII]

CONTENTS

I. INDOOR STUDY OF MOULT

Fundamental Principles

The moulting of birds is a subject so complicated, so extensive, and so difficult of study, that it is not surprising to find it wrapped, even to-day, in dense clouds of ignorance which obscure the true principles underlying it. Doubts have arisen even in the minds of those who have come nearest to the truth, because they have been unable to explain certain seasonal discrepancies in the plumage of birds, and theories have sprung up and flourished. Theories not founded on facts, must necessarily fall to pieces when the truth is known, and the present paper sets forth a number of indisputable facts derived from personal investigations, which, rightly interpreted, will explain not only the problems of moult and plumage, but also the theories of those whose published opinions differ widely from my own. It is my present purpose to demonstrate the principles dominating the plumages and moults of no less than one hundred and fifty North American species of the great order *Passeres* or Perching Birds, and at the same time indicate the wider application of these principles, which the study of other groups leads me to believe prevail among all species of birds modified only by circumstances.

The fundamental facts of moult have been grasped so imperfectly by some observers, that much theorizing about color changes has taken the place of actual information upon the seasonal variations of birds' plumages, and much superficial work has been done, although some excuse for it may be found in the existing lack of suitable specimens for study. The folly of guessing at age or sex from plumage characters is exemplified in many collections, and museum collections especially contain many undated specimens, which are positive hindrances rather than helps in settling vexed questions of moult. Worse than all is the great dearth of birds actually in process of moult. My own collection remedies, in a measure, all these defects, for the subject of moult has interested me for many years and I have devoted much time to securing moulting birds, the sex of which has been determined by dissection, and the age, when possible, by osteological characters. I have obtained several thousand of such birds and studied them before they were skinned, and also prepared hundreds of young birds in early stages of plumage. Among large series of the commoner species, I have birds taken every month in the year and oftener, so that not only are all the successive plumages illustrated, but in many species all the intermediate transition stages. Gaps in some of my series that a lifetime of field work might not fill have been bridged to a certain extent through the kind assistance of friends. The extensive collections in the American Museum of Natural History have been put at my disposal by Doctor J. A. Allen and Mr. F. M. Chapman. Mr. William Brewster has accorded me like privileges with his private collection and Mr. Robert Ridgway has furnished me with birds from the collection of the United States National Museum, while Mr. Charles F. Batchelder, Mr. Witmer Stone and Mr. William Palmer have all furnished me with specimens to throw light on obscure points.

Equipped with such material, it has been possible for me to tread safely where others have slipped, and possessing in it a key which fits locks hitherto unopened, I have endeavored to use it to the best advantage. There may be little that is quite new in these pages, for many have traversed the subject before me, but no one has taken just my point of view, and my work has been on absolutely independent lines. Nothing whatever has been taken at second hand, and every statement is fortified by specimens to prove its truth. No previous attempt has been made to link together the successive plumages of so many species, and yet this very linking together of isolated facts affords the only highroad by which we may arrive at a true understanding of plumage or of moult. Specimens are isolated facts, and hundreds of them taken at the wrong season may prove nothing, while one taken at the proper time may prove everything, provided the principles of moult are understood. Quality and not quantity of material for study determines its value.

Moult and plumage truly go hand in hand; moult a vital process at definite intervals for the production of new feathers, plumage an assemblage of feathers produced by one or more moults; and the underlying principles or laws by which every moult and every plumage may be explained are the following:

1. Every species has a definite series of plumages and moults.
2. Moult is periodical feather growth.
3. Moult is complete or incomplete.
4. Moult is modified by age, sex and individual.
5. Plumage is renewed by moult.
6. Plumage is modified by wear.

This is the whole matter in a nutshell—no "undiscovered law of nature," no "restoration," no "rejuvenation" of feathers, no "repigmentation," in fact, no "aptosochromatism," what is left of it being represented by the good Anglo-Saxon word *wear*. The only question to ask in order to solve a plumage is: When did each feather grow? Could anything be simpler? Every feather develops with a definite color and pattern which it retains modified only by wear until the next moult. This is the A B C of it and only those ignorant of facts can maintain the contrary, and assert that a feather once grown can rebuild or recolor itself. A mature feather is acknowledged by physiologists (and by everyone except those with theories) to be a completed appendage of the skin, cut off from vital connection with the body and incapable of any but destructive changes. I shall show that regenerative processes occur only by moult in some of the very species that have been exploited as undoubted examples of abnormal color change without moult, and I hope to protect other species that as yet have escaped the imputation. The highroad to such conclusions is not an easy one to travel, but those who will begin at the beginning and follow me will find it everywhere avoiding the pitfalls of doubt, that end in blind theories, and leading straight to an understanding of the significance of plumage.

Determination of Age by Osteological Characters

One of the first essentials in the study of moult, and one hitherto almost wholly disregarded, is the ability to distinguish an old bird from a young one. The plumage is, of course, a guide in many species, when we know which is which, but it is surprising how little is actually known of autumnal plumages, especially of adults. Fortunately until a young bird is five or six months old, immaturity may be recognized among Passerine species by a very simple osteological character, and one requiring no microscope for its demonstration. I have made constant use of it for a dozen years past and doubtless others have done the same, but as yet I have never seen any explanation of it. It is simply this,—the prominent frontal bones of the young bird are thin and transparent showing the brain beneath, while those of the adult are thicker and flecked with little whitish dots, which show even better as black dots, when, with the brain removed, the skull is held up to the light. As the skull of the young bird ossifies, with the advance of the season, it assumes the adult characters, the dotted area of ossification creeping irregularly from behind forward and from the sides upward, until perhaps a couple of transparent spots anteriorly may be all that is left to show immaturity. When these disappear this valuable diagnostic feature is, of course, lost. The dots mark the ends of slender branching columns of bone that partly fill the open space between the two tables of the mature skull, and bind them together. Mutilation, or the infiltration of blood or fluid from the brain, may obscure the dotted appearance, but it is usually obvious at a glance.

This progressive ossification is scarcely perceptible in any New York species before the end of October, and seems to be completed in the frontal bones about two months later. The migrants that press further south seldom show more than the beginning of the process for they have nearly all departed by the middle of October. Resident species, such as the Chickadee (*Parus atricapillus*), and early nesting species, may complete the ossification before the middle of December; early broods of the Song Sparrow (*Melospiza fasciata*) at about the same time, late ones a month later; and late nesting species, such as the Cedar Bird (*Ampelis cedrorum*) and Goldfinch (*Spinus tristis*), often as late as February. Many of our winter visitors arrive with skulls incompletely ossified; the Horned Lark (*Otocoris alpes-*

tris) being one of the earliest (early in December), and the Tree Sparrow (*Spizella monticola*) one of the latest (early in January), to complete the ossification. These dates are approximate, but they throw some light on a neglected page of bird study that I now turn for the first time. The late ossification of other bones should be mentioned in passing, but most of them require such careful examination as to preclude their ready use in determining the age of the bird.

The bearing all this matter has on the question of moult is this: if, when a species departs south in the autumn, we know exactly the plumage of the adult and exactly that of the young bird, it is far easier to interpret the changes that have taken place in each when they return in the spring, for the amount of moult and the amount of wear varies according to age. The new aspect of the plumage may be entirely due to wear, to moult, or to a combination of the two. A method has been suggested for telling old from young in the fall by the presence of sheaths on the primaries in adults and their absence in young birds, because the latter do not usually moult these feathers in assuming fall dress, but it fails both in young birds that *do* renew the primaries, and in old birds that often show moult elsewhere after the primaries have lost their sheaths.

Wear or Feather Disintegration

Some of the effects of this complex process are illustrated on **plates I, II, IV, VI** and **VII,** where a change in the shape and color of feathers is produced by loss of substance, generally at their margins. The destructive influences to which feathers are exposed may best be summed up under the word *wear*, which means a great deal and should be thoroughly understood in studying the relation of plumages and moults. The chief factors concerned in wear are abrasion and fading, which always go hand in hand the one mechanical disintegration, the other chemical decoloration, but there are a number of minor factors which modify their effects. The age of a feather, its position, its structure, its color and the habits of the bird, are all matters that modify wear. The longer a feather is exposed to the bleaching of the elements and to the effects of mechanical abrasion, the more ragged in appearance it becomes, and the older it is the more rapid becomes its disintegration ; so that plumage showing perhaps comparatively little wear during the winter, will rapidly become tattered during the few months of the breeding season.

Much of the abrasion is not due to external causes but to the attrition of the feathers themselves one upon another. This may be observed, for instance, upon the nape of the neck where from the constant movements of the head the feathers become much worn. The wing coverts, tertiaries and scapularies also show markedly the effects of opening and closing the wings. The feathers of the anterior parts of the body however seem to suffer from contact with leaves and grasses while the bird is gathering its food and the flight feathers of some species show marked wear depending also of course upon their habits. It is in all of these ways that *position* modifies wear.

Another minor factor affecting wear and a very important one is *structure*. The large strong remiges and rectrices by their compactness, as well as the long-barbed abdominal feathers by their yielding quality, both suffer less from abrasion than those of intermediate weight and stiffness. The weaker feathers, too, of young birds are peculiarly liable to abrasion, aided no doubt by the clumsy efforts at locomotion of the birds themselves. Even the remiges and rectrices are less resistant than those of the adult, the borders being less compactly rounded out and the pigment deficient.

The *color* of a feather is another factor of considerable importance in determining its wear, and it is well to bear in mind that color may be due to pigment, to optical effects produced by structural interference with rays of light or to a combination of the two. As a matter of fact, black or iridescent feathers are most resistant to wear, other things being equal, while certain buffs and browns yield most rapidly.

The pale contrasting borders and the paler areas of the feathers of many species tend to decolorize and disintegrate as far as the adjacent dark portions. There are many striking illustrations of this among them, the Meadow Lark (*Sturnella magna*) (**plate II, fig. 17**) the Grasshopper Sparrow (*Ammodramus savannarum passerinus*) (**plate II, fig. 3**) the Rose-breasted Grosbeak (*Habia ludoviciana*), and many others where bars and spots of light color become singularly eroded during the breeding season.

Buff or pale-tinted edgings of dark colored feathers, producing in the plumage a veiled effect, are acquired by many species at the time of moult both in the spring and in the autumn and seem to owe their deciduous character as much to their color as to their structure. I have examined hundreds of such feathers under the microscope and can find little evidence that they wear down to the black or other darker color, because at this point an "interlocking" or strengthening of the barbules takes place as has been stated and even figured. No such conditions regularly prevail, for the black color often extends distally far beyond the point where the barbules cross and often the breaking off of the barbs either does not reach the black, or on the other hand, the black may be involved to a considerable extent, as for instance in the Meadow Lark (**plate II, fig. 14**). It is significant, however, that each overlying feather tip should reach only to the limits of the black area of the feather beneath, leaving its pale margin wholly exposed to wear. Veiled species are the rule in autumn and the loss of feather edgings produces remarkable color changes in the plumage, although there is no actual pigmentary change in the individual feathers, an important difference to be noted. By wear alone the brown Snowflake (*Plectrophenax nivalis*), for instance, becomes entirely black and white in the breeding season and the brown young of the Red-winged Blackbird (*Agelaius phœniceus*) assumes a black breeding dress. In these and many other species the actual shape of the individual feathers is changed but always by destruction of their substance. It is equally true that whatever pigmentary color change takes place in a feather there is always destruction of color, never a recoloration. I find no slightest exception, the apparent exceptions being optical delusions. In proof of one such delusion I need cite but two species: the

Purple Finch (*Carpodacus purpureus*) and the American Crossbill (*Loxia curvirostra minor*) figured on **plate VII** which shows at a glance what has occurred. Ordinarily in most species, wear removes the barbs, bit by bit, so that each terminates in a V formed by the barbules on either side. In the case of these two as well as other species, the barbs of certain feathers are blunt and heavy and the barbules are gradually lost, leaving them bare. Such barbs are apparently brighter red than when the grayish barbules between them produce an effect that to the eye is pinkish. This is the "brightening" that has also been observed in certain Finches, for instance the Redpoll (*Acanthis linaria*) and its allies, but it is not "repigmentation" nor even "recoloration." The red color is in the barbs when the feather grows in the autumn and the eye is simply deceived.

There is still another factor that modifies wear,—the *habits* of a species or of the individual. Birds that live from morning till night in the air, like the Swallows, the Flycatchers, the Vireos and some of the Warblers, suffer little wear from outside sources while Sparrows and other grass-loving species, are prone to become exceedingly ragged in a very short time. No better examples can be cited than the Sharp-tailed Sparrow (*Ammodramus caudacutus*), the Bobolink (*Dolichonyx oryzivorus*) and the Long-billed Marsh Wren (*Cistothorus palustris*) all of which species, by clinging to harsh reeds and grasses, rapidly fray out even the resistant remiges and rectrices, thus, perhaps, necessitating two complete moults annually, although there are other species, such, for instance, as the Seaside Sparrow (*Ammodramus maritimus*), which have but one, although they are apparently exposed to the same amount of wear.

The subject of wear is a large one and its possibilities are by no means exhausted, although many writers have already discussed it most minutely, but there is need of getting beyond the narrow field of a microscope focused on single parts of single feathers. To base theories on pigment granules and exuding pores is perhaps simpler than to prove that color and pattern were present when the feather first grew and yet those who have been masters of microscopic technique have sometimes signally failed to grasp the rudiments of wear, let alone those of moult.

It would seem to be an easy matter to determine the age of a feather by the amount of wear, but as a matter of fact it is not. All of the factors I have mentioned must be taken into consideration. Minute and careful study, not only of single feathers, but of many feathers, the whole plumage in fact, is necessary in order to reach conclusions. Even then, in some cases, one must make comparison of many birds in order to eliminate individual irregularities. It is not difficult to say that a feather is not new, but without some corroborative evidence, aside from the feather itself, it is not easy to estimate whether it has been worn, let us say a couple of months, or perhaps three times as long. A dark feather growing at the side of a light one shows far less wear in a given time, and in the same way remiges and rectrices of young birds, compared with those of adults, show much more wear, but it is only possible to prove this by knowing that all of these feathers grew at the same time of the year. Hence the importance of knowing the autumnal plumage of both young and old birds in order to estimate wear. On a correct estimate often hinges the question of a moult that may have occurred in southern latitudes during the winter months.

It is, however, quite possible to reach intelligent conclusions in many cases without other aid than the naked eye, although a lens magnifying ten or fifteen diameters achieves better results.

II. PROCESS OF MOULT

The moult of a bird is a physiological process, whereby new feathers grow periodically to replace the old ones. The whole plumage may be renewed or only a part of it and the moult periods must not be confounded with occasional new growth at any time and anywhere to replace feathers accidentally torn out. There are two seasons of moult peculiar to the adults of most of our Passerine species, one in all species which is complete following the breeding season, and one in some species, which is usually incomplete, preceding it. The first, the post-nuptial, restores the worn-out plumage, the second (when it is not suppressed), the pre-nuptial, adorns birds for the nuptial season. In a few of our species the latter moult is complete, usually the wings and tail are not involved, and often the renewal is limited to a sprinkling of new feathers here and there, so limited, in fact, that it sometimes becomes a difficult matter to draw the line between a moult and the regular tendency, in nearly all species, at this season, to the renewal of a few feathers. A limited, or suppressed, pre-nuptial moult is peculiar to many females, while the males may undergo an extensive renewal, and young birds of some species undergo a pre-nuptial moult once, that is apparently not repeated another year. There are also several moults peculiar to young birds before they even acquire feathers of adult structure, and many species need to pass through at least two moults besides those of the first summer before the plumage becomes wholly of the pattern and color of the adult. With all of these possibilities it is easy to understand, I think, why the moult has been considered complicated. In reality it is the resulting plumages that are perplexing rather than the moults by which they have been produced. Closely allied species may not moult alike but it is evident that subspecies follow in the footsteps of the parent stock.

On account of certain irregularities and peculiarities in the moult of young birds, I have deemed it best to describe first the process of moult as it occurs in the adult and take up that of the young bird later.

Protective Sequence in Feather Loss.

The feather loss at the time of a moult is so compensated for by feather gain that but few birds lose either the power of flight or the protection of their plumage. The plan on which a moult proceeds is a perfectly definite one although often much modified and obscured. Old feathers or rows of feathers tend to remain until the newcomers adjacent have matured sufficiently to assume their function, when the old fall out and their places are taken by the new which develop from the same papillæ. How the old feather is pushed out by the new, so to speak, is a matter for microscopic study and a subject by itself, but it usually falls when the follicle of the new is barely visible to the naked eye as a bluish spot beneath the skin.

The systematic replacement of areas of feathers shows most obviously in the wings where not only do the remiges fall out one after another in definite sequence and almost synchronously from each wing, but the greater coverts are regularly replaced before the fall of the secondaries beneath them, the lesser coverts before the median and even in the rows of the lesser coverts alternation seems to be attempted. Furthermore the under wing coverts are usually replaced after the moult of the upper surface of the wings is completed (regularly so in young birds) the row nearest the quills of the remiges following the more distant. On the body the protective sequence is less obvious, but the moult regularly begins at fairly definite points in the feather tracts radiating from them in such manner that the outer rows of feathers where the tracts are widest and the feathers of their extremities are normally the last to be replaced. The tail coverts, too, precede the rectrices which fall on either side in pairs, the outer protecting in a measure the inner ones. If this sequence is borne in mind many supposed discrepancies will nicely adjust themselves, and exceptions will be individual and in no wise mar an evident and far reaching plan of moult.

The important part that the blood-supply plays in this plan appears to have been quite overlooked, nor have I had opportunity to fully investigate it. I may say, however, that the radiation of the moult from given points corresponds very closely to the distribution of the superficial arteries, beginning where the main trunks come to the surface and ending with their ultimate ramifications.

Advance of Moult in the Feather Tracts.

Reference to **plate III**, will give some idea of how the *pterylæ* or feather tracts are distributed in a Passerine bird. The subject photographed is a young American Robin (*Merula migratoria*) five days from the egg, the tracts being the same as in the adult. The only way to get any idea of how a moult proceeds is to appreciate the fact that it begins almost simultaneously at a number of points in the different tracts and advances independently from each of them. This is why a bird seems to be moulting at irregular spots all over. There is, as might be expected, a good deal of individual irregularity in the growth of new feathers, but when each tract is studied separately, each will be found to have a definite plan of development which in its turn fits into the general scheme of the process we call the moult. There is far more symmetry in all this than would be imagined from the study of a few specimens and the moult may well be likened to a flood tide which gradually spreads over the different islands of feathers found on a bird's body. It is important to note that the tide of moult may pass by certain feathers which later succumb to it so that a few new ones are always to be expected on the body very near the points where the moult began. What is more important yet, certain feathers or groups of feathers are often entirely passed by and persist old and worn until another period of moult. This suppression is the rule at the prenuptial moult, especially in young birds and females, but rarely occurs at the postnuptial period. When such feathers are of a different color from those of the new plumage surrounding them, they are very conspicuous, but may usually be recognized as belonging to a previous plumage by their frayed and faded appearance. Young birds are most apt to fail to renew these stray feathers, often whole patches of them, particularly when the adult plumage is brilliantly colored, as for instance, in the Indigo Bunting (*Passerina cyanea*) or Orchard Oriole (*Icterus spurius*). It would seem that the tide of moult fails to rise or exhausts itself sooner in the young bird than in the adult, consequently the young of some species pass their first breeding season in a plumage adorned with only a few new feathers colored like those of the adult. This is true of the species just mentioned, and the Redstart (*Setophaga ruticilla*) and Summer Tanager (*Piranga rubra*), are also other good examples. When only a few new feathers are assumed they are confined chiefly to the head and chin with stray ones here and there on the other feather tracts. The process of moult begins at the usual points and is then checked, producing the mottling of different colored feathers so obvious in species with contrasting plumages. Whenever a complete moult occurs either in young or old, left-over feathers are the exception probably because functional activity is called into full force, but when a partial moult takes place, as it does in many species prior to the breeding season, parts only of the feather tracts are renewed, and left-over feathers abound. They are valuable landmarks, and more will be said of them later for they are the chief prop of the theory of "color change without moult."

Whenever a complete moult is about to take place the first tract to show activity is usually the alar, and the fall of the innermost or proximal primary is the starting signal closely followed by the feathers of the breast on either side at a point posterior to the forking of the ventral tract into its lateral branches. Very shortly, new feathers appear among the interscapularies, the scapularies and the greater wing coverts, and usually a little later the feathers of the forehead, occiput, throat, lesser wing coverts and tail coverts begin to be renewed. The moult of each tract is traced elsewhere so it will suffice to say here that as a rule the moult of the wings is completed before that of the body and that there are some pretty definite spots on each where the last evidences are to be found. The latest feathers of the alar tract are the inner secondaries (excluding the tertiaries which are earlier), the under surface of the wing and the humeral surfaces. On the head the latest feathers of the new dress are regularly found in the postauricular region, on the nape and at the nostrils ; on the back at the expansion of the dorsal tract, and at the anterior extremity of the humeral tracts ; and on the ventral tract at the chin, at the lateral forking, at the wide part of the lateral branches and at the sides of the unfeathered central portion of the abdomen.

The down feathers that clothe the so-called featherless spaces (*apteria*) keep pace with the contour feathers adjacent, but usually are later. Other modified feathers, such as filoplumes, semiplumes or bristles, moult along with the contour feathers with which they are associated. In adults there is regularity in the development of the tracts all bearing a fairly definite time relation to each other but in young birds an outbreak of moult in any of the tracts earlier or later is less unusual.

A knowledge of the distribution of the feathers of each tract, their relative numbers and arrangement is indispensable in following their successive growth, but it is not possible in the present paper to go too deeply into the niceties of pterylographical differences. Other writers, notably Nitzsch, have discussed them and mapped out the feather tracts of various species. It is well to remember that among our Passerine species contour feathers grow on all the tracts, a small part of the alar and caudal tracts furnishing the remiges and rectrices respectively. It is well to observe that these too are contour feathers—a fact that some writers overlook. They are renewed in adults but once in twelve months as a rule and no oftener in most young birds but there are exceptions among a number of species. The body feathers of a great many species are renewed twice a year in both old and young.

1. **Alar or Wing Tracts** (*Pterylæ alares*). The power of flight depends upon the remiges of these tracts, and until they have reached maturity after the moult regularly subsequent to the breeding season, there appears to be little or no attempt at migration on the part of most birds, some of the Flycatchers, Swallows and, perhaps, a few others, being marked exceptions. As flight then, is the first object to be attained, it is not surprising the moult should begin where it does near the middle oi each wing with the fall of the respective innermost or proximal *primary*. In nine-primaried species it is the ninth as usually counted, omitting the one aborted, and the tenth when ten are found. The upper *primary coverts* fall with or a little after the primaries to which they belong and are almost never moulted independently of the primaries. As soon as a primary falls the follicle or envelope containing the new forming feather pushes into view, often reaching one quarter the length of the old feather and a diameter exceeding it by one half before the

feather itself breaks from the apex. The follicle is pulpy, dark and bluish in appearance owing to the developing feather within, the quill of which, after it is grown, remaining pulpy until one or two of the adjacent quills have reached maturity. The remains of the follicle persist in the form of a scaly sheath at the base of each quill until several of the new feathers are fully grown and often much longer. This development of the new feather is not peculiar to the primaries, but is true of every other feather on a bird. Before, however, the follicle of the proximal primary has opened, the primary adjacent regularly falls, closely followed by its upper covert. It probably falls at very nearly the same time as the proximal in many cases and even in advance of it in a few, as may be inferred from the relative length of the two new feathers, but as a rule the order is the one indicated. Both are out of their follicles before the next adjacent, and its covert falls, and this is followed in order by the more distal primaries one after another. At no time is a gap left of more than one or two whole feathers at most and perhaps one or more partly grown so that a Passerine bird is never much hampered in its flight.

From the examination of specimens it is impossible to determine the exact time required for a complete renewal of this most important row of flight-feathers which is usually the first to be affected by the moult in adults although outstripped in development by some of the other areas. I should estimate the time at about one month or probably a little longer. In extensive series of a few species, I find that the period between the earliest date of a specimen showing loss of the proximal primary and the earliest date of a specimen showing the distal primary fully grown varies between a month and six or eight weeks.

The primaries are rarely moulted more than once in a year. Adults and year-old birds at the end of the breeding season both male and female always renew them. In a few species, all the primaries are again renewed by moult in the winter or early spring. Young birds of a few species moult these feathers in acquiring their autumnal or first winter dress, but the majority retain them until the moult following the first breeding season.

Some few young birds however have the peculiarity of renewing only the outer or distal four or five at the prenuptial moult. This partial moult is easily overlooked particularly in worn spring specimens. The Indigo Bunting (*Cyanospiza cyanea*) and Short-billed Marsh Wren (*Cistothorus palustris*) are examples of this peculiarity.

Primaries are almost never left over—if any moult takes place in this series all are involved except as just indicated. Whenever they undergo a moult so do their upper coverts with rare exceptions and as the latter fade and wear more than the primaries they are often a key to the age of the bird, in the young differing more in color from those of the adult than do the primaries themselves. Occasionally one or more of the primary coverts is left over until the next moult. Primaries show the least wear of any feathers when compared with others grown at the same time. Their compact structure and deep pigmentation make them unusually resistant.

The *secondaries* are always six for each wing in the species under consideration, it being desirable to recognize the three proximal feathers of this series as tertiaries. Coincidently very nearly with the fall of the fifth or sixth primary the first or outermost of the secondaries is lost, followed in succession by the second, third, fourth, fifth and sixth or proximal, the preceding feather usually reaching a considerable length before the next in the series is moulted. There seems to be some irregularity in the loss of the inner members which are replaced more rapidly than are their predecessors, but the innermost falls at very nearly the same time as the outermost primary so that the moult appears to begin near the middle of the remiges and proceed evenly in either direction.

Whenever there is a complete moult of the primaries there is also one of the secondaries and there seems to be few exceptions to this rule in young or old although the outer primaries as already explained may be moulted when no renewal occurs among the secondaries. The secondaries are never renewed as a series without moult of the primaries preceding their moult.

The three *tertiaries* of each wing which, from their position, appear to be only inner secondaries, do not as might be expected, follow their sequence of moult. The middle one falls with or even before the distal secondary, and in spite of some irregularity the three are almost always grown in advance of the inner secondaries. The middle feather is the first to be lost, followed by the innermost, and this in turn by the outermost, which often acquires complete maturity before the adjacent secondary, the sixth, falls out.

The tertiaries follow in their moult most frequently, perhaps, the example of the adjacent body plumage, but are very irregular, individuals of the same species acting in defiance of what might be expected of them. Some adults regularly renew them at the prenuptial moult when the body plumage is renewed, but even these birds may replace only one or two feathers and asymmetrically in either wing. Young birds are still more irregular and old feathers frequently persist in one bird and not in another of the same species, as may be seen in the Rose-breasted Grosbeak (*Habia ludoviciana*), or Baltimore Oriole (*Icterus galbula*) and many others. When young birds acquire plumage of adult structure in the early autumn of their first year, the tertiaries are often replaced by others so similar in color, pattern and structure, that it is very difficult to be sure of their moult, unless they are caught in the act. As they moult quickly, it is not always easy to do this, and as they wear quickly it is easy to mistake their age. Sometimes a precocious young bird acquires one or two of adult color that are not normally due until a later moult. It is doubtful if such feathers, when assumed in the autumn, are again renewed in the spring.

The moult of the *alulæ*, the feathers on the "thumb" of each wing usually follows the example of the wing coverts, most frequently being renewed when they are, but often not. The three larger feathers fall with or a little after the proximal primary. The proximal feather falls first, sometimes the middle one, followed by the distal. The smaller feathers which act as coverts are earlier and related in moult to those of the carpo-metacarpal region adjacent. The *alulæ* are quite irregular and are moulted by some individuals of a species and not by others.

The row of *greater coverts*, usually eleven in number for each wing, lie directly over the secondaries and tertiaries, but do not, like the primary coverts, follow the moult of the remiges beneath them. They usually reach full development before feather loss fairly begins in the series beneath them; and do not fall out regularly but many of them at about the same time, the inner feathers, however, being a little later than the others. This row sometimes begins to fall before the inner primary is lost, especially in young birds, usually very soon after. They are more frequently renewed than are the tertiaries when a moult of the body plumage occurs and often are renewed only in part. At the prenuptial moult the inner members only may be renewed and one here and there so that a curious alternation of old and new feathers results, some of the Warblers and Tanagers illustrating this point to perfection. The outer members of the series are the ones most frequently left over and the contrast in color is often striking, especially when precocious young birds assume a few of adult pattern and color.

The *median coverts*, eight in number for each wing, do not begin to fall as a rule until the greater coverts on one side of them and the lesser coverts on the other have been largely renewed. Like all of the minor wing series this one falls out irregularly, the tendency being for the outer members to be replaced earlier. They are renewed whenever the other coverts show moult and may like them be left over here and there until a later moult. Young birds of the Summer Tanager (*Piranga rubra*) may, for instance, have a red band of these feathers across an otherwise greenish wing.

The *lesser coverts* or cubital coverts clothing what are often inappropriately called the "shoulders," are very small feathers in several rows, usually about five, so easily disarranged that it is difficult to follow their sequence in renewal. They seem to moult in alternate rows, beginning with the row next to the one that protects the anterior margin of the wing membrane, and the last to be replaced are those nearest to the body and to the median coverts. The series may be only partly renewed. The feather loss begins as a rule just as the greater coverts are well sprouted and precedes by a distinct interval feather loss in the median coverts. They are usually renewed with the adjacent body plumage, and are the coverts most likely to be renewed if the wings show any moult at all. In some species there is a striking difference in the color of these coverts by which young birds one year old in breeding plumage may be distinguished from those that are older, as for example in the Goldfinch (*Spinus tristis*) or Red-winged Blackbird (*Agelaius phœniceus.*)

Renewal among the *under wing coverts* which are often spoken of as "lining of the wing" takes place after the moult of the upper surface of the wing has been nearly or quite completed. They are among the last feathers to develop in young birds after leaving the nest. The first row of those lying upon the bases of the remiges remains as a rule until the adjacent second row has been replaced. The moult begins among the secondary coverts of the second row extending irregularly outward and inward, the innermost being the latest, followed closely by the second row of primary coverts. The first row completes the moult of this surface of the alar tract, perhaps excepting the tiny down feathers growing at the bases of the secondaries and over the wing membrane.

The long *infra-marginal coverts*, a double row of alternating long and short feathers that sweep backward over the comparatively bare under surface of the wing membrane, begin to fall somewhat irregularly near the carpal joint, the row of long ones preceding the short ones, and the moult moves inward, the feathers close to the body being late in renewal. The thatch-like row of lesser coverts that grow at the anterior margin of the wing are equally late, the renewal being irregularly towards the body from the carpal joint.

The tiny *carpo-metacarpal coverts*, or feathers of the wrist and hand, both above and below may show moult early, but in young birds the contrary prevails. The moult tends to proceed in the two principal median rows from the carpal joint, distally.

The few *feathers of the upper arm* (excepting those of the humeral tracts), especially those on its posterior edge, are among the latest of the wing series.

2. **Humeral or Shoulder Tracts** (*Pterylæ humerales*). A tolerably symmetrical, bilateral outbreak of new feathers takes place very early in this pair of tracts showing usually at the median and internal portion. The moult proceeds forwards, seemingly effecting a junction with the lateral branches of the ventral tract near the edges of the wing membranes at the very time the moult in them has reached this point; and backwards to the posterior margin of the upper arm joining very nearly the humeral coverts. Old feathers frequently persist at these junction points and also externally, particularly in young birds. These tracts follow the example of the body plumage in their moult, and not that of the alar tract, being renewed in many species twice a year.

3. **Capital or Head Tract** (*Pteryla capitis*). The pterylography of this important tract requires a little more explanation than is usually given it in order to understand its moult. Although the head is practically entirely covered (save a small spot behind the eye) with a multitude of extremely small feathers in Passerine species, they are arranged in several groups or series. Starting at the nostrils near the base of the upper mandible two rather broad bands pass backward over the crown, but before reaching the occiput they widen out curving laterally to the postauricular region, the lines of feathers on the occiput extending laterally. On each side of the head is a narrow band corresponding to the superciliary stripe; another includes the loral and circumocular region; another passes from the gape backward in a loop including the auriculars; and finally there is a submalar band starting beneath the middle of the ramus of the lower mandible and joining the auriculars at a point near where they are joined by the short auricular branch of the ventral tract. There seems to be some relation between these minor tracts and the distribution of color; and moult begins independently in any or all of them at about the same time and, as a rule, tends to proceed from before backwards. The auriculars being the largest areas are usually the first and often the last to show moult. A frequent point of departure is just back of the extreme anterior

feathers of the forehead which fall out a little later. We see new feathers centrally on the crown in advance of those on the occiput, and the loral and circumocular regions are often bare when the crown and auriculars are largely renewed, and especially is this noticeable in very young birds. The last traces of moult are, as a rule, to be found in the postauricular and cervical regions.

The head tract is of paramount importance because if any partial prenuptial moult takes place, the new feathers will be found here and on the chin and often nowhere else. In some species the renewal is limited chiefly to the loral feathers and those adjacent, or it may involve the crown and anterior parts of the throat. Adult males may or may not renew this tract at the prenuptial moult according to species; young males in many species renew it their first spring only (possibly their second in some cases); and females may moult the same as the males, but more frequently either omit this moult altogether or assume a very limited number of new feathers. Young males of the same species may show the greatest individual variation, especially in highly colored species, some of them assuming plumage indistinguishable from adults, others only a few scattered feathers at the anterior parts of the head and throat. Each species, however, has a tolerably definite area of renewal peculiar to itself and although the feathers of the head tract are very numerous they are, most of them, so extremely small that their moult may be very easily overlooked.

4. **Dorsal or Spinal Tract** (*Pteryla spinalis*). The slight variations in the distribution of this tract among our families of Passeres need not be here specified. It extends in most of them from the occiput to the oil gland at the base of the tail, widening posterior to the scapulæ into a triangular "saddle," sometimes dividing into two bands and enclosing an elliptical space instead, and sometimes forking and ceasing before reaching the oil gland.

The first place where new feathers show is at a spot in the anterior interscapular region. There seems also to be another spot behind the saddle where as the tract is narrow the moult is soon completed. The central rows of feathers tend to precede the outer and the moult advancing rapidly forward and backward soon reaches the base of the head and the wide saddle behind the shoulders, at both of which points will be found the last traces of new feathering. It is sometimes the first tract to show new growth. If a species has a prenuptial moult this tract is not usually involved unless all the body plumage is renewed, except in a few cases where only the interscapular portion is included with the head and throat.

5. **Ventral or Inferior Tract** (*Pteryla gastræi*). From this extensive tract grows the whole plumage of the lower surface of the body. It may be said to begin at the interramal space, it gives off two short auricular branches near the angle of the jaw and it forks at the mid-neck into two lateral, or sternal, branches which passing along the sides of the body, end on either side of the vent or at some distance from it. On the breast there is regularly a widening of the lateral bands, the external half of each ending abruptly under the wings nearly midway between head and tail.

It is not surprising that the first as well as the last traces of a moult are frequently to be found on this extensive tract. A few new feather follicles may be expected on either side of the breast even before the proximal primary is lost and soon a V-shaped band is seen, the point of the V reaching the mid-throat forking. The tide of moult seems to sweep chiefly backwards, beginning in the middle rows and new outbreaks take place a little later on the throat. The sides of the chin and throat may precede or follow as the case may be, the throat in their feather development owing to the submalar bands which seem properly to belong to the head tract. The feather growth extending forwards from the breast is met by that extending backward from the throat, the lower part of which is consequently late in acquiring new feathers. The last traces of moult in the ventral tract will be found at its extremities on chin and abdomen, or among the outer rows of feathers where it is widest as at its forking and under the wings. The feathers which hide the middle of the abdomen are conspicuously among the last to be moulted. If the species undergoes a partial prenuptial moult a few throat feathers may be all that are renewed, but usually new growth extends as far as the pectoral forking. In some species with a more extensive moult at this season, the whole tract, or all of it except its posterior extremity is renewed, and there is much individual variation besides in the amount of renewal.

6. **Caudal or Tail Tract** (*Pteryla caudalis*). From this tract grow the rectrices and their upper and under coverts, and the anal circlet and crissum may conveniently be included for their moult coincides with that of the adjacent coverts. Most of the feathers of this tract are large and not numerous, the twelve *rectrices* or tail feathers being the most important of them all. Their moult is late and is usually preceded by that of the *upper and under coverts* nearest to them. At about the time the sixth or fifth primary is lost the renewal of the rectrices begins but it is irregular especially in young birds. The rectrices fall out approximately in pairs beginning with the central pair, and followed by the quills next adjacent on either side. The process is so rapid however, that when the outer pair falls, the middle ones are seldom more than half grown and the whole series is usually found in a pulpy condition at a time when the rest of the body plumage is well developed and the first primary nearly or quite grown. The sheaths of these feathers adhere unevenly giving the impression of more irregularity in their moult than really exists, but there are evidently a good many cases where the normal sequence is violated.

In young birds just from the nest, the wings are often well developed before the tail shows much growth and bob-tailed adults as well as young birds are often seen together at the season of moult. The coverts mostly reach maturity before the tail itself, the rows nearest to its roots tending to precede in their order of moult those at a distance, although there is considerable irregularity.

The rectrices are regularly renewed whenever all the remiges are moulted, and they are often moulted when the latter are not, especially in young birds which assume much of the adult plumage at the prenuptial moult preceding their first breeding season. The Baltimore Oriole (*Icterus galbula*) and Rose-breasted Grosbeak (*Habia ludoviciana*) are examples and in these and many other species the renewal may not be complete or the color may be deficient, producing tails that have been said to be in process of "recoloration." When a young bird acquires a new tail in autumn without moult in the remiges it often suggests, either individual precocity or accident, for there seem to be very few species in which this regularly occurs without simultaneous moult of the remiges. Unilateral moult of a few rectrices only generally indicates a mishap by which the feathers have been pulled out and this is not an uncommon accident.

7. **Lumbar, Femoral or Thigh Tracts** (*Pterylæ lumbales seu femorales*). Two narrow bands, one on either side of the posterior part of the back, form the areas from which the feathers of the flanks grow, but the name flank generally applies to the external lateral rows of the posterior extremities of the ventral tract. The renewal in these tracts proceeds approximately from above downward and from before backward, there being little evidence of moult as a rule until the process is well under way elsewhere. They are less often involved when there is a spring moult than are the other body tracts and at this time may be only partially renewed.

8. **Crural or Leg Tracts** (*Pterylæ crurales*). The contour feathers of these bilateral tracts are scattered, small and inconspicuous, although most abundant near the tarsal or ankle joint. Their moult easily escapes notice, beginning usually with the superior and external feathers and ending among the closely imbricated rows of the lower part of the tibiæ or legs. The process begins quite early and may be completed early. The failure of these tracts to moult when there is a general moult elsewhere is frequent, especially with young birds in the spring, and old feathers persist, noticeable chiefly when of a different color from the new. These old feathers are often a valuable key to the age of the bird.

III. EARLY PLUMAGES AND MOULTS OF YOUNG BIRDS

The plumages and moults of young birds differ so much from those of adults as to deserve further elucidation. Although feathers of adult structure are acquired and worn during the first winter after leaving the egg there are two antecedent stages of plumage in all species and in some, several subsequent stages indefinitely classed as immature, all of which are but imperfectly understood.

A bird on emerging from the egg may be absolutely naked, of which the Woodpeckers furnish an example, scantily clothed with downy tufts as in most of the Perching Birds, or completely invested with downy growth as in the Ducks, the Water Birds and the Birds of Prey. The structure of this "nest-down" varies greatly in the different groups of birds, and it is always replaced by several other plumages before that of the adult bird is assumed. Among the Passeres, which is the only group here under consideration, the downy growth is present (at least part of it is) before the chick hatches. It is found at only a few points. A longitudinal row or two is found above the eyes corresponding nearly to the location of the superciliary stripes, several rows occur on the occiput and nape and tufts are found on the dorsal, humeral and lumbar tracts as well as filaments at the tips of the secondaries and their coverts. No down is found at the tips of the primaries or rectrices nor does it occur on the ventral tract in any of the Passerine species I have examined, the protection of the nest perhaps obviating its necessity below. A nest full of young birds gives one the impression that they are covered with a fluffy blanket of down. The distribution of these downy filaments may be dimly seen by consulting **plate III**, and their microscopic structure is shown by **plate V** which illustrates for the first time by means of photography the exact structure of this peculiar plumage. These peculiar feathers are interesting under the microscope being long weak filaments with a few short lateral branches. They are gathered into a bundle at the tip of the new feather, which takes their place and they adhere at its apex or at the apices of its barbs, especially about the head, for some time, after the youngster has left the nest. Their color is usually pale brown, gray or white, but unfortunately many of the specimens I have examined are young birds that have been dropped into alcohol without note having been made of the color when fresh.

This "nest-down" or as it might most appropriately be called *natal down* represents a first stage of clothing in young birds even if it be scanty or suppressed. In a systematic scheme of plumages it must stand first although soon replaced by a second stage on which the name "first plumage" has unfortunately been fastened in all good faith. Without entering into the question of whether "down" that is not true down can be called first plumage, I find it expedient, if not necessary, for the sake of uniformity and clearness to bestow a new name on the second stage, reserving the numeral adjective "first" for more exact and important application.

Juvenal plumage is a term definite and readily understood as indicating the second plumage of a young bird which at this stage usually differs in structure much from that of the adult, and it is this very difference that is implied in the term I have selected. The juvenal stage succeeds to the natal and feather growth takes place over additional areas of skin bare during the natal stage of development. The juvenal feathers differ more or less in structure from those of adults, being, as a rule, weaker, softer and looser in texture, as shown by the photomicrograph (**plate IV, fig.** 1).

During the early days of the newly-hatched chick, feather growth is comparatively slow, but shortly it proceeds with marvelous rapidity. A couple of weeks, more or less, accord- to the size of the species, suffices to develop a helpless birdling into a bold bundle of feathers ready to essay flight. The feathers first fully grown are the wing coverts, those of the body and top of head next appearing, while the remiges are a little later and the rectrices last of all. The flight-feathers which at first lie as bluish lines beneath the skin or barely protruding from it, develop evenly, all the quills remaining pulpy for a considerable period after they are full length. The under wing coverts as well as the feathers of the carpo-metacarpal area on both the upper and under surfaces are among the latest feathers to appear in the wing tract, and the throat and sides of the head are often still bare when the rest of the body and head is well covered.

When the next plumage, that of a third stage worn during the first autumn and winter, is assumed, it may be gained by a complete moult of the juvenal plumage, but, perhaps, more frequently the wings and tail are retained, not to be renewed for a twelvemonth. The only feathers regularly retained at this time are the nine (or ten) primaries, their upper coverts and the six secondaries. The tertiaries are sometimes renewed, sometimes not, and the tail is irregular, usually following the example of the primaries. All other feathers, with occasional exceptions, are replaced by new, a moult which may properly be called the postjuvenal, beginning in many species, especially the Warblers, even before the flight feathers have reached functional length. In some species, however, the juvenal plumage is worn for a considerable period, even several months before any moult takes place. These birds lose all trace of the adherent feather sheaths indicating recent growth and are the ones that most frequently renew the whole plumage, including the wings and tail. Summed up there are two classes of young birds, viz., those that acquire the plumage of the first winter by a complete moult, and those that retain the quill feathers of the wings and the tail, losing all others of the juvenal plumage. There are individual exceptions in both classes that may retain old feathers or series of feathers here and there of the juvenal dress until the next moult, which may be within a few months or not for a twelvemonth, many species breeding in the plumage of the first winter.

In some species the plumage following the juvenal may be indistinguishable from that of the adult, in others the adult dress may be assumed just before the first breeding season and in still others not till after this season. Beyond this point it is not possible, except in a very few cases, to follow the immature bird which at one or the other of these three periods of moult becomes indistinguishable from the adult and may be so classed. It is well to grasp the idea that the flight-feathers may outwear two or three sets of body feathers and a bird does not really attain full adult dress until the former are replaced. In most, if not all cases where mixed plumages are seen during the breeding season, they do not represent birds of different ages but illustrate individual variation at the first prenuptial moult. Unmixed plumages—adults and young being of uniformly different colors like the Purple Finch (*Carpodacus purpureus*)—are presumptive evidence that no prenuptial moult occurs.

I have occasionally seen birds still partly in immature dress after the moult at the end of their first breeding season as may be determined by left-over feathers, but these birds usually show a plumage so nearly of the adult type as to suggest that they are exceptions in which there has been some individual lack of vitality. Unfortunately we have no other available guide except plumage to determine whether a bird is one, two or more years old and moreover there is a great dearth of winter specimens from the tropics showing while fresh the changes produced by the prenuptial moult. Summed up, there are three periods of moult at any one of which a young bird may assume full adult plumage, the postjuvenal, the first prenuptial and the first postnuptial, and prior to each of them the plumage may be immature and made up of feathers which have grown at different periods. These successive plumages follow each other with the regularity of the seasons and will be more fully discussed under the following section. More light is needed on some species, but whether the immature dress requires one moult or two or three to convert it into adult plumage is immaterial and does not alter one whit, the fact that it is lost and replaced by actual moult at definite periods.

IV. SEQUENCE OF PLUMAGES AND MOULTS

The relation between plumages and moults is so perfectly definite and at the same time has been so little comprehended that only by a radical rearrangement and delimitation of the terms used may further confusion be avoided. The chief thing to bear in mind is that every species passes through a definite series of plumages and a definite series of moults, each plumage being succeeded either by a moult or the place of the moult may be taken by wear alone. There is no theory about this cardinal principle and there are ample facts to support it. Of many species, I have examined specimens taken every month in the year showing not only the sequence of plumages and moults but all of the intermediate steps by which the plumage has been acquired or modified. With an abundance of material there is not the slightest difficulty in explaining plumages, but in many species there are gaps which careful study of the feathers and the application of fundamental principles must be trusted to fill. For instance, when the Scarlet Tanagers (*Piranga erythromelas*) leave the vicinity of New York towards the end of September, *all* of them are in the olive green body plumage of the female, the young males with similarly colored wings and tails, the adults with black wings and tails. When the males return in May *all* are in bright scarlet dress with black tails, but a certain number of them have worn brown wing quills. The red feathers examined under a glass are quite as fresh as the green ones seen in September. If the wings are examined, both the brown and the black quills will show wear, the black least as might be expected from their color. If the tails are examined those of the black-winged birds are slightly worn, those of the brown-winged fresh and new. It is a perfectly natural inference that the brown-winged birds are young males and that they have acquired the red body plumage and the black tail by a recent moult while the adults have not moulted the wings and tail, but merely assumed the red body plumage. Further evidence in support of this conclusion is afforded by patches of worn green feathers left over among the red, such feathers occurring most frequently in the brown-winged young birds and finally we sometimes find red feathers still invested with their scaly sheaths. The only gap left is a Tanager showing extensive moult, and it is safe to predict that such a specimen will some day be forthcoming from the tropics where the change from green to red probably takes place. Similar facts point to a similar moult in the Rose-breasted Grosbeak (*Habia ludoviciana*) which a winter specimen from Ecuador in the British Museum collection confirms, and I have seen one bird taken near New York still showing several rectrices partly grown. Again if we examine Baltimore Orioles (*Icterus galbula*) when they reach us in May we shall find birds with black worn wings, wing coverts, tertiaries and tails and others with brown worn wings while the rest of the plumage is fresh and new. The inference is a moult in young birds and none in adults and this is proved by two young winter birds from Central America, unfortunately without other data which show new growing feathers at the points where a moult regularly begins. These examples are only several among many that could be adduced to show upon what slender but conclusive evidence one must work. The only reason it is slender is because the number of specimens from southern latitudes is small, and when this deficiency is remedied, I am convinced the difficulties with which I have had to contend will vanish. We will then know, for instance, when it is that the young King-bird (*Tyrannus tyrannus*) exchanges the two outer rounded primaries for the emarginate ones with which it returns and when the young Barn Swallow (*Chelidon erythrogastra*) assumes the attenuated lateral tail feathers so different from the ones worn when it leaves us in the autumn. (See **plate II, figs. 18-21.**) Probably no one claims nowadays that these new shapes are attained without growth of new feathers, and yet equally strange claims of color change without moult have been put forth when there were no specimens taken at the proper season to prove their absurdity.

In order to show at a glance the relation that exists in the sequence of plumages and moults they are tabulated below in such form that they may be made applicable to any species. The terms employed have been chosen, so far as is compatible with conciseness, from those in common use. Some are necessarily new but I have selected all of them with the object of making antithesis as obvious as possible.

The first column contains the plumages in their natural sequence and the second the moults which (unless suppressed) follow each of them.

Plumages	Moults
1. Natal	Postnatal
2. Juvenal	Postjuvenal
3. First Winter	First Prenuptial
4. First Nuptial	First Postnuptial
5. Second or Adult Winter	Second or Adult Prenuptial
6. Second or Adult Nuptial	Second or Adult Postnuptial
etc.	etc.

Just as soon as a young bird becomes indistinguishable in plumage, from an adult, " first," " second" or " third" may be dropped and " adult" substituted, both for plumages and for moults, the plumages being thereafter " Adult Nuptial" and " Adult Winter" and the moults simply " Prenuptial" and " Postnuptial" as long as the bird lives. As a matter of fact in none of the Passerine species which I have studied are there more than six plumages and six moults, except in a few rare individual cases, before a bird becomes indistinguishable from one that may have had twice as many. In most species the identity of old and young is lost much earlier, the rule being that young assume adult plumage never later than the moult at which they first renew the remiges and rectrices. Wear with its abrasion and fading often takes the place wholly or in part of a prenuptial moult, modifying in marked degree either the first winter or the adult winter dress. Consequently the plumage to which I would restrict the name nuptial may be acquired by moult, by wear or by both, and it is not the true breeding plumage. The latter may be either a fresh nuptial or a worn nuptial, but as the differences produced by wear after the prenuptial moult are usually not very obvious, it would be inexpedient to try to draw too sharp a line between " nuptial" and " breeding," although recognizing a distinction. The breeding plumage, then, on which descriptions of species are based does not, in very many cases, represent the highest plumage of the species ; it may be a mixture of several and all of them badly worn. For this reason I have chosen nuptial to represent a stage of plumage following immediately either the prenuptial moult or the time when it would naturally occur, if not omitted.

In studying the plumages and moults in the natural order in which they follow each other one can hardly fail to be struck by the fact that in spite of many apparent contradictions they make up for each species a purposeful and harmonious whole and the series for any given species is always the same when proper allowance is made for age, sex and individual. Stone ('**96**) has been one of the few to grasp the idea of sequence, but he has not fully nor clearly developed it. Foreign observers have devoted much time to the study of feather development and feather colors and have even recognized "generations" of feathers, but there is still lack of definite information regarding the moults of the commonest species, and the relations between plumages and moults remains in many cases a matter for dispute.

It is well worth one's while to take up each of the plumages in sequence. They represent separate stages or periods in a bird's life, however much they may blend with one another. The first two are peculiar to young birds before they assume feathers of the adult type (excepting the remiges and rectrices in some species). Later stages mark a winter plumage and a summer plumage alternating as long as the individual is alive. These stages make up what I have designated as the sequence of plumages and unless this idea of sequence is firmly fixed in mind no adequate conception of the beautiful symmetry which underlies the development of plumages will be gained.

1. **Natal Plumage or Natal Down** (**plates III and V**). Enough perhaps has already been said regarding this first stage, scanty and evanescent as the plumage is in Passerine species. It has been recognized as the "downy stage" of the Raptores, it clothes the "chick" of the Grouse and their allies, while "young in down" and other similar terms have been used in the groups just mentioned and in the multitudes of species known as the Water Birds. This "down," however, lacks the structure of true down feathers. In Passerine birds it is

usually brown or gray, is found at only a few points on the upper surface of the bird, fades rapidly and begins to be lost by a complete *postnatal moult* before the nest is abandoned. It persists but a few weeks at most and is last seen as waving filaments at the apices of the feathers which succeed it.

2. **Juvenal Plumage (plate IV, fig. 1, and plate V).** This second stage has also been explained earlier. It has gone by a number of names, and the succeeding plumage is very often confused with it. "Nestling" and "fledgling" are names that have currency, but the most generally accepted term in this country has been "first plumage." If it were not that a much better and more exact use of the numeral adjective "first" requires its use elsewhere, the term might stand, misnomer that it is, but I feel that it should be displaced by "juvenal" to which the chief objection must be its novelty.

The juvenal plumage has been a good deal neglected and comparatively few specimens have found their way into collections until of late years. The most valuable contribution to the subject was made twenty years ago (Brewster, '78–'79) and only here and there since then we have heard more about it. Much of the juvenal plumage is acquired in Passerine species before the bird leaves the nest, not only directly displacing the natal down, but growing from an increased area of the skin. It is completely assumed in about three weeks at most. Males and females of most species are indistinguishable in this plumage unless the wing quills and tail are different in the two sexes. The body plumage of the male may be brighter or darker in a few cases, but as a rule the only difference is in the wings and tail. The body plumage is softer and the feathers less distinctly pennaceous than those of the adult while the remiges and rectrices although frequently appearing identical with adult feathers are regularly less pigmented and suffer more from wear probably because of their less compact margins. This plumage may resemble somewhat that of the adult although usually it is quite different in pattern and color. Young birds in this dress are frequently spotted or streaked below while the adults are immaculate and less often the reverse is the case.

In many species, especially among the Warblers and Vireos, a moult begins at the usual points on the breast almost as soon as the birds leave the nest and the succeeding winter plumage is assumed usually without loss of wings or tail. In many other species, however, this plumage is worn for several weeks or even several months before the *postjuvenal moult* sets in, and such birds as a rule completely renew their plumage. Without specimens taken at just the proper time it is extremely easy to overlook the moult of the flight-feathers which often resemble very closely in pattern or color those which they replace. Most of the Swallows and Flycatchers and a few other species after wearing the juvenal plumage for a long period leave for the south without apparent renewal. This is indicated by specimens from the tropics which prove a later or midwinter postjuvenal moult at a period when other species have begun their prenuptial. Only occasionally parts of this plumage fail to be replaced, and are, of course, retained until the next occurring moult, becoming meanwhile worn and ragged. As a rule the primary coverts are regularly retained with the primaries, the greater coverts usually renewed, but sometimes retained as in the Thrushes and some others, the median and lesser coverts almost always renewed and the tertiaries sometimes renewed and sometimes not, even in the same species. The alulæ are regularly renewed, but not in all cases. The moult of the remiges and rectrices depends upon the species, many retaining them for a whole year until the postnuptial moult takes place the following summer. All other feathers not already specified are regularly moulted.

3. **First Winter Plumage (plate IV, fig. 2, plate VI, fig. 1).** This is the plumage usually designated as "immature fall," "young in autumnal plumage," "young of the year," "hornotine" and various other appellations with elastic meanings. It seems to me the name selected is most appropriate for this third stage to the exclusion of others, for the plumages of successive winters may then be called "second," "third," etc., if desirable, or "adult" take the place of these adjectives as soon as age characters are lost. The first winter plumage, always assumed by a more or less complete postjuvenal moult, differs little if

any in texture from that of the adult and in a number of species adults and young cannot be told apart, except by osteological characters. This plumage is acquired within about three weeks after leaving the nest in some species, the first signs appearing as V-shaped patches on the breast. In other species which have a complete postjuvenal moult the process of acquisition takes longer and does not begin for a considerable period after leaving the nest. Among the Passerine species of New York, at least, this plumage is fully assumed before the young birds migrate, except among the Swallows, the Flycatchers and, perhaps, a few others. Sometimes one may see a feather of the juvenal plumage borne at the apex of a feather of this dress, and, rarely, even a filament of natal down will be found adhering in turn to the juvenal feather. To what extent new feather papillæ develop and where is of interest in all early stages, and the subject is perhaps not exhausted. The feathering in the first winter plumage is dense, a dozen layers or more covering the breast for instance, and the colors are usually bright and much "veiled" by the overlapping of the long feather tips, the barbs of which are almost always terminally of a paler or different color, the most frequent edgings being buff. The amount of this edging or tipping varies greatly and there is apparently always more of it in young birds than in adults of the second or third winters. It readily wears away and in some species striking changes are produced without moult by the time the breeding season arrives. Not only are the concealed colors brought out by the loss of the overlying feather tips, but the shapes of the feathers themselves are changed. This may be called a color change without moult, but there is a sharp dividing line between this result of wear and the alleged color change ascribed to some sort of unknown cell activity within the feather itself.

The first winter plumage is completely donned in some species in the vicinity of New York city, as early as the first of August, in others not before the middle of November, while the departed Swallows and Flycatchers are sometimes even later. It may be worn a full year without any moult occurring as for example in the Song Sparrow (*Melospiza fasciata*), or Bluebird (*Sialia sialis*), or a prenuptial moult, usually partial sometimes complete, takes place evidently for the purpose of supplying a portion at least of the bright feathers of the adult. In the plumage of the first winter males and females may usually be told apart for the first time and the tendency is for males in this dress to resemble, although brighter in color, the adult female in winter dress. There is however great individual variation, some males assuming here and there few or many feathers fully adult in pattern and color. It is fair to suppose such birds to have unusual vitality and mere precocity must not be confused with what generally takes place. Then there is the other extreme where a bird fails to reach the standard and a deficiency of pigment or failure to moult the juvenal feathers occurs ; and it requires a great many specimens to be sure of what the normal acquisitions really are. As a general rule the depth of color in the wings and tails of young birds will average less than that of adults, and in some species this character becomes more pronounced the longer the plumage is worn. The increasing depth of color apparent in some species while they are assuming first winter plumage, is I think, largely due to superimposed layers of new feathers.

The small size of the bill of young birds is a character distinguishing them from adults for a long time and a deepening or change in its color is marked in some species. The color too of the iris is sometimes strikingly different in young birds and helps determine their age. The change during the winter from brown to red in the iris of the Red-eyed Vireo (*Vireo olivaceus*) and from gray to white in the White-eyed Vireo, (*Vireo noveboracensis*) is only somewhat more striking than what occurs in many other species. Legs and feet also deepen in color.

About nine out of ten birds in most collections are in first winter plumage, and it is one that ought to be thoroughly understood.

4. First Nuptial Plumage (plate IV, fig. 3 ; plate VI, fig. 3 ; plate VII, fig. 4). This is a fourth stage representing the dress assumed by young or immature birds during their first breeding season, and contrasting with the "second" and "third" (or adult) nuptial of successive breeding seasons. It may be simply the first winter plumage plus a certain amount of wear, it may be the result of a complete prenuptial moult or it may be the result of a partial prenuptial moult plus wear of the retained feathers. Consequently it is not infrequently made up of feathers belonging to three diffferent stages, the old wings and tail of the juvenal dress, part of the old body plumage of the first winter dress and new feathers of the first nuptial dress. The most confusing admixture of these different plumages may be seen in some species, individual variation and sex being also potent factors in producing combinations of feathers that furnish even to-day some very puzzling problems. Species that complete the postjuvenal moult before moving south and those that consummate their prenuptial moult in our latitude offer at the present time no problems at all, and when material illustrating the moults of species that undergo the process while in distant lands is obtained, I venture to predict that problems will cease to exist. It is suggestive that theories have clustered chiefly about brightly colored species few of which attain adult dress without passing through a series of moults, the counterpart of which may be found among less conspicuous species. Bright adults taken at the same season as young birds variously sprinkled with irregular patches of color have furnished a theme for endless argument, and assertions of "restoration" and "repigmentation." These irregular patches will be found to correspond in every case with the points in the feather tracts where the moult usually begins or in the series of feathers that ordinarily precede other series. There is some irregularity, of course, but these feathers will almost invariably be less worn than those adjacent. I find just such patches and sprinklings of feathers on birds of inconspicuous plumage, and I can prove their growth at the prenuptial moult in many species of which I have large series and in some others from southern latitudes represented by only a few specimens. It would be difficult to say why some species pass their first breeding season in the plumage of the first winter altered only by wear, while others closely allied whether specifically or by habit undergo a more or less complete prenuptial moult, but the fact is incontestable. It is unfortunate that we have so little material illustrating this moult which takes place in so many species while they are away in their southern haunts, their winter wanderings carrying some of them beyond the equator.

The facts concerning the time of this moult are these. In the vicinity of New York, resident species and birds that winter begin to moult towards the end of March as exemplified by the Myrtle Warbler (*Dendroica coronata*) or Ipswich Sparrow (*Ammodramus princeps.*) A little later such species as the American Goldfinch (*Spinus tristis*) and White-throated Sparrow (*Zonotrichia albicollis*) begin a moult completed early in May. Many other species that do not winter very far to the south appear to moult in February or March sometimes arriving here with visible traces of recent feather-growth. The most difficult plumages to explain are those of birds which move south early in the autumn before the customary postjuvenal of young birds or the postnuptial of adults has taken place. It seems probable that in these species, which include some of the Swallows and Flycatchers, there is a late postnuptial moult of adults simultaneous with a partial postjuvenal of young birds the latter in some cases shortly after passing through a complete or partial prenuptial moult. This is the usual sequence in species that moult while with us and a few specimens from far southern counties near the tropics show moult in mid-winter and in spring. The fact that new growth of feathers occurs during the winter in many species is beyond doubt—the only question to be solved is, when? That the postjuvenal and prenuptial seasons of moult overlap, although not in the same species, is proved by numerous specimens of Warblers I have seen which begin to assume their first nuptial dress as early as November and December (in Jamaica, West Indies) although January and February specimens are in more active moult. In some species the prenuptial moult appears to proceed very slowly and irregularly.

The prenuptial moult is certainly a most interesting subject and it is one upon which we have had very little light shed. Its purpose is double, to approximate the plumage of the young bird to that of the adult and to adorn the adult with his brightest colors. In females the prenuptial moult is either limited or even altogether suppressed, and a fresh complication arises in species in which it occurs only in the young bird, not to be repeated a second year. Each species appears to have a definite type of moult although individual vigor and sex modify it and produce all sorts of combinations of plumage.

Some species undergo a complete moult like the Bobolink (*Dolichonyx oryzivorus*), Long-billed Marsh Wren (*Cistothorus palustris*), or Sharp-tailed Sparrow (*Ammodramus caudacutus*) others acquire distal primaries and part of the body plumage like the Indigo Bunting (*Passerina cyanea*) or Short-billed Marsh Wren (*Cistothorus stellaris*); others renew the whole body plumage but not the wings or tail like many of the Warblers, or the American Goldfinch (*Spinus tristis*); and still others renew but a small area of the head and throat like the Chipping Sparrow (*Spizella socialis*) or Palm Warbler (*Dendroica palmarum*). These are some of the classes into which the birds naturally fall but there is no hard and fast line between them. Ordinarily the anterior parts of the body are most frequently subject to moult, the posterior parts less and the flight-feathers least, but a few stray feathers are apt to develop on all of the body tracts at this moult in presumably vigorous individuals. The sprinkling of new feathers is well shown in such species as the Summer Tanager (*Piranga rubra*), and is only less conspicuous in the Palm Warbler (*Dendroica palmarum*). From what I have said it is obvious that the first nuptial plumage is the most difficult of any to properly understand. It is the culmination of the rapid series of moults through which a young bird passes and in many species lands him in full adult dress. When adults and young appear to be alike in plumage in the breeding season some clue to their age may often be found in the duller and more worn wings and tail retained from the juvenal stage of the previous summer. The primary coverts are valuable keys as well as any feathers retained elsewhere, but all other plumage characters are unreliable. I can only suspect that freak plumages and albinism occur most often in young birds judging by a few that I have examined.

When no prenuptial moult occurs the first nuptial plumage *is* the first winter plumage plus wear, and perhaps no more deserves a new name than does the continuation of a street. There are, however, some advantages in changing the name in either case. Wear in many species effects striking color changes by loss of feather edgings or feather barbules, when concealed colors are brought into view or modified in intensity by contrast. As these changes are varied and fully discussed under the species in which they occur they need not be particularized here. It must not be forgotten that wear is a constantly acting force, its effects being perhaps most noticeable in those species in which black areas are veiled by buff feather tips.

The importance of understanding the first nuptial plumage has been I hope, sufficiently demonstrated and with full knowledge of its intricacies, there remains no peg on which to hang silly theories which are disproved by every established fact.

5. Second or Adult Winter Plumage (**plate VII, figs. 1 and 3**). This fifth stage known usually as the "adult autumnal" plumage is always the result of a complete first postnuptial moult, usually directly at the close of the breeding season and before migration begins, except among the Swallows, Flycatchers and possibly a few others that press south first. This plumage is often quite different from the first winter dress and even when practically indistinguishable to superficial observation, the wings and tail are of a deeper color and the edgings richer and darker. Streakings will average broader and spots larger in the adult while veiling seems to diminish according to age, as shown by specimens in moult or retaining tell-tale feathers of the old plumage, but unfortunately age can seldom be determined after a bird is one year old. It is contrary to popular belief that birds acquire adult plumage within so brief a time, but all the evidence points that way. In many species young and old are indistinguishable in winter dress, as may be demonstrated beyond doubt by the cranial character on which I would lay so much stress. The Purple Grackle (*Quiscalus quiscula*) and many of the Sparrows are examples. The prenuptial moult may obliterate distinctions that survive the postjuvenal moult, for instance in the Yellow Warbler (*Dendroica æstiva*) or White-throated Sparrow (*Zonotrichia albicollis*). Distinctions that have survived the two earlier moults, whatever may have been their extent appear to vanish at the first postnuptial. If I had ever found autumnal specimens in immature plumage, showing the characters of the adult skull, I would be ready to admit that some species pass a second winter in immature dress, but I fail to find any such birds. On the other hand I do find birds in adult winter plumage with a few of the feathers that characterize the first nuptial dress. I have seen such specimens actually in moult of the Indigo Bunting (*Passerina cyanea*), Orchard Oriole (*Icterus spurius*), Redstart (*Setophaga ruticilla*) and others supposed to require several years to attain fully adult plumage. That variety of plumages is due primarily to individual variation can be proved beyond dispute by many specimens in first winter plumage, and also by many in first nuptial dress when parts of the previous plumages are retained. That even the most highly colored species require but one year to attain fully adult plumage is therefore not a matter so difficult of demonstration when adult autumnal specimens are secured in moult still retaining the tell-tale feathers of their first nuptial dress.

6. **Second or Adult Nuptial Plumage** (plate VII, fig. 2). This sixth stage acquired like the fourth by wear alone, by moult or by a combination of the two can only be distinguished from later nuptial plumages in a very few exceptional cases in which either first nuptial feathers have been retained after the first post-nuptial moult or birds are taken in the midst of it. As this moult is normally complete, the second nuptial plumage will be made up at most of parts of two, the second winter and the second nuptial. It is therefore less complex than the first nuptial and may or may not differ from it in pattern and color. It has been pretty generally taken for granted that brilliancy of plumage increases with age, but it is not an easy thing to prove

this. It seems to be true of the *average* adult, yet many young birds either at the postjuvenal, the first prenuptial, or the first postnuptial moult do assume colors quite as bright as the most highly colored adults.

It seems probable that females which assume male plumage contrary to their usual habit are old adults. The most difficult problem to solve in connection with this stage is whether all adults continue to have a prenuptial moult after the first year. There are few species which do not show renewal of a few scattering feathers, chiefly noticeable on the ramal margins of the chin, at the season of the prenuptial moult and perhaps as we learn more of it we may be obliged to consider this moult universal and merely suppressed in certain species just as it is in the females of certain species. We can easily tell how extensive it is in young birds from differences of plumage, but with adults it is difficult, for many of them assume a winter plumage that wear alone *might* easily convert into the nuptial dress. A mere sprinkling of new red feathers among the yellow ones of the young Summer Tanager (*Piranga rubra*) for instance, is conspicuous, but the same sprinkling might occur a second season and be quite overlooked among the old red ones especially when wear has assailed both sorts. When the prenuptial moult is fairly extensive, old tell-tale feathers show that both young and old undergo a moult, but when it is limited to small areas and to few feathers the problem is anything but easy even with specimens actually in process of moult. With specimens taken long after the prenuptial moult it may be impossible to make out from the amount of wear whether the feathers of the perhaps identical winter plumage have been renewed or not. If all the spring specimens of a species show evidences of moult, it is fair to assume that both adults and young have been affected. In spite of the evidence *pro* and *con* I must admit the question of the adult prenuptial moult is one that in a number of species has not been settled to my entire satisfaction. If young and old could be told apart in all cases at this season the matter would be much simplified. It depends now chiefly upon knowledge of winter plumages and estimates of wear.

The part that age plays in dichromatism, albinism, melanism, etc., is one as yet little understood and also offers an inviting field for investigation.

Beyond the second nuptial plumage it is not possible to trace the age of a bird, for the second postnuptial moult removes the last tell-tale feathers that in a few individuals of a few highly colored species have survived earlier moults. Whether more careful study of a greater number of species will show age characters of plumage persistent to seventh or eighth stages, I cannot say, but so far as the Passerine species of eastern North America are concerned I feel confident that the usual time assigned for the acquisition of adult plumage has been greatly overestimated.

V. COLOR FACTS *vs.* COLOR THEORIES

The number of investigators who have studied feathers, ever since the days of Aristotle, is almost incredible. All general works deal with plumages, while a number of special papers on feather development, feather structure, moult and color are worthy of particular mention, among them those of Meckel ('15), Dutrochet ('19), Cuvier ('25), Bachman ('39), Geoffroy Saint-Hilaire ('41), Schlegel ('52), Homeyer ('53), Gätke ('54 and '91), Meves ('55), Engel ('56), Holland ('60 to '64), Fatio ('66), Stieda ('69), Samuel ('70), Pernitza ('71), Studer ('73 and '78), Palmén ('80), Klee ('86), Davies ('88 and '89), Ficalbi ('90), Gadow ('91–'93), Maurer ('92 and '95), Meijere ('95), Stone ('96) and Keibel ('96). Besides these writers there are some who have studied color and pigment especially, and among these may be mentioned Gloger ('53), Altum ('54 and '55), Weinland ('56–'59), Bogdanow ('58), Severtzov ('63), Krukenberg ('81), Jeffries ('82), Gadow ('82) and Rabl ('97). Still others (including some of those already cited) have discussed the theory that a feather once grown could be recolored months afterward, an idea that seems to have originated with Cartwright (1792); to have been advanced by Fleming ('17 and '20), Whitear ('18), Ord ('30), Yarrell ('33 and '35), Schlegel ('52) and other German writers of his period; and to have received recent attention at the hands of Allen ('96), Chadbourne ('97) and Chapman ('96 and '97). It is to this theory, so far as it concerns Passerine species, that I now invite attention.

In view of the endless complexity of birds' plumages and the wide diversity in the manner of their acquisition demonstrable even among a few Passerine species, it is not surprising that theoretical explanations should flourish as long as the facts of moult regarding any species are not known. To catch a bird in moult is no easy matter, to catch him in all his moults is a task of considerable magnitude and yet as fast as this has been accomplished, theory has become superfluous.

Theory has even gone so far as to assert new growth of abraided barbs and barbules by exudations from a frayed weather-beaten feather, although most writers have contented themselves with alleging a fresh influx of pigment or a redistribution of color granules. No two of the upholders of this theory of so-called "color change without moult," or "aptosochromatism," have agreed as to how a feather that to all appearances has been histologically dead for many months may suddenly absorb, create or redistribute fresh coloring matter and the weakest point of their theory is the necessity for a new law of some sort to explain the theory. The mental attitude of those who believe in these changes is a curious one. They usually admit that moult is responsible for the renewal of one feather but claim a color change they cannot exactly explain in the feather adjoining. They would have Nature work according to well established laws in renewing feathers numbers 1, 2 and 3 of a series and then adopt a new one for number 4! They would have us believe that the shaft of a feather is a sort of an avian thermometer tube up and down which coloring fluids slip according to the seasonal systemic warmth of the bird! There is an element of the absurd about the position taken by theorists, but it is only fair to them to sift the evidence they bring forward in support of their theories. This is the evidence of live birds and the evidence of dead ones. Live birds must of necessity be caged birds, and dead ones of course are chiefly museum or cabinet specimens.

It has been asserted that various species of caged birds have been seen to change color without feather loss. Well, it is perfectly true that some do change color, but in these birds, as can be proved, no actual pigmentary change takes place. Colors concealed by feather edgings or optical effects produced by structure may be intensified by gradual loss of parts of the feathers and as these minute parts will not be found in the cage, those who are ignorant of simple principles of wear will see a "brightening by influx of pigment." The adult Purple Finch (*Carpodacus purpureus*) and adult Indigo Bunting (*Passerina cyanea*) both brighten very perceptibly by wear alone as I can testify. The former has no prenuptial moult, the latter has one confined to the body plumage. Theorists class both together and lump with them a lot of other species, among which similar changes are observed by them or by their friends and the crudest observations and baldest statements are offered as "proof" of new color.

From the extensive literature of the subject we learn that observers of caged birds have failed to bar out the possibility of moult, and in species that regularly only renew a small portion of their plumage at the prenuptial moult (particularly the small feathers about the head) I have no doubt that moult has occurred, the tiny feathers being whirled out of the cage by a puff of air or rolled up to almost nothing if sprinkled from the bath or drinking cup. It is not often that many are cast off at one time and they are so extremely small that the entire plumage of the head of a bird the size of a Song Sparrow (*Melospiza fasciata*) may be held between the thumb and forefinger. Did any of the theorists ever try blowing away such a pinch of feathers even in a small room and see how many he will find? Some idea of the relative size of feathers may be gained from **plate I**, on which those of a Bobolink (*Dolichonyx oryzivorus*), a good sized Passerine bird are figured. In order to give some idea of their relative number, I have made actual count of all the contour feathers on a spring male. The enumeration of the minute down-feathers, semiplumes and filoplumes I leave to others. The result of my count is as follows:

Alar Tracts	492	Ventral Tract	465
Humeral Tracts	96	Caudal Tract	55
Capital Tract	1385	Lumbar Tracts	70
Dorsal Tract	506	Crural Tracts	166
		Total	3235

The actual number of feathers, however, is not nearly so important as their size, and I will venture to assert that over 50% of the total number are no larger than those shown on **plate I, fig. 17,** while hundreds of them are almost microscopic. The Bobolink is one of the species cited by several observers as changing from buff to black without feather loss because no feathers are found in cages. The most plausible evidence yet advanced is Dr. A. P. CHADBOURNE'S (**'97**) but even this observer admits that his cage was not protected by any netting. Furthermore he leads us to expect tremendous feather-loss and estimates the number of feathers, kind not specified, at 2634. As most of the feathers of a Bobolink are extremely small, a wing beat would readily drive them out of the cage. Suppose now a caged bird possessed the dark wings and tail often found in autumn. Without moult the loss of their buff edgings combined with the ragged state in which we find them later might easily produce a color that would pass for black and if numerous body feathers had been knocked out, as is often the case, before observations upon a specimen began, it would be easy to overlook a partial moult. I know from personal experience how easy it is to fail to find by examination the tiny feather sheaths which are quickly lost even before the black portion of the yellow tipped feathers pushes out into view among the concealing buff feathers. Having pointed out some of the possibilities of error in observations, I may add that Dr. CHADBOURNE'S Bobolink and one or two others that have not been preserved by their owners are certainly unique. There is no lack of evidence that other caged Bobolinks undergo a fairly complete moult in the spring and I have personally watched several birds and seen others that had completed the process. Even admitting that some birds can and do turn black as asserted, it is no proof whatever that such change ever can or does occur in the wild state. If caged birds prove anything they prove that under peculiar and abnormal environment the process of moult is curiously suspended or modified by such factors as food, warmth, fright, etc., but if color changes in wild birds are to be explained by what a few captive birds are alleged to have done, there are likely to be sceptics who question the accuracy of such observations.

The dulness of the plumage of sick birds and subsequent brightening has been noticed, but it is simpler to attribute the improvement rather to the renewal of the neglected oiling and preening than to colors within the feathers themselves.

Theorists support their arguments by telling us that the color of Canary Birds may be changed by food, but they fail to tell us that the administration of Cayenne pepper must be begun weeks before a moult, the *new* feathers coming in of a different color from the old. Therefore any bald statement that diet will effect color change in feathers needs to taken with a grain of salt. Sauermann ('89) has made some interesting experiments that any bird-fancier will confirm if questioned.

Another assertion of theorists is that a feather is not a dead structure, but possessed of some sort of vital connection with the body or capable at least of internal cell activity. Experiments with feathers, even while attached to the skin of a living bird, show that mechanical recoloration is possible, but this is no proof that such a thing can occur except by artificial means. The penetrative power of oils and staining reagents, be the absorbing substance organic or inorganic, is well known and every biologist is aware that dead tissues stain more readily in most cases than living ones. In the case of feathers we are dealing with structures that are (except in the minds of theorists) when mature, cut off from further vital connection with the body, and to assume a re-opening of this connection, or stranger still, a revival of cell activity in dead tissue is simply a tacit confession that the first principles of moult have not been apprehended. Microscopic investigations are always impressive, but they lose force when employed in support of a theory which is not only quite superfluous, but does not even accord with known facts.

Turning now from the evidence of caged birds to that derived from museum skins what do we find? Again superfluous theory, and a perversion of facts to fit, based on the most superficial observations. Without taking pains to learn even the simplest facts, our foreign brethren and some too on this side of the ocean have offered triumphantly mixed plumages as proof of color change without moult, and extremists believe in a rebuilding of the worn margins of feathers, or at least in their vitality, because they see with a microscope pores which exude something. Some writers wax eloquent upon the subject.

"Foci" and "spreading areas of color" are observed and a series of feathers showing the changing pattern are plucked out and figured in blissful ignorance that all the various patterns were present in the feathers when they developed at the last period of moult. Just such feathers (as, for instance, some from the breast of a Bobolink **plate I, figs. 1–6**) may be found fresh and new after a moult or worn and frayed and perhaps in juxtaposition with newly grown ones at a later season of moult, as proved by scores of species treated in the present paper. There is not the slightest evidence of recoloration, the alleged changes being easily and naturally explicable, as due to the normal sequence of normal moult modified by normal wear. The true explanation of the plumages of such species as the Rose-breasted Grosbeak (*Habia ludoviciana*), Baltimore Oriole (*Icterus galbula*), Orchard Oriole (*Icterus spurius*), Indigo Bunting (*Passerina cyanea*), Bobolink (*Dolichonyx oryzivorus*) and other alleged examples of color change without moult will be found under these species, and all mixed plumages are readily explained without resort to theory, if the fundamental principles of moult are once firmly fixed in mind. I have examined something like 15,000 birds during the last few years and I find none which do not conform to the definite laws of moult and wear which I have laid down. I often wonder at the temerity of theorists who, with a mere handful of specimens taken, perhaps, all at one season, do not hesitate to betray their ignorance of the foundation facts of plumage. As long as they do not apprehend them, their conclusions are not to be taken seriously and as long as they are unaware that the plumage of a specimen may be the resultant of no less than three moults, that old and young may moult quite differently and that males and females may not moult alike, of what value are their theories?

Dr. CHADBOURNE in his paper previously cited asserts that the skin of a Bobolink taken March 1, in Brazil, proves color change and moult going on simultaneously. An understanding of the A B C of moult shows that the first assumption is without support and that the bird is a typical adult male undergoing a perfectly normal and complete prenuptial moult as already explained by Mr. CHAPMAN ('97). The feathers of the worn adult winter dress are found at exactly the points where they are regularly found in all Passerine species before a moult is completed and the whiteness of the abdomen is not due to albinism as the writer suggests, but to the normal fading of feathers that were almost white when assumed in the autumn. I have examined the bird and agree with Mr. CHAPMAN that no new white feathers are discoverable (the one figured by (CHADBOURNE, *Auk*, '97, plate 1a, fig. 2) certainly does not look like a new one), all of them being much worn. Therefore the "proof" that they will turn black rests on a single feather by what means determined as of new growth we are not informed. In like manner his statement that the black feathers regularly sprinkled on the throats of adults in autumn will shortly turn buff is not in accordance with facts for these feathers become the old worn ones found on the March bird. (*i. e.*, feather, plate 1a, fig. 4 would wear to fig. 3). In fig. 5 is shown an autumn feather that would be found in spring with the foci unchanged. In fig. 1 we see another old black feather that was just the same color when it grew at the postnuptial moult. Not one of these feathers therefore has been correctly interpreted and what is true of this plate is true of others that are considered convincing proofs of alleged color changes in other species.

Now, to maintain in the face of these facts about which there can be no question, that moult and a color change may coexist in such a warping of facts to fit a theory, that even the emphasis of italics and small capitals is not convincing. While Dr. Chadbourne's paper is a model of exactness in details, the real facts do not bear out his conclusions, nor are his explanations the simplest possible. As his evident skill in microscopic tecnique will be apt to carry much weight, I have criticized his paper at some length because it embodies most of the unsubstantial foundations on which modern theory rests. The views of many of the earlier writers have already been analyzed by Dr. Allen ('96) and need not be specified here. Suffice it to say, therefore, that however pleasing all the various theories may have been they have set aside the following facts: *First* the normal histology of the feather; *Second*, the normal moult; *Third*, the normal sequence of plumages; and *Fourth*, the normal effects of wear. A proper comprehension of these four basal facts will entirely eliminate the necessity of abnormal color change while at the same time explaining every plumage easily and naturally. If Nature must be assisted in a perfectly well understood moult by a process of color change about which no two of its champions offer the same explanation, it seems to me that Nature's ability to follow the same laws in all cases is discredited because these champions of supposed new ones have failed to recognize the old. I am not the first to reach these conclusions, but many of my predecessors in the field were much hampered by lack of material to confirm their opinions. Bachman ('39) had a good idea of moult among North American species in spite of some errors. Since his day no comprehensive article touching upon our birds has been written until Mr. Witmer Stone ('96) made clear the different plumages of certain species. I might cite other reliable writers besides these two so far apart in point of time so near together in point of view, but it would serve here no good purpose.

Years ago a theory was current that Swallows hibernated beneath the mud of ponds. The fact that they could not do it and did not do it is a lesson that our modern color-change theorists would do well to take to heart. Nowhere among living organisms do restorative changes in tissue take place without destruction or casting off of the old. Consequently belief that a feather which regularly develops, dies and is cast off, can possibly violate such a universal law is not only contrary to common sense but contrary as well to every established fact regarding the moulting of birds.

VI. OUTDOOR STUDY OF MOULT

Seasons of Moult

This is a pleasant and fascinating side of the subject of moult for it takes us out into the open air of woods and fields. Hot, muggy August has been considered, the month of moult in the vicinity of New York city, and it will surprise some of us to learn that many of our local species quite complete their winter plumage before August arrives, while others do not begin to assume it until the month has long passed. Although this month does mark the high tide of moult, especially among the adults of a great many species, there are few months in the year when one species or another does not show evidences of feather loss just past or just beginning. A complete moult is accomplished in from four to six weeks, stray feathers continuing to appear for a much longer period, but partial moults require much less time. The young of most of our Passerine species remain in the nest about two weeks, a little more or less according to size, this period corresponding very nearly to the duration of the natal down.

The growth of the juvenal plumage begins while the young bird is still in the nest, the wings and tail requiring several weeks to reach maturity. Birds hardly able to fly will be found which already show signs on the breast of the first winter plumage; these species as a rule do not lose the wings and tail at the postjuvenal moult; others however do, and usually such birds will have worn the juvenal plumage for many weeks before the postjuvenal moult begins.

The blending together of the moults of the young bird makes it difficult to assign the time required for any one of them and the time varies with each species. It can be said, however, that the first winter plumage *may* be practically complete within a month after the nest is abandoned, the juvenal having been completed in less than half that period.

The adults of early nesting species, for example, the Crow (*Corvus americanus*) or Worm-eating Warbler (*Helmitherus vermivorus*), begin to moult by the end of June when the postnuptial moult may be said to begin. These represent an ill-defined class of early breeding birds whose young appear towards the end of May or earlier and who raise but one brood in the season. Another class comprises the later breeding species raising but one brood hatched towards the end of June like the Bobolink (*Dolichonyx oryzivorus*) or Wood Thursh (*Turdus mustelinus*), which moult late in July. A third class comprises birds that regularly raise two broods like the Song Sparrow (*Melospiza fasciata*) or Field Sparrow (*Spizella pusilla*), the first appearing towards the end of May, the second in July. The first brood begins the postjuvenal moult late in August, the second moults in September and October. Belated broods are puzzling and are probably mistaken for third broods by the average observer. It is my opinion that none of our local species regularly raises more than two broods (and few of them more than one) in one season, for a bird taken in nuptial dress, whether accompanied by young or not, when many other birds of the same species show a symmetrical and extensive development of the moult is suggestive evidence, not of a third, but of a belated brood. My grouping into three classes is purely artificial, however, and only done because it is convenient to think of species thus grouped.

From what I have already said it is easy to understand what a confusion of moulting birds may be found during July, August and September. The postnuptial moult of adults regularly precedes the postjuvenal in the same species although young birds may overtake adults in assuming fall plumage if they do not renew the flight feathers. If adults, then, begin a moult in June they complete it in July, if they begin in August they end in September and late-nesting species like the Goldfinch (*Spinus tristis*) begin in September to finish in October and even November. Belated broods of young birds may delay the moult of their parents far beyond the usual limits. As for the migrants which reach us from the north their moult is usually completed almost entirely before they reach us.

December and January are generally the only months in the whole year when most evidences of moult are lacking in the specimens obtained here. In February some of the birds that have wintered with us begin to shows signs of the prenuptial moult. The Ipswich Sparrow (*Ammodromus princeps*) from the end of this month to the end of March acquires new feathers about the head and throat and the last of March marks the beginning of a nearly or quite complete renewal of body feathers in the Myrtle Warbler (*Dendroica coronata*). April marks a partial prenuptial moult in several local species, among them the Goldfinch (*Spinus tristis*) and the White-throated Sparrow (*Zonotrichia albicollis*). During April and May the young of early hatched species begin to appear and among a host of migrants on their way north a few birds are found showing stray "pin feathers" which tell of a moult accomplished perhaps far away in the south. I have roughly indicated what each month in the year may teach us regarding the moult and I turn now to another subject which has been a matter of some controversy.

Migration After Moult

It is, perhaps, not generally believed that birds depart from their breeding grounds immediately after the moult, but there are two cogent reasons in favor of this view. One is the fact that many species in the vicinity of New York city do disappear directly after and sometimes before assuming winter plumage, and the other is the fact that none of the species which breed farther north arrive here before the last traces of the moult are nearly if not quite obliterated. I have never seen a passing migrant, except possibly the White-bellied Swallow (*Tachycincta bicolor*), showing signs of immaturity in the flight-feathers. In the spring too for that matter very few of the arrivals from the south show any signs of the moult, through which, from the freshness of their feathers we know they must have passed. The postjuvenal and the postnuptial moults are virtually completed so far as the flight-feathers are concerned before the species moves south. Most of the Flycatchers and Swallows, however, disappear before these moults begin, but they and a few others are exceptions. The progressive shrinkage or involution of the sexual organs of adults is, as a rule, quite marked before the postnuptial moult sets in, and it is highly improbable any further attempt to rear young is ever made once this retrograde process has begun. When the last brood is on the wing and well able to care for themselves, the moult of the parents begins, that of the male starting a little before that of the female as becomes evident when a pair can be secured. As the female attends to the wants of her family longer than does the male, it is not surprising that her moult should be the later. We can readily believe that when a brood is raised to take the place of accidentally destroyed eggs or young, the involution and the moult are both delayed. As almost all of our migratory species move south on the completion of a moult which is accomplished somewhat earlier in adults than in their progeny, it is natural to expect the former to go first. My actual experience is that the last loiterers of many of our summer breeding species are young birds. Some species disappear almost entirely, as for instance the Golden-crowned Thrush (*Sciurus aurocapillus*) and later reappear when migrants from the north arrive to replace them. The first comers are not always adults but they are very apt to be.

Species near the northern limit of their breeding range, such for instance as the Hooded Warbler (*Sylvania mitrata*) or Blue-winged Yellow Warbler (*Helminthophila pinus*), rapidly disappear on completing their moult. The specimens obtained late in the season all prove to be young birds, and this is the case with many species that I have pursued with the object of securing adults. The evidence of moult is that old birds migrate south first because they are ready first.

It is an undoubted fact that when a species has an extensive breeding range, the birds towards its southern limits begin to moult earlier than those at its northern. I fancy that this has something to do with the great individual variation we see in immature birds the following summer. A species that might raise two broods at the south would perhaps raise but one at the north and we might suppose the older birds to be more vigorous. It is apparently the case with species raising two broods everywhere. Young birds show variable vigor and presumably the highest plumaged are the oldest and the ones most likely to assume at the postjuvenal moult feathers that in the younger would not be donned until the prenuptial period.

Preponderance of Young in Autumn

There is another matter which comes in naturally at this point. The vexed question why young birds are obtained in the autumn in such overwhelming abundance as compared with adults has never been solved. Various explanations have been offered but none of them seems adequate. Several causes probably contribute to make adults in fall plumage so rare in collections and I have a new one to add which I believe is an important factor in the case. It is simply that the old birds take better care of themselves and the young most frequently fall victims to our powder and shot. Anyone who has chased a family of Towhees (*Pipilo erythrophthalmus*) along a hedge row will be prepared to admit that it is the parents who skip along at the head of the procession with surprising alacrity. In the autumn do we not find adult Wood Pewees (*Contopus virens*) and Scarlet Tanagers (*Piranga erythromelas*) almost inaccessible at the very tops of the tallest trees? If anyone doubts whether old birds take good care of themselves let him use his gun with this idea in view before the woods and fields are invaded by a host of passing migrants from the north. Just as soon as the young of our summer species reach a stage when they no longer need to be fed by their parents, the latter cannot be lured by the most seductive squeakings one can muster which earlier would have thrown them into a high state of excitement and remonstrance. It is the young that are attracted by the sounds and the adults may sometimes be observed slipping away at the first alarm. Their timidity is probably increased by the somewhat disabled state in which they find themselves owing to the moult. While the feather loss at this time is so carefully compensated for by feather gain that birds as a rule are very little crippled in their locomotive powers, still we may well suppose they feel some anxiety as to their ability to escape when their feathers are only partly developed or new and untried. We must also take into consideration the endeavor manifested by birds to lead their young out of danger, a trait which may influence them to a greater or less extent after the young are quite able to shift for themselves. In flocks of migrants, too, it seems to be the old birds that first take alarm and the loiterers almost invariably prove to be the young birds that have not learned the dangers of delay. The early banding together and departure south of the adults of a particular species that has reared young in a locality near the northern limit of that species may account in great measure for the apparent rarity of local adults because few of us care to brave the midsummer sun, in pursuit of them, but it does not explain why among the hords of migrants from more northern breeding regions so few adults are secured. The theory of a migration of adults by a different route from that taken by the young birds *may* explain some cases and the relatively greater number of young due to the natural increase of species will account for a part of the existing disproportion but none of these explanations is adequate. It is a subject where field work and closet study go hand in hand and it remains to be proved whether my theory of personal safety, the only one I advance in these pages, will be displaced by a better.

In collections the proportion of young birds taken in the spring when it is possible to determine their age is far smaller than in the fall. In fact adults and young seem to be about evenly divided in numbers, except in the case of bright colored species where the brilliant adults have evidently attracted the collector's attention more than the duller young birds.

VII. PLUMAGES AND MOULTS OF NEW YORK SPECIES

Classification of Moult

No attempt has ever been made to group North American birds according to the manner of their moulting and it is certainly desirable that an outline of some system of classification should be traced, imperfect as is our present knowledge of the subject. Among the Passerine species of New York, which include nearly all of those of eastern North America, will be found the greatest diversity of moult not only in the different species, but in individuals of the same species, not to mention the peculiarities due to the age and sex of these individuals. Large series of birds taken at the proper season are necessary to determine which are the exceptions and which the rule, and until more positive light of this nature is thrown upon the species that moult when south of the United States, the status of some of them must remain a matter of doubt.

Aside from ascertaining the facts of moult in each species, the greatest difficulty lies in the impossibility of drawing any hard and fast line between groups or classes that may be proposed. The only invariable moult is the postnuptial which, except in a very few rare cases, is absolutely complete and takes place in all species at the close of or soon after the breeding season peculiar to each. The dividing line, however, between species with a postnuptial moult only and those that undergo a prenuptial as well, is not a definite one. Some appear to undergo only one prenuptial moult, that of the first year of their life, and form a connecting link between groups of birds that moult annually and those that moult twice a year, but as the females of such species usually omit the prenuptial changes of the male, it seems advisable to consider them all as a special class of birds moulting annually.

As in plumage so in moult, classification must depend primarily upon the males and the extent of their prenuptial changes seems to afford a good basis for classifying birds with semiannual renewal of plumage. With those of annual renewal, however, we must go back to the postjuvenal moult which imposes upon species characters that they retain for a twelvemonth. But here again there is no sharp dividing line, and without large series of specimens to eliminate individual variations, it is extremely easy to classify wrongly. For instance, the Horned Lark (*Otocoris alpestris*) would seem to belong to Group A, and yet many late winter specimens show new growth of a few feathers about the chin and the eyes, suggesting the transference of this species to Group J. In another species, the Snowflake (*Plectrophenax nivalis*), the regular and more extensive growth of feathers in the same regions has led me to place it, with some hesitation, in Group J, because a like extent of renewal in the Lapland Longspur (*Calcarius lapponicus*) produces visible changes that in the Snowflake are not apparent.

It is possible that when we know more of the birds classed under E and F, both these groups may prove superfluous and the species turn out to moult to an extremely limited extent every year, but I hardly think so. They now contain birds that in some individuals at least accomplish by moult at the postjuvenal period what is delayed in others until the prenuptial.

The groups I propose are fairly distinct for the majority of the species included in them although there are some birds that vary so in the extent of their moult as to properly belong to several. For example, there may be enough difference in two male White-throated Sparrows (*Zonotrichia albicollis*) to warrant placing one in Group I and the other in J, while of two females one might be placed in J and the other in C.

In species that undergo a prenuptial moult there may be found every gradation from birds that renew the whole of their plumage to those that merely gain a few feathers about the anterior parts of the head. It is even probable that some of the species I have included under J belong more properly under F and possibly even to the groups of birds with annual moult. With much material for study, it has been impossible for me to be positive about some species but their status will be discussed later on under the species themselves.

I. ANNUAL OR SINGLE MOULT (Postnuptial).

1. *Postjuvenal Moult complete.*
   - *a.* Young and adults nearly alike in Winter and Nuptial Plumages. A
   - *b.* Young and adults unlike in Winter and Nuptial Plumages. B
2. *Postjuvenal Moult incomplete,* not involving remiges nor rectrices.
   - *a.* Young and adults nearly alike in Winter and Nuptial Plumages. C
   - *b.* Young and adults unlike in Winter and Nuptial Plumages. D
3. *Young with a First Prenuptial Moult,* following incomplete Postjuvenal Moult.
   - *a.* Extensive, including often rectrices and even a few remiges. E
   - *b.* Limited chiefly to the head. F

II. SEMIANNUAL OR DOUBLE MOULT (Postnuptial and Prenuptial).

1. *Prenuptial Moult complete.* G
2. *Prenuptial Moult of body complete* (in young including often the rectrices and sometimes a few remiges). H
3. *Prenuptial Moult of body incomplete,* never involving rectrices nor remiges. I
4. *Prenuptial Moult of body very incomplete* and limited chiefly to the head. J

CLASS **A**

Otocoris alpestris	Ammodramus maritimus
" " praticola	Melospiza fasciata
" " leucolæma	Cardinalis cardinalis
Sturnus vulgaris	Petrochelidon lunifrons
Molothrus ater	Chelidon erythrogastra
Sturnella magna	Tachycincta bicolor
Scolecophagus carolinus	Clivicola riparia
Quisculus quiscula	Stelgidopteryx serripennis
" " æneus	Vireo noveboracensis (C ?)
Passer domesticus	Icteria virens (C ?)

Class B

Agelaius phœniceus
Passerina ciris
Progne subis

Class C

Alauda arvensis (?)
Myiarchus crinitus
Sayornis phœbe
Contopus borealis
" virens
Empidonax flaviventris
" virescens
" traillii alnorum
" minimus
Pica pica hudsonica
Cyanocitta cristata
Perisoreus canadensis
Corvus corax principalis
" americanus
" ossifragus
Coccothraustes vespertinus
Acanthis linaria
" " rostrata
Carduelis carduelis
Spinus pinus
Poocætes gramineus
Spizella monticola
" pusilla
Junco hyemalis
Melospiza lincolnii
Passerella iliaca
Pipilo erythrophthalmus
Ampelis garrulus
" cedrorum
Vireo olivaceus
" philadelphicus
" gilvus
Vireo flavifrons
" solitarius
" " plumbeus
Protonotaria citrea
Helinaia swainsonii
Helmitherus vermivorus
Helminthophila pinus
" chysoptera
Dendroica dominica
" vigorsii
Seiurus aurocapillus
" noveboracensis
" " notabilis
" motacilla
Sylvania mitrata
Mimus polyglottos
Galeoscoptes carolinensis
Harporhynchus rufus
Thryothorus ludovicianus
Troglodytes aëdon
" hiemalis
Certhia familiaris americana
Sitta carolinensis
" canadensis
" pusilla
Parus bicolor
" atricapillus
" carolinensis
" hudsonicus
Regulus satrapa
" calendula
Turdus mustelinus

Turdus fuscescens
" aliciæ
" " bicknelli
" ustulatus swainsonii
Turdus aonalaschkæ pallasii
Merula migratoria
Hesperocichla nævia
Sialia sialis

CLASS D

Pinicola enucleator
Carpodacus purpureus
Loxia curvirostra minor
" leucoptera
Dendroica cærulescens (F ?)

CLASS E

Icterus galbula

CLASS F

Tyrannus verticalis (J ?)
Icterus spurius
Guiraca cærulea
Piranga rubra
Dendroica virens
Setophaga ruticilla

CLASS G

Dolichonyx oryzivorus
Ammodramus caudacutus
" c. nelsoni
" c. subvirgatus
Cistothorus stellaris
" palustris

CLASS H

Milvulus tyrannus
Tyrannus tyrannus
Spinus tristis
Habia ludoviciana
Passerina cyanea
Calamospiza melanocorys
Piranga ludoviciana
" erythomelas

CLASS I

Ammmodramus princeps
" sandwichensis savanna
" savannarum passerinus
" henslowii
Zonotrichia albicollis
Spiza americana
Mniotilta varia
Dendroica tigrina
" æstiva
" coronata
" maculosa
" cærulea
" pensylvanica
" castanea

Dendroica striata	Anthus pensilvanicus
" blackburniæ	Saxicola œnanthe

CLASS J

Plectrophenax nivalis (A ?)	Helminthophila peregrina
Calcarius lapponicus	Compsothlypis americana
" ornatus	Dendroica palmarum
Chondestes grammacus	" " hypochrysea
Zonotrichia leucophrys	Geothlypis formosa
Spizella socialis	" agilis
Melospiza georgiana	" philadelphia
Lanius borealis	" trichas
" ludovicianus	Sylvania pusilla
Helminthophila ruficapilla	" canadensis
" celata	Polioptila cærulea

Descriptions of Species and their Moults.

The following pages contain a description of each of the successive plumages of every Passerine species accredited to New York state including introduced foreign species. My object is not so much to give a precise description, such as may now be found in every book, as to throw light on the changes effected by moult and wear, therefore only the JUVENAL and FIRST WINTER PLUMAGES have been treated at length because upon them depends a proper understanding of later stages. The JUVENAL PLUMAGE of a number of species is here described for the first time but I have not succeeded in obtaining this stage of *Alauda arvensis*, *Carduelis carduelis*, *Ammodramus caudacutus nelsoni*, *Passerella iliaca*, *Dendroica palmarum*, and *Geothlypis agilis*. The others are in my own collection with the exception of eleven loaned me by Mr. WM. BREWSTER, ten by the American Museum of Natural History and six by the United States National Museum. The "Nomenclature of Colors" by Ridgway ('86) has been carefully followed, comparisons have been made in a bright light and the nomenclature chosen is that of the A. O. U. Check-List, 2d edition ('95).

For the excellence of the photographic work I am indebted to the painstaking endeavors of Dr. Edward Leaming and the photomicrographs are unquestionably the best and practically the only ones of feathers that have ever been reproduced. It is needless to specify the difficulties encountered in selecting feathers of similar size to avoid distortion by photographic enlargement and gravure reduction.

In conclusion, I would say that as I trace out the sequence of moults and plumages in species with which I have been unfamiliar, it becomes more and more evident that moult and wear are quite sufficient to explain the most puzzling plumages, and the only problems as yet unsolved are those dealing with birds of which we do not possess enough specimens to link together all the successive plumages into a symmetrical chain.

TYRANNIDÆ.

The Flycatchers offer one of the most puzzling problems of moult to be found among our Passerine birds and the reasons for this are not far to seek. With the exception of two species, *M. crinitus* and *S. phœbe*, young birds and old migrate southward in the fall before moulting, to any marked extent and when they return, show by their plumage that at least one, and in some cases probably two moults have been accomplished during their absence of six or seven months. A few specimens from South and Central America, taken in January and March, show new growing feathers—but the material is, much of it, undated and far too scanty to render satisfactory conclusions possible. Another reason may be found in the plumage itself, which does not vary much in color from season to season and close scrutiny of the feathers is required in order to distinguish old from new. The body plumage, too, is soft and of loose texture, even the juvenal differing little from later stages, so that wear is not very obvious. When, however, suitable material from the tropics is forthcoming, the exact time of moults and their extent will be settled; but until then we must draw inferences largely from the comparative study of plumage.

Some young birds undoubtedly replace the body plumage extensively before they move south, as shown by specimens in my collection ; others, as proved by their juvenal dress conspicuous for brownish wing bands, reach Guatemala or adjacent countries before moulting. It seems more than probable that the incoming feathers observed on birds when they leave us denote a slow process of moult involving later the wings themselves, an order of moult that would be a reversal of the usual method. If, however, this prove to be the case then the transition would be effected by a very late postjuvenal moult in young birds and the first nuptial plumage would be the first winter modified by wear. Some adults, like the young birds, begin to assume a few new feathers before moving southwards, others reach their winter haunts in worn breeding dress. That a complete postnuptial moult takes place we may hardly doubt, for this moult is common to all species and it probably takes place during the last months of the year, or just prior at least to the postjuvenal moult of young birds. This would explain why all specimens arriving from the south in spring are in almost equally fresh plumage, whether young or old, seemingly too fresh to have been worn since the previous autumn.

I have indicated the difficulties to be overcome in studying this family and the same ones confront us among the *Hirundinidæ* and a few other species. If my conclusions are erroneous they fail in matters of time rather than facts of moult.

Milvulus tyrannus (Linn.). FORK-TAILED FLYCATCHER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including wings and tail, olive-brown ; coverts and wing-quills narrowly edged with pale russet. Below, white. Orbital region dull clove-brown. Bill and feet brownish-black in dried specimen. The tips of the primaries are rounded and there is no yellow crown-patch. The tail is but five inches in length.

3. FIRST WINTER PLUMAGE acquired by a complete postjuvenal moult as shown by two specimens from Costa Rica, September 18 (Amer. Mus. Nat. Hist. No. 48225 ♂ and No. 48228 ♀),

the male with two old primaries still unrenewed, the female with five old ones, and both with brown heads, and many other feathers of the juvenal plumage. Young and old become practically indistinguishable.

Males become glossy black with yellow crown patch ; the outer pair of rectrices are fully nine inches in length and blacker than those of the juvenal dress ; the three distal primaries are deeply incised at the tips, a peculiar emargination.

4. First Nuptial Plumage acquired apparently by a partial prenuptial moult which involves usually only the body plumage. The evidence as to just what moult occurs is inconclusive. Two specimens from Brazil, of February 1, and March 15 (Amer. Mus. Nat. Hist. No. 36336 ♀ and No. 36338 ♀), appear to be in worn juvenal plumage and are assuming a few new feathers here and there. Males would probably show an extensive and possibly a complete moult, and it may be that these two birds were males that failed to accomplish the postjuvenal moult at the usual time. A specimen (Amer. Mus. Nat. Hist., No. 36339 ♂, Brazil, March 11), is moulting the primaries, only five old ones remaining, two of which are emarginate, suggestive of a young bird, but nevertheless the bird may perhaps be an adult.

5. Adult Winter Plumage acquired by a complete postnuptial moult during August and September as shown by several Costa Rican, Venezuelan, and Brazilian birds. October specimens begin to show wear which has become very marked in one of December 5.

6. Adult Nuptial Plumage acquired by a partial and perhaps complete prenuptial moult. The rapid and excessive wear shown by this species points to a complete moult which No. 36339, referred to above, may exemplify. A female (Amer. Mus., Nat. Hist. No. 36337) Brazil, February 1, also points to this, the two proximal primaries being new.

Female.—As indicated above males and females in juvenal plumage are alike and both acquire adult dress at the postjuvenal moult, this being delayed perhaps, in some females, until the prenuptial moult. In later plumages the sexes are very similar, the females usually with less emargination.

The difficulties of reaching positive conclusions from a small series is well illustrated by this species, especially as the age and sex of some specimens is open to doubt.

Tyrannus tyrannus (Linn.). Kingbird.

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including wings, dull clove-brown usually darkest on pileum, the feathers of nape and rump obscurely edged with cinnamon, wing coverts edged with pale buff including two indistinct wing bands, secondaries with yellowish white, primaries and tertiaries with dull white; tail black, tipped with brownish white especially outer rectrices. Below, pure white, a grayish band tinged with buff across jugulum. Bill and feet dusky, becoming black. The first and second primaries are rounded, and without emargination (**plate II, fig. 18**) and no crown patch exists.

3. First Winter Plumage acquired by a late postjuvenal moult which is probably complete, so far as indicated by a few scanty facts. Specimens taken late in August and up to September 16 show new growth of feathers scattered about the head, throat and back. The head and back evidently become darker, the pectoral band grayer and more diffused and a few yellowish feathers may appear on the crown but the birds seem to pass south before the moult is complete. Birds taken in Central America, unfortunately without dates, show that the species reaches the tropics without any moult of the flight feathers or of the wing coverts and often in full juvenal plumage. It is an interesting problem whether the wings and tail are renewed at the end of the postjuvenal moult or at a prenuptial moult, the former conclusion being most probable. A bird from South America taken March 31 (which may possibly be an adult) shows a recently completed moult the sheaths still adhering to the new primaries. More winter material is much to be desired.

4. First Nuptial Plumage acquired probably by a partial prenuptial moult. This I believe is the true explanation of why birds return in spring in fresh plumage including the two outer emarginate primaries (the shape being indicated on **plate II, fig. 19**), a new white-tipped tail and the orange crown patch,

young and old being indistinguishable. April specimens from Georgia and Florida often show a few "pin feathers." Wear is marked in this species before the end of the breeding season less than four months later which is an argument in favor of a prenuptial moult, because the feathers seen in April, even if acquired late in the autumn, ought to be as much worn as those of August specimens.

5. Adult Winter Plumage acquired by a complete postnuptial moult few traces of which appear before the species migrates southward late in August. Whether birds renew the flight-feathers on the journey or after reaching winter quarters, material does not show for the wear of flight-feathers in aërial species is so trifling that their study proves little positively. Perhaps one moult and probably two takes place during the six or seven months this species is absent.

6. Adult Nuptial Plumage acquired, probably by a partial prenuptial moult. Mid-summer birds become paler and the feathers a good deal frayed.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the sexes are alike ; at the postjuvenal or possibly prenuptial moult, the crown patch and one emarginate primary are acquired, the latter character distinguishing the sexes in later plumages. Some females, however, have two emarginate primaries, but these are regularly less narrowed than those of males.

Tyrannus verticalis (Say.). Arkansas Kingbird

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Crown and nape ecru-drab obscurely vermiculated with paler edgings, back olive-buff, upper tail coverts pale clove-brown. Wings pale clove-brown with whitish edgings faintly tinged with yellowish buff. Tail dull black, tipped with pale brown, the outer webs of outer pair of rectrices white. Below, primrose-yellow, ashy on throat and white on chin, lores dusky. Bill and feet dull, brownish black in dried specimens. The first primary is not attenuated nor is the crown patch present.

3. First Winter Plumage acquired by a postjuvenal moult

which is possibly complete, young and old becoming indistinguishable.

The head and throat are plumbeous, there is an orange crown-patch, the back is olive-green, the chin white, and elsewhere below canary-yellow prevails. The lores are duller than in juvenal dress. The first and third primaries are attenuated suddenly at their tips, the second less so.

4. FIRST NUPTIAL PLUMAGE acquired apparently by a partial prenuptial moult which involves some of the body plumage but not the wings nor tail. Western March and April specimens show a few "pin feathers." The new, greener ones on the back are mixed with the worn greyer ones of the winter dress which is partly retained. The mid-tertiary is sometimes renewed.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult occurring in September in southern California. The plumbeous of the head and yellow of lower parts are rather richer in adults.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird.

Female.—The moults and plumages correspond to those of the male, the colors being a little duller and the crown patch smaller. There is usually only a trace of attenuation in the first primary and none in the others. In juvenal plumage the sexes are indistinguishable.

Myiarchus crinitus (Linn.). CRESTED FLYCATCHER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including sides of head and neck, dark olive brown, upper tail coverts cinnamon-rufous. Wings and tail clove-brown, edgings of the median and greater coverts, and inner webs of rectrices rich cinnamon-rufous, of the tertiaries very pale buff. Below, primrose-yellow, throat and breast ashy-gray, palest centrally on chin. Bill black. Feet sepia brown, black when older.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult beginning by the middle of August, which involves the body plumage, wing-coverts and tertiaries (apparently), but not the rest of the wings nor the tail, young birds becoming practically indistinguishable from adults.

Above, dull brownish olive-green, greener than in previous plumage, the feathers darker centrally, producing a streaked effect chiefly on the pileum; upper tail coverts dark cinnamon-rufous; wing covert edgings, including two wing-bands, grayish or yellowish-buff. Below, bright lemon-yellow, brighter than in previous dress, throat lores and auriculars ashy-gray.

4. First Nuptial Plumage acquired by wear, which is quite obvious, the edgings of the wing coverts and tertiaries fading to a dingy white and the whole plumage becoming paler.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning early in August and completed before the birds move south in September. Practically indistinguishable from first winter, the colors often richer.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—Moults and plumages correspond to those of the male, the colors often duller.

Sayornis phœbe (Lath.). Phœbe

1. Natal Down. Mouse-gray

2. Juvenal Plumage acquired by a complete postnatal moult

Above, including sides of head and neck, wings and tail, olive-brown, distinctly clove-brown on pileum and nape. Below, yellow-tinged white, breast, throat and sides of chin, brownish olive-gray. Greater and median coverts (*i. e.*, wing bands) and rectrices tipped with cinnamon-rufous, secondaries and tertiaries, edged with brownish or yellowish white Bill and feet raw umber-brown, black when older.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning about mid-August which involves the body plumage, wing coverts and tertiaries, but not the rest of the wings nor the tail. Birds in juvenal dress occur as late as the end of September. After moulting they are yellower below with pale grayish wing bands and practically indistinguishable from adults.

Above, olive-brown, greener than in previous plumage, pileum nearly black, the olive of the upper parts encroaching on sides of chin, throat and flanks. Below, primrose-yellow, a grayish pectoral band very faintly indicated. The wing coverts are narrowly edged with yellowish white.

4. First Nuptial Plumage acquired by wear, the brown of the upper parts and the yellow below becoming paler. During

the breeding season the plumage becomes excessively worn and ragged, pale brown prevailing above, and below a dirty mottled white produced by exposure of the grayish bases of abraided feathers.

5. Adult Winter Plumage acquired by a complete postnuptial moult, beginning after August 15th. Adults are perhaps a trifle darker than young birds, especially the remiges.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—The sexes are alike and the moults correspond to those of the male. I have examined birds taken every month in the year, both males and females.

Contopus borealis (Swains.). Olive-sided Flycatcher

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, together with sides of head the throat and flanks deep olive-brown, pileum, wings and tail deep clove-brown ; sides of rump, white ; wing coverts edged with ochraceous-buff, tertiaries tipped with brownish white, sides of rump and flanks white. Below, primrose-yellow, narrowed to a median line on the breast by olive-brown streaking on throat and sides. Bill black, the under mandible buff centrally. Feet bistre, black when older.

3. First Winter Plumage acquired by a late postjuvenal moult beginning in September which possibly is complete. I have seen no extra-limital specimens but I should expect to find them retaining the brown wing edgings. Pale wing bands are probably acquired at this moult when young birds become practically indistinguishable from adults.

4. First Nuptial Plumage acquired apparently by wear. Birds return from the south in fresh little worn plumage, the young birds with a dull clay-colored lower mandible. Old worn feathers may be found mixed with the new in some specimens, very strongly suggestive of a recent limited prenuptial moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult seldom begun until the birds have migrated southward in September. A specimen from Pinal County, Arizona,

September 28 (Amer. Mus. Nat. Hist., No. 29020), is still in much worn nuptial dress ; also a bird without date from Guatemala (No. 42767).

6. Adult Nuptial Plumage acquired by wear or possibly by partial renewal of the body plumage.

Female.—The sexes are alike in plumages and moults.

Contopus virens (Linn.). Wood Pewee

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult

Above, including sides of head olive-brown, much darker on the pileum, the feathers of the crown and rump faintly edged with pale russet and those of the nape with ashy gray, producing a distinct collar. Wings and tail clove brown, wing coverts edged with ochraceous buff, at tips of median and greater coverts producing two wing bands. Below, pale primrose-yellow, sides of throat, flanks and an indistinct olive-gray pectoral band. Bill black, under mandible wood-brown dusky at tip and edges, paler in spring. Feet sepia, nearly black when older.

3. First Winter Plumage acquired probably by a partial postjuvenal moult beginning early in September. Resembles closely the previous dress, but grayish instead of brownish tinged above, the edgings and collar lost and the new wing-bands grayish. The juvenal plumage persists in specimens taken near New York city, September 30, in North Carolina October 5 and 17, and Guatemala is reached with brown wing bands as proved by an undated specimen (Am. Mus. Nat. Hist., No. 42273).

4. First Nuptial Plumage acquired by wear which is never marked in this species.

5. Adult Winter Plumage acquired by a complete postnuptial moult chiefly or wholly after the birds have migrated southward. A very few new body feathers begin to appear towards the end of August, and a worn adult from Guatemala, undated (Am. Mus. Nat. Hist., No. 42771), shows that migration may precede moult in this species.

6. Adult Nuptial Plumage acquired by wear which is insignificant even up to the end of the breeding season.

Female.—The sexes are alike in plumages and moults.

Empidonax flaviventris (Baird). Yellow-bellied Flycatcher

1. Natal Down. Brownish olive-green.

2. Juvenal Plumage acquired by a complete postnatal moult.

Upper parts, sides of head and throat, an obscure pectoral band, and lesser wing coverts olive-green, the crown feathers centrally darker. Wings and tail deep olive-brown; median and greater wing coverts edged with rich buff yellow forming two distinct wing bands, secondaries narrowly and tertiaries broadly edged with yellowish white. Below, sulphur-yellow, including the orbital ring. Bill black, the under mandible flesh. Feet dusky flesh-color.

3. First Winter Plumage acquired by a postjuvenal moult possibly complete after the birds migrate southward. Mid-August specimens begin to show moult, the upper parts becoming greener and the lower yellower, but others as late as September 24 and a few without dates of capture from Guatemala and Mexico still bear the juvenal dress with the brownish wing bands.

4. First Nuptial Plumage acquired by wear. Young birds are practically indistinguishable from adults, the wing bands of all early arrivals from the south being whitish, yellow tinged, and the individual feathers little worn indicating a late postjuvenal moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult occurring probably late in the year after the birds have reached southern latitudes. A specimen from Tehuantepec, Mexico, January 1st (Am. Mus. Nat. Hist., No. 42940), shows actual moult in progress of the body plumage and wing coverts, the wings and tail being old and worn. This may, however, be a young bird. Another bird from Panama (No. 42946), without date, shows moult of the body plumage. The wing bands are new and faintly yellow in both, but they prove little except a midwinter moult.

6. Adult Nuptial Plumage acquired probably by wear alone after a late autumnal or midwinter acquisition of new plumage.

Female.—The sexes do not differ in plumage nor in moult.

Empidonax virescens (Vieill.). Green-crested Flycatcher

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and neck olive-green, the crown feathers darker centrally, the pileum not darker than the back. Wings and tail deep olive-brown, median and greater wing coverts edged with rich buff forming two wing bands, edgings of secondaries and tertiaries paler buff. Below, pale greenish sulphur-yellow, the chin white, a faint olive-gray pectoral band. Bill black, the lower mandible pinkish buff. Feet sepia, nearly black when older.

3. First Winter Plumage acquired apparently by an incomplete postjuvenal moult. Young and old pass south before moulting as indicated by birds taken near New York up to September 19. I have seen no specimens from southern latitudes.

4. First Nuptial Plumage acquired by wear. Light wing bands and greener plumage are acquired during the winter absence.

5. Adult Winter Plumage acquired by a complete postnuptial moult probably after the birds have reached winter quarters.

6. Adult Nuptial Plumage acquired probably by wear. which at all seasons seems to be insignificant.

Female.—The sexes are alike in plumages and moults.

Empidonax traillii alnorum (Brewst.). Alder Flycatcher

1. Natal Down. Pale olive-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and lesser coverts olive-brown, pileum darker and in contrast (usually) with the back, the crown feathers darker still centrally. Wings and tail deep olive-brown, median and greater wing coverts edged with rich buff forming two distinct wing bands; secondaries and tertiaries edged with pale buff. Below, dull white, usually tinged with pale sulphur-yellow on crissum and sides of abdomen; an olive-gray wash on sides of breast and flanks and across jugulum where it forms an indistinct pectoral band slightly tinged with buff. Buffy orbital ring. Bill black, the lower mandible pinkish buff. Feet sepia, nearly black when older. Some specimens are wholly ashy everywhere below without yellow tinge. Differs from *E. flaviventris* and *E. virescens* in being browner above, the head dark in contrast.

3. First Winter Plumage acquired by an incomplete postjuvenal moult. Birds became yellower below and greener above, but many, as shown by specimens taken near New York up to September 26, pass south in juvenal plumage. I have seen a few extra-limital specimens, without dates, from Central America.

4. First Nuptial Plumage acquired probably by wear, which tends to make the plumage paler and brings the dark centers of the crown-feathers into prominence during the breeding season. The wing bands are buff-tinged as compared with those of *E. minimus* in corresponding plumage.

5. Adult Winter Plumage acquired by a complete postnuptial moult after the birds have passed south as proved by Central American specimens.

6. Adult Nuptial Plumage acquired apparently by wear.

Female.—The sexes are alike and the moults identical.

Empidonax minimus (Baird). Least Flycatcher

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnuptial moult.

Above, including sides of head, olive-brown, greener on the back, a faint ashy gray collar. Wings and tail deep olive-brown, median and greater coverts edged with pale buff forming two wing bands, secondaries and tertiaries with dull white. Below, grayish white, a smoky gray pectoral band; pale primrose-yellow on abdomen and crissum. Orbital ring dull white. Bill black, under mandible pinkish buff. Feet sepia, nearly black when older.

The species in this plumage is not so green above as *E. virescens*, but browner and very like *E. t. alnorum* from which it may be differentiated by its grayer lower parts, somewhat paler wing bands and smaller bill.

3. First Winter Plumage acquired by a postjuvenal moult, possibly complete, after the birds have migrated southward. Some specimens become greener above and yellower below before they leave for the south late in August, but others reach southern latitudes in juvenal dress. A bird from Tehuantepec, Mexico (Am. Mus. Nat. Hist., No. 42957), on January 9, still retains the brown wing bands.

4. First Nuptial Plumage acquired probably by wear. Pale grayish wing bands are acquired, during the winter absence differences between young and old birds being lost. Old brownish wing coverts retained among the new are sometimes found, and the greener, fresher appearance of some of the feathers of the back suggests a possible partial renewal in spring. This species shows more wear than *E. flaviventris*.

5. Adult Winter Plumage acquired by a complete postnuptial moult after the birds have passed south. Two specimens (Am. Mus. Nat. Hist., Nos. 42957 and 42959) from Tehuantepec, Mexico, January 9 and 4 respectively, appear to be still in worn adult nuptial dress as compared with two (Nos. 66879 and 66877), March 7 and 26, from Yucatan in fresh plumage. It is perplexing however to find two birds (No. 66881, March 2, and 66878, March 12) from Yucatan in worn plumage with whitish wing bands. It is possible they are all young birds that originally had the wing bands very pale and they have faded to nearly white before the postjuvenal moult has begun. The difficulties of reaching definite conclusions are well exemplified by this species.

6. Adult Nuptial Plumage acquired by wear, which is inconspicuous.

Female.—The sexes are alike in plumages and moults.

ALAUDIDÆ

It is pleasant to turn from the puzzling Flycatchers to the Larks represented by the Horned Lark, a widely distributed species in North America and divided into numerous races. All these appear to moult the same, adults undergoing one annual moult and young birds assuming a plumage practically identical with that of adults by a complete postjuvenal moult. Wear takes the place of a prenuptial moult and produces marked effects. The veiled black of breast and head in the fall is brought into prominence in the spring by extensive loss of the buff feather edgings, while during the breeding season birds become extremely ragged and worn.

Alauda arvensis Linn. Skylark

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult. No specimen seen; said to be tawny and spotted.

3. First Winter Plumage acquired probably by a partial (possibly complete) postjuvenal moult.

Above, yellowish brown with darker streakings, the wings and tail with buff edgings. Below, dull white with tawny suffusion, streaked rather narrowly, with brownish black.

4. First Nuptial Plumage evidently acquired by wear, the colors becoming paler.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Adults are less tawny and the edgings less pronounced than in young birds.

6. Adult Nuptial Plumage acquired by wear.

It is somewhat presumptuous for me to attempt, from the mere handful of specimens I have examined, an explanation of the moults of this well-known European songster which has been introduced and become established near New York city, but I believe the material warrants the above conclusions.

Otocoris alpestris (Linn.). Horned Lark

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult and worn for a long time.

Above, including sides of head and lesser wing coverts, clove-brown, mixed with sepia, dotted with buffy white. Wings deep sepia, quills and coverts edged with dull vinaceous cinnamon. Tail dull black, the middle pair of rectrices mottled and paler, edged with vinaceous-cinnamon, the outer ones with buffy white. Below, white, yellow-tinged, the chin flecked with clove brown, a pectoral band wood-brown, streaked and spotted like the chin. Bill pinkish buff, darker at the tip, deep plumbeous when older. Feet raw umber-brown, black when older.

3. First Winter Plumage acquired by a complete postjuvenal moult occurring in August in Newfoundland.

Unlike the previous plumage, unstreaked below, unspotted above. Above, vinaceous buff, brightest on nape, vinaceous cinnamon on rump flanks and wing coverts streaked on head and back with sepia. Forehead, lateral "horns," lores, auriculars and triangular breast patch black, veiled by overlapping pale buff or pinkish feather tips. Wings deep sepia, primaries much darker, edged with whitish, the rest of the wing feathers edged with vinaceous cinnamon. Tail brownish black, the outer rectrices edged with white, the middle pair paler, broadly edged with pinkish Isabella-color. Below, dull white, the chin, sides of head and forehead strongly suffused with lemon or canary-yellow, a buffy band across breast below the black patch, flecked with dusky spots.

4. First Nuptial Plumage acquired by wear, which brings the black areas into prominence. A number of spring specimens show a few growing feathers about the sides of the head and chin, but it is doubtful whether this slight renewal betokens a prenuptial moult. As the birds leave for their northern breeding grounds early in the spring the matter is worthy of further investigation.

5. Adult Winter Plumage acquired by a complete postnuptial moult probably in August on the northern breeding grounds. Hardly distinguishable from first winter dress in many cases. The pectoral buffy band is less conspicuous and less spotted, and adults are perhaps pinker above.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In juvenal plumage females are indistinguishable from the males. In other plumages they lack the black forehead, of the male, being streaked instead, the breast patch is limited, the back is more streaked and the colors are duller. The moults are identical.

Otocoris alpestris praticola Hensh. Prairie Horned Lark

All plumages correspond to those of *O. alpestris,* darker colors and lack of yellow being the chief differences aside from relative size. The juvenal plumage is very dark brown above, spotted with brownish white, and white below, heavily spotted on the breast with dull black. In first winter and later plumages the white superciliary lines, perhaps faintly tinged with yellow, are a good diagnostic character.

Otocoris alpestris leucolæma (Coues). Pallid Horned Lark

The adult plumages correspond to those of *O. alpestris*, paler colors and larger size being the principal differences. The juvenal plumage is nearly black above, spotted with pale buff and similar below to *O. a. praticola*.

Pica pica hudsonica (Sab.). American Magpie

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult. Above, and on throat, breast and crissum, dull black; abdomen and feathers of humeral tracts white, the latter with buff or dusky tinge. Wings, including coverts, iridescent greens and blues, the latter chiefly on the secondaries and tertiaries, the primaries white except on outer edge. Tail iridescent or metallic purples, greens and blues.

A bird of June 22d, from eastern Washington, is in full juvenal dress, the tail one-half grown.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage but not the wings nor the tail. Young and old become practically indistinguishable. A metallic purplish, greenish and bluish dress is assumed, the white of the humeral tracts is more conspicuous and the rump becomes grayish white. The feathers of the throat are white basally.

A Western specimen of August 18th is beginning the postjuvenal moult and one of September 18th is in full first winter plumage except an area of pulpy feathers on the mid-throat.

4. First Nuptial Plumage acquired by wear which is very inconspicuous as is commonly the case in species with iridescent plumage.

5. Adult Winter Plumage acquired by a complete postnuptial moult and practically indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male.

CORVIDÆ

The Crows and Jays have but one moult annually, young birds assuming adult plumage except for the flight-feathers at the postjuvenal moult.

Cyanocitta cristata (Linn.). Blue Jay

1. Natal Down. Pale mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Pileum, flax-flower blue separated from the blue-tinged white forehead and white superciliary line by a narrow black line. Nuchal collar continued across the throat as a U-shaped band, lores and postocular streak black. Back and lesser wing coverts mouse-gray, tinged with blue. Wings various shades of azure and China-blue, brightest on secondaries and tertiaries which are broadly tipped with white and narrowly barred with black. The greater coverts are obscurely barred and are terminally white, forming a single wing band. Tail centrally, China-blue, barred with black, the outer rectrices largely white. Throat white. Breast and abdomen laterally smoke-gray, centrally and on crissum, yellowish white. Bill brownish black. Feet raw umber-brown becoming black with age.

3. First Winter Plumage acquired by a partial postjuvenal moult early in August which involves the body plumage, the wing coverts, and apparently the tertiaries, but not the rest of the wings nor the tail. Young birds become practically indistinguishable from adults.

Similar to the previous plumage but the blue of head, back and wing coverts now distinctly barred with black and much brighter, and the crest feathers longer.

4. First Nuptial Plumage acquired by wear which is marked by the end of the breeding season, the blues becoming grayish and the white edgings diminished.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the end of July. Not distinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—Plumages similar to those of the male, the colors duller, with less black and barring. Both sexes have identical moults.

Perisoreus canadensis (Linn.). Canada Jay

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Everywhere brownish slate-gray, darker on the crown, paler on the abdomen and crissum. The feathers are lighter basally and faintly tipped with brown producing an obscurely mottled effect. Lores, region of eye and forehead dull black. Malar region whitish with a dull white spot anteriorly. Wings dull clove-brown with plumbeous edgings on secondaries and inner primaries, all the remiges tipped with grayish white, the greater coverts with smoke-gray. Tail slate-gray tipped with brownish white. Bill plumbeous. Feet brownish black.

3. First Winter Plumage acquired by a partial postjuvenal moult in August which involves the body plumage but not the wings nor the tail. Several birds kindly loaned me by Mr. Wm. Brewster show different stages of the postjuvenal moult which is completed in Maine before the end of August.

Old and young become practically indistinguishable.

Unlike juvenal dress. The back is brownish slate, neck whitish, crown and nape brownish black with a large brown-tinged white area on the forehead. Below, drab-gray, white on chin, throat, lores, auriculars, sides of neck and crissum. Above, dull black; dusky beneath and behind the eye.

4. First Nuptial Plumage acquired by wear which is inconspicuous in the soft, loose-textured feathers.

5. Adult Winter Plumage acquired by a complete postnuptial moult.

6. Adult Nuptial Plumage acquired by wear.

Female.—In moults and plumages females are practically indistinguishable from males.

Corvus corax principalis Ridgw. Northern Raven

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Everywhere dull lustreless brownish black, except wings and tail which have greenish and purplish reflections. Bill and feet black except when very young.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts, but not the remiges and rectrices. The glossy dress with the peculiar

separated throat feathers is assumed and young and old become indistinguishable.

4. First Nuptial Plumage acquired by wear, the plumage becoming somewhat brown late in the season.

5. Adult Winter Plumage acquired by a complete postnuptial moult, beginning, as shown by Greenland specimens, early in July.

6. Adult Nuptial Plumage acquired by wear.

Female.—In plumages and moults the sexes are practically alike.

Corvus americanus Aud. American Crow

1. Natal Down. Grayish clove-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Body plumage dull brownish black, wings and tail glossy black with greenish and some purplish reflections. Bill and feet grayish black.

3. First Winter Plumage acquired by a partial postjuvenal moult in July which involves the body plumage and wing coverts but not the rest of the wings nor the tail. The plumage becomes lustrous greenish black everywhere, and young birds are practically indistinguishable from adults although averaging greener.

4. First Nuptial Plumage acquired by wear, the feathers becoming brownish and worn by the end of the breeding season.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning as early as the end of June, this bird being one of the earliest species to begin this moult. Practically indistinguishable from first winter dress, but purplish rather than greenish black.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike in plumages and moults.

Corvus ossifragus Wils. Fish Crow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Body plumage brownish black, wings and tail lustrous black with greenish reflections. Bill and feet grayish black becoming jet black.

3. First Winter Plumage acquired by a partial postjuvenal moult in July which involves the body plumage and wing coverts but not the rest of the wings nor the tail. The full greenish black glossy plumage, rather bluer than the last, is assumed, old and young becoming indistinguishable.

4. First Nuptial Plumage acquired by wear which is not very obvious even late in the season.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike in plumages and moults

STURNIDÆ

Sturnus vulgaris Linn. Starling

1. Natal Down. Drab-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Everywhere, including wings and tail, brownish mouse-gray, the wings with fawn-colored edgings. Bill and feet pinkish buff.

3. First Winter Plumage acquired during August in New York city by a complete postjuvenal moult.

Everywhere bottle or purplish green with metallic reflections, the feathers above with cinnamon terminal spots, smallest on the head, the feathers below with white spots. Wings and tail greenish black edged with cinnamon, the wing quills having a pale terminal spot bordered with black.

Young and old become practically indistinguishable, the cinnamon spots and edgings averaging deeper in young birds.

4. First Nuptial Plumage acquired by wear. A large part

of the spotting is entirely lost and the shape of the feathers changed thereby. Wear involves more of the feathers than the terminal spot, their tips becoming lanceolate.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress ; the edgings narrower but deeper in color.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The moults and plumages are similar to those of the male, females being somewhat duller and more heavily spotted.

ICTERIDÆ

The peculiarities of moult in this Family will be explained under each species, most of them being subject to a complete postjuvenal moult thereby assuming plumage practically adult, like *M. ater*, *S. magna*, *S. carolinus*, *Q. quiscula* and its races. A complete semiannual or double moult is peculiar to *D. oryzivorus*, while *I. spurius* and *I. galbula* undergo a limited first prenuptial moult in winter which is not repeated a second year.

Dolichonyx oryzivorus (Linn.). Bobolink

1. Natal Down. Buff. (**plate V, fig. 1**)

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull brownish black, median crown stripe, superciliary line, nuchal band and edgings of the other feathers of back and wings buff deepest on nape ; primaries, their coverts, secondaries and alulæ tipped with grayish white. Below, rich buff paler on chin and faintly flecked on sides of throat with clove-brown. A dusky postocular streak. Bill pinkish buff, clay-color with dusky tip when older. Feet clay-color becoming deep Vandyke-brown.

This plumage is worn but a short time and the postjuvenal moult is well advanced by the end of July as shown by four specimens in my collection.

3. First Winter Plumage acquired by a partial postjuvenal moult in July which involves the body plumage, tertiaries and wing coverts, but not the rest of the wings nor the tail.

Similar to the previous plumage, but darker above and yellower below, a rich ochre or maize-yellow prevailing, palest on chin and abdomen, the sides of the breast and flanks and under tail coverts conspicuously streaked with dull black veiled by the overlapping feather edges.

The relative size of the feathers of this plumage and their pattern is shown on **plate I,** where the feathers of a September male are figured. They have been reproduced much darker than their pale brown color would indicate. There is some variation in the distribution of the black pattern of lateral feathers of the ventral tract in young birds and this may be seen on **plate I, figs. 1–6, 19–22.**

4. First Nuptial Plumage acquired by a complete prenuptial moult.

Plumage almost wholly black, the body plumage veiled by long maize-yellow feather tips. The nape is rich ochre and the scapularies white, the inner plumbeous, both edged with olive-gray. The outer primary is edged with white, the two adjacent with maize-yellow, the tertiaries, greater coverts and interscapularies with wood-brown. Rump plumbeous, upper tail coverts white, both areas veiled with olive-gray or olive-buff. Tail tipped with olive-gray. Bill black.

The terminal inch of the webs of the outer primaries is paler as if the black color had not extended so far, but the borders are, in May, less abraided than are many of these feathers when the birds pass southward in September. It would be safe to assume a prenuptial moult of the Bobolink from this fact alone and a bird taken March 1, 1886 (Amer. Mus. Nat. Hist., No. 32783), near Corumbá, Brazil, on the Bolivian boundary, proves it, although this specimen is doubtless an adult. I have also seen several caged birds which have undergone a complete moult in the early summer. Spring birds reach New York about two months after this moult and the fugaceous yellowish feather tips have so worn away (see **plate I, figs. 23–25, 28, 29**) that the specimens are chiefly black, white and buff, except on the abdomen, flanks and under tail coverts where the tips persist longest.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the end of July. Similar to first winter plumage, usually whiter below especially on the chin and middle of the abdomen, and above with richer brown edgings especially of the tertiaries. The bill becomes clay colored or purplish. The

chief differential character is however the presence of a few black feathers, usually yellow tipped, irregularly scattered on the chin and breast. A specimen from Jamaica, West Indies, September 25th (Amer. Mus. Nat. Hist. No. 42134), is an extreme example with numerous black and mottled feathers, the black distributed irregularly, varying from shaft streaks to asymmetrical blotches. As these feathers all show wear similar to those adjacent, there can be no doubt that all of them grow at the postnuptial moult. I have seen a few autumnal adults, but they are excessively rare in collections and their rarity is largely responsible for the ignorance that has prevailed regarding the normal plumages of the Bobolink which conform to the ordinary laws of moult and are in no respect unique.

6. Adult Nuptial Plumage acquired by a complete prenuptial moult in midwinter. Differs inappreciably from first nuptial dress, but it is probable that (as in other species) the yellow edgings diminish with age. The classic Corumbá bird mentioned above and discussed at p. 122 of the present article, was first described by Chapman '90 and later figured in (Auk, X, 1893, pp. 309–311, pl. vii.). It is completing a perfectly normal prenuptial moult, and seems to be an adult, because a few old black feathers of the adult winter plumage are present and the whiteness of the abdomen indicates the fading of feathers that are nearly white over this area in adults in the autumn. At all events the worn and faded feathers that remain on this specimen are exactly where the last traces of moult are found in a normal moult not only of this species but of all Passerine species examined and there is not the slightest evidence of the supposed color change to black without moult that has been alleged.

Female.—The plumages and probably the moults correspond to those of the male. In juvenal and first winter plumage the sexes are indistinguishable. The first nuptial is no doubt acquired partially at least by a prenuptial moult, judging by wear and by a caged female examined when moulting the remiges, the buff being paler than in first winter dress. The adult winter plumage is practically indistinguishable from the first winter. The adult nuptial is similar to the first nuptial. A bird seen by

Stone ('96, p. 134), has assumed some black feathers on the lower parts doubtless at the prenuptial moult and is probably an unusually vigorous bird approaching the plumage of the male as sometimes occurs in other species.

Molothrus ater (Bodd.). Cowbird

1. Natal Down. Olive-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and neck, wings and tail, dark olive-brown, the feathers edged with pale buff, whitish on the primaries. Below, dull white, buffy on throat, breast and flanks much streaked with olive-brown. Chin white or yellowish. Bill and feet raw umber-brown, darkening to black after postjuvenal moult.

3. First Winter Plumage acquired by a complete postjuvenal moult which begins about September first. Unlike the previous plumage, chiefly black instead of brown, young birds becoming practically indistinguishable from adults.

Above and below, lustrous black with iridescent green and purple reflections. Head, nape and throat purplish clove-brown. Some birds show faint buffy edgings.

4. First Nuptial Plumage acquired by wear, which shows very little, and chiefly in the paler brown of the head. I have seen one specimen which retains a large part of the juvenal plumage even to the wing quills and the brown feathers are excessively worn as compared with the black ones, acquired at the postjuvenal moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult in September. Adults are not distinguishable, as a rule, from young birds in first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In natal down and juvenal plumage indistinguishable from the male. Females assume a mouse-gray first winter plumage by a complete postjuvenal moult and this, modified by wear, is the first nuptial plumage. All later plumages are similarly mouse-gray with indistinct dusky streaks.

Agelaius phœniceus (Linn.). Red-winged Blackbird

1. Natal Down. Pale mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, wings, tail, and lesser coverts (*i. e.*, the so-called "shoulders") dull brownish black (no red at this stage), the feathers edged with buff, palest and narrowest on primaries, rectrices, head and rump, and richest on scapularies and secondaries. Below pinkish buff, ochraceous on the chin, thickly streaked (except on the chin) with brownish black. Obscure superciliary line ochraceous-buff. Bill and feet olive-brown, black when older.

3. First Winter Plumage acquired by a complete post-juvenal moult beginning towards the end of August. Resembles previous dress, the general effect being that of a brown streaked bird the black being heavily veiled by brown feather tips and mottled orange "shoulders" are acquired.

Entire plumage, including wings and tail, greenish black much veiled with buffy and ferruginous edgings, palest below and faint or absent on primaries and rectrices. Lesser wing coverts ("shoulders") dull orpiment-orange each feather with subterminal bars or spots of black. Median coverts rich ochraceous buff usually mottled with black subterminal areas chiefly on the inner webs, the shafts usually black.

4. First Nuptial Plumage acquired by wear which is considerable birds becoming a dull brownish black by loss of the feather edgings and by fading. The mottled "shoulder patches" are characteristic of young birds, the amount of orange varying greatly. The wings and tail show marked wear.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning in mid-August, young and old becoming practically indistinguishable.

Lustrous greenish black, feathers of head and back, greater wing coverts and tertiaries edged more or less (according to the individual) with buff and ferruginous brown. Below, the edgings are paler or absent. The bright scarlet-vermilion "shoulders" are acquired together with the rich ochraceous buff median coverts.

6. Adult Nuptial Plumage acquired by wear which produces less marked effects than in the young birds. The exposed edges of the buff median coverts fade to a dull white. The more resistant nature of adult feathers is strikingly shown by

this species, the worn and faded remiges and rectrices of young birds contrasting sharply with those of adults.

Female.—In natal down and juvenal plumage females differ little from males, the juvenal dress perhaps averaging browner above with less buff below and the chin narrowly streaked. The first winter plumage is acquired by a complete postjuvenal moult as in the male, from which the female now differs widely being brown and broadly streaked. The first winter plumage is hardly distinguishable from the adult winter and passes into the first nuptial by wear which produces a black and white streaked bird, brown above. A pinkish or salmon tinge is often found in females in any of these plumages especially about the chin and head and an orange or crimson tinge may show on the "shoulders" of the older birds.

Sturnella magna (Linn.). Meadow Lark

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, clove-brown, the feathers broadly edged with buff palest on the nape, those of the back having double subapical spots of russet. Median crown stripe, and superciliary line cream-buff. Wings sepia-brown, the primaries and secondaries obscurely barred on the outer web with darker brown and edged with pale vinaceous cinnamon shading to white on the first primary, the tertiaries clove-brown broadly edged with buff and having a row of partly confluent vinaceous cinnamon spots on either side of their shafts producing a barred effect (the pattern of a tertiary of this plumage contrasted with one of the first winter dress is shown on **plate II, figs. 15 and 16**), the rest of the wing coverts obscurely mottled with light and dark browns and edged with buff, the alulæ with white. The three outer pairs of rectrices are white with a faint dusky subapical shaft-streak, the next pair largely white and the others hair-brown confluently barred with clove-brown and whitish edged. Below, including "edge of wing" pale canary-yellow, nearly white on the chin, the sides of throat, breast, flanks, crissum and tibiæ washed with pinkish buff, streaked and spotted with brownish black which forms a pectoral band. Bill and feet pinkish buff, the former becoming slaty, the latter dull clay color.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning about September first after the juvenal dress has been worn a long time, young birds and old becoming practically indistinguishable.

Above, similar to the previous plumage, but all the browns even to the wing and tail quills much darker, often black, and distinct barring rather than mottling, the rule. The feathers of the back have large single subapical spots of rich Mar's-brown crossed by two faint dusky bars, and the primary edgings are usually grayer. Below, a rich lemon-yellow (including the chin and a supraorbital dash) veiled with buff edgings and a black pectoral crescent is acquired completely veiled with deep buff and ashy edgings. The streakings below are heavier and darker, many of the feathers with subapical russet spots and the buffy wash on the sides is deeper and pinker.

4. First Nuptial Plumage acquired by wear which is excessive by the end of the breeding season producing a dingy brown and white appearance above with yellow and black below. The subapical spots of the feathers of the back are almost entirely lost by abrasion and the same force scallops out the light portions of the tertiaries, wing coverts and tail. This is shown on **plate II, figs. 16 and 17.** Neither the yellow nor the black below fades very appreciably, but the shining denuded shafts of the feathers project far beyond the abraided barbs. The yellow seems even to be intensified by the loss of paler barbules.

5. Adult Winter Plumage acquired by a complete postnuptial moult in September. Usually indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In natal down and juvenal plumage the sexes are indistinguishable. Later the female differs only in slightly duller colors and a more restricted black area on the throat. The moults are exactly the same as in the male.

Icterus spurius (Linn.). Orchard Oriole

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and neck, pale grayish olive-green, buffy on rump. Below, pale sulphur-yellow. Wings pale clove-brown, the primaries and secondaries narrowly edged with dull white, the median and greater wing coverts with pale buff forming two indistinct wing bands. Tail yellowish olive-green. Bill pinkish buff, becoming deep wood-brown, the upper mandible slaty. Feet olive-gray, blackish when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the end of July, which involves the body plumage and wing coverts, but not usually the rest of the wings nor the tail.

Differs little from the previous plumage, a brighter olive-green above and canary-yellow below, the edgings of the wing coverts paler.

An unfortunate dearth of specimens in this greenish plumage makes it impossible for me to say whether any precocious individuals, perhaps of the first brood, acquire tails mottled with black or assume black or chestnut feathers about the wings or body. It is almost certain, judging by analogy of moult and by plumage that some do, as is the case apparently in other species. Observations made on caged birds by Dr. Bachman ('**39**) also point to this probability, for he states that a young bird of a first brood assumed the black throat by moult in November, and the full black and chestnut plumage the following August, while a bird of a second brood assumed a new green plumage in January, the black throat the following August and the chestnut and black plumage in January, wholly by moult. This evidence, although the unreliable testimony of caged birds, is at least in confirmation of the sequence of the plumages and indicates that a year is sufficient for the acquisition of the adult dress.

The only bird I have seen showing prenuptial moult is one taken in Nicaragua, February 23d (U. S. Nat. Mus., No. 91034), which has new black feathers coming in on the throat and sides of the head and green ones on the forehead and crown, as already referred to by Stone ('**96**, p. 137). There are a few old black feathers on the throat, but it seems likely that these, the worn mottled tail and a few chestnut feathers on the throat and under tail coverts may represent individual precocity in a previously acquired first winter plumage, for the brown juvenal primary coverts indicate a young bird. I have seen several autumnal birds in first winter dress with a few black feathers on the throat, although they had plain greenish tails. Without a better series of birds in first winter dress than is now available the relation of moults and plumages cannot be fully solved, but that moult will explain everything, I have not the slightest doubt. In birds that suffer so great wear, it is well nigh impossible to estimate the age of a feather from the amount of abrasion, especially when the color is black.

4. First Nuptial Plumage acquired by a partial prenuptial moult which apparently involves chiefly the throat and head and perhaps the tail. The black throat is present in most spring specimens, in some it is lacking or represented by a few black feathers. Greenish tails are regularly found with such birds; those with chestnut feathers have tails mottled with black, these signs of individual vigor or precocity going together and considerable individual variation being apparent. The bill becomes slate-gray. All of the plumage is so worn when the birds arrive from the south that it is impossible to estimate how long the individual feathers have been subjected to wear, which seems to be considerable. The primary coverts, a key to young birds, are always brownish unless they have been partly renewed by black, probably at the postjuvenal moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult apparently after the birds have migrated south judging by the freshness of extra-limital specimens and the total absence of local specimens. Contrary to general belief it is likely that the chestnut and black plumage is assumed at this moult. Several specimens from Guatemala without other data show the end of a postnuptial moult from the greenish into the chestnut dress, some of the new feathers still with sheaths and the old worn greenish nuptial ones still in place among the auriculars and elsewhere. Both the black and the chestnut feathers are broadly edged with greenish buff or brown, which probably diminishes in amount with age giving a less veiled appearance, in older adults.

6. Adult Nuptial Plumage acquired by wear through which the edgings are largely lost. There is no prenuptial moult as in the young bird. The frequency of a few greenish feathers on breeding birds indicates their liability to be left over even at the first postnuptial moult which is usually so complete although it

is possible such feathers developed of a greenish color at this season. There is not the slightest reason for believing in an abnormal color change without moult in this species even if I am wrong in concluding the greenish plumage is worn but one summer. It may possibly be that no chestnut or black is assumed by any birds until the first postnuptial moult and the second winter plumage is still partly greenish with the mottled tails that give rise to the unwarrantable idea of color redistributing itself in old feathers, but until greenish autumnal adults (as determined by cranial characters) having black throats, mottled tails, and chestnut scattered on the abdomen are forthcoming, there is no good reason for supposing that more than a twelve-month, as in other species, is required to attain adult dress.

Female.—The natal down and juvenal plumage are identical with those of the male. Later the female undergoes the same moults as the male, the one prenuptial which occurs being very limited or even suppressed. Females always remain in a greenish dress like the male first winter plumage or at most assume, when fully adult, a few black feathers on the throat.

Icterus galbula (Linn.). Baltimore Oriole

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, olive-brown, slightly orange tinged, brightest on head and upper tail coverts. Wings clove-brown, the primaries narrowly, the tertiaries broadly edged with dull white, two wing bands at tips of greater and median coverts pale buff. A tertiary is figured on **plate II, fig. 8.** Tail chiefly gallstone-yellow, centrally much darker and brownish. Below, including "edge of wing" ochre-yellow, sometimes orange with ochraceous tinge, palest on chin and middle of abdomen, brightest on breast and crissum. Bill pinkish buff, becoming slate-gray with age. Feet olive-gray, black when older.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in July which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Similar to previous plumage but dull orange brown above and much brighter orange below, although lacking the black areas of the adult. The greater and median wing coverts become dull black, white tipped, the latter and the lesser coverts orange tinged. There is much individual variation in the intensity of the orange everywhere.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the plumage except only the primaries, their coverts, and the secondaries. The tide of moult often passes by wing coverts, alulæ, tertiaries or in fact any feathers which often remain here and there worn and in sharp contrast to new feathers adjacent, and the outer wing coverts are frequently left over and sometimes a rectrix or two. The full orange and black body plumage is assumed at this moult, the tertiaries and wing coverts being broadly edged with white, and the black and yellow tail is acquired. The orange is usually paler than in adults and the black feathers of the back are generally edged with orange. There is a Panama bird (Am. Mus. Nat. Hist., No. 41939) showing the prenuptial moult in progress on the back, forehead, occiput, sides of head and breast, throat and chin, upper and under tail coverts, the two central rectrices and the greater wing coverts ; and a Guatemala specimen (Bost. Soc. Nat. Hist.) also without date shows moult on the head. Birds in this dress may be distinguished from adults by the worn brownish primaries in contrast to the new black, white edged tertiaries. **Plate II, figs. 9 and 10** shows the difference between a first nuptial tertiary which is new grown and an adult nuptial tertiary which is really a worn adult winter feather. Similar differences in the rectrix next to the middle pair are shown by **figs. 11 and 12**, a large amount of black belonging to the adult feather. I have seen one young bird in this plumage with the orange mostly replaced by blood-red which invades even the wing coverts and the black nape.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July, the birds usually disappearing soon after. Two males in my collection (J. Dwight, Jr., No. 6883, August 26th, and No. 6885, September 13th, Long Island, New York), are in fresh winter dress without trace of their recent moult. Different from first winter dress, jet black wing quills and central rectrices being assumed with rich orange and black body plumage. The feathers of the back are narrowly edged with dull

orange (absent in older birds) which also suffuses the median and lesser coverts. The greater coverts, secondaries and tertiaries are broadly edged with white. The variable black area of the throat seems to increase in older birds.

6. Adult Nuptial Plumage acquired by wear through which the white wing edgings are largely lost (see **plate II, fig. 10**). Yellow barbules are lost from the orange barbs so that the color is perhaps intensified in some cases.

Female.—The natal down and juvenal plumage are the same as in the male and subsequent moults are the same but limited in extent at the first prenuptial so that little or no black is assumed on the chin, back and tail. The black on the chin of females is always very restricted in extent.

Scolecophagus carolinus (Müll.). Rusty Blackbird

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Whole plumage slate-color washed on back and throat with sepia-brown. Tail darker with greenish reflections. Tertiaries and wing coverts edged with Mar's-brown. Bill and feet seal-brown, black when older.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning in eastern Canada, the end of July, young and old becoming practically indistinguishable.

Everywhere lustrous greenish black more or less veiled above with Mar's-brown, below with wood-brown. The wings and tail are without edgings.

4. First Nuptial Plumage acquired by wear through which the veiling is almost or completely lost, birds becoming entirely greenish or purplish black.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the middle of July. Not appreciably different from first winter plumage, the veiling probably less the older a bird grows.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The natal down and juvenal plumage are the same as in the male. By a complete postjuvenal moult the first winter plumage is assumed which is very like the juvenal but with much Mar's-brown above chiefly on the head and strongly washed below with wood-brown, these colors edging slaty feathers; the lores and auriculars are dull black in contrast. The first nuptial plumage is acquired by wear and later plumages vary little from the first winter.

Quiscalus quiscula (Linn.). Purple Grackle

1. Natal Down. Pale sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Whole plumage dull clove-brown, the body feathers often very faintly edged with paler brown. Tail darker with purplish tints. Bill and feet sepia-brown, black when older.

3. First Winter Plumage acquired by a complete postjuvenal moult early in August.

The iridescent black dress is acquired, old and young becoming indistinguishable.

Some birds assume metallic green heads and some blue, while the backs are of all colors and patterns so that age can have nothing to do with the varied colors of this species.

4. First Nuptial Plumage acquired by wear which produces no noticeable effect as is regularly the case with iridescent plumages.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the first of August. Indistinguishable from first winter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In juvenal dress the female is perhaps paler below than is the male and usually indistinctly streaked. There is a complete postjuvenal moult and later plumages differ from the male only in being much duller and browner with few metallic reflections. They also show more wear.

Quiscalus quiscula æneus (Ridgw.). Bronzed Grackle

Plumages and moults correspond to those of *Q. quiscula*, the two forms in natal down and juvenal plumage being practically indistinguishable. The bronzed back is assumed at the postjuvenal moult, old and young becoming indistinguishable.

FRINGILLIDÆ

The types of moult in this large Family are almost as numerous as the species. Many moult twice every year, the prenuptial being complete in at least one species, *A. caudacutus*, and partial in many, producing a large variety of curiously mixed plumages. *P. domesticus, A. s. passerinus, A. henslowi* (probably), *A. maritimus, C. grammacus, M. fasciata, C. cardinalis* and probably some others undergo a complete postjuvenal moult more or less regularly. Several species pass their first breeding season in the immature dress assumed at the postjuvenal moult, exchanging it for the full adult dress at the first postnuptial moult. The peculiarities of moult and wear, which in some species produce most startling changes in their apparent color and in the shape of the feathers, will be discussed under the respective species. The apparent brightening of color in some of the Finches and the Crossbills is also explained under each species.

Coccothraustes vespertinus (Coop.). Evening Grosbeak

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, pale bistre, greenish tinged on back, wood-brown on rump and forehead. Wings black narrowly edged with white; the tertiaries pale drab, their inner borders dull black; two or three inner secondaries terminally dull white with dingy black apical blotches; inner greater coverts dull white on outer webs and edged with canary-yellow. Tail black. Below, pale cinnamon or wood-brown, merging into canary-yellow on throat and chin. Rictal and submalar streaks dusky. "Lining of wings" canary-yellow. Under tail coverts white. Bill and feet in dried specimen dull brown.

3. First Winter Plumage acquired by a partial postjuvenal moult in August in British Columbia which involves the body plumage but not the wings nor the tail. The wing coverts are renewed but not usually the tertiaries.

Bright olive-yellow washed with rich olive-brown, deepest about the head; crown and nape black, forehead, superciliary stripe, rump and under tail coverts lemon-yellow. Young may be distinguished usually by the dusky inner margins of the tertiaries but differ very little from adults.

4. First Nuptial Plumage acquired by wear which removes much of the wing edgings. Browner more worn remiges and especially primary coverts with distinct edgings distinguish young birds.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs little from first winter dress, but fewer edgings, and blacker primaries with their coverts and the tertiaries white.

6. Adult Nuptial Plumage acquired by wear.

Female.—The moults and plumages correspond to those of the male but the colors and markings are quite different. The sexes are similar in juvenal plumage. In first winter dress females are deep mouse-gray about the head, paler on the back and grayish wood-brown on the rump. The primaries have a white spot at their bases and the secondaries and tertiaries are wholly drab-gray with dull black on the inner webs. The tail has the inner webs of all the rectrices white and the upper tail coverts have white spots. The first nuptial plumage is assumed by wear and the adult winter dress by a complete moult, this plumage being rather grayer than that of the first winter.

Pinicola enucleator (Linn.). Pine Grosbeak

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult

Above, bistre, tinged on crown and rump with dull ochre-yellow. Wings and tail clove-brown with pale buff edgings sometimes whitish especially on tertiaries and tail. Wing bands indistinct, pale buff. Below, hair-brown or drab, washed, especially on breast and sides, with ochraceous, the feather edgings wood-brown. Bill and feet dusky pinkish buff becoming darker with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in September in eastern Canada which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Above, chiefly pale olive-brown, sometimes with reddish or yellowish tinge veiled with smoke-gray edgings, the crown, auriculars, rump and upper tail coverts ochre to gallstone-yellow, often orange, the feathers dark centrally, usually a sprinkling of brick-red feathers and sometimes the yellows completely replaced by red, occasionally carmine. Below smoke-gray, the breast and throat usually with some red and yellow not very pronounced. Wing coverts tipped with white forming two distinct bands the lesser coverts plumbeous and ochre tinged.

4. First Nuptial Plumage acquired by wear, apparently brightening and assuming a golden sheen, this optical effect being due to loss of barbules, a similar loss taking place in *Carpodacus purpureus,* under which species a full explanation is given.

5. Adult Winter Plumage acquired by a complete postnuptial moult. The pinkish plumage is assumed and young and old become indistinguishable.

The back is clove-brown with olive-gray edgings, elsewhere geranium-red, the wing bands and even primary edgings tinged with geranium-pink.

6. Adult Nuptial Plumage acquired by wear as in the young bird, which apparently intensifies the color by a gradual loss of the distal barbules of each feather.

Female.—Plumages and moults are similar to those of the male. In juvenal plumage the sexes are practically indistinguishable. In first winter plumage duller than the corresponding dress of the male; above, olive-brown with smoke-gray edgings, the crown and rump ochre or dull olive-yellow, entirely smoke-gray below. The first nuptial plumage is acquired by wear. The adult winter plumage is similar to male first winter, but duller with only a tinge of red at most on crown, rump or breast. The adult nuptial plumage is acquired by wear.

Passer domesticus (Linn.). English Sparrow

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, hair-brown somewhat buffy, wings and tail slightly darker, and streaked broadly with clove-brown on the back; secondaries, tertiaries and wing coverts edged with wood-brown. Below, mouse-gray darkest across jugulum and on the sides, the chin and mid-abdomen nearly white. A dusky postocular stripe. Bill and feet pinkish buff, the former becoming dusky and black before spring, and the latter sepia-brown.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning the end of August.

Unlike previous plumage, the black chin and throat patch being assumed. Pileum, rump and upper tail coverts smoke-gray, the feathers brownish edged and dusky basally. The back streaked with black each feather partly Mar's-brown and edged with buff. Below, dull white tinged with French-gray on throat and sides, the feather tips with buffy wash, the shafts faintly grayish ; the chin and throat, loral and postocular stripe, black veiled with grayish or buffy edgings ; sides of chin and throat and mid-abdomen nearly white ; auriculars olive gray ; posterior part of superciliary line, postauricular and nuchal regions chestnut veiled with buff edgings. Wings and tail dull black edged with pale cinnamon, rich chestnut on the greater and lesser coverts, the median coverts white, buff edged forming a wing band.

4. First Nuptial Plumage acquired by wear which brings the blacks, chestnuts and grays into prominence by loss of the veiling feather edgings, and the buff wash is lost. The wing bands, sides of throat and abdomen become noticeably whiter.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the end of August. Differs very little from first winter dress, the black of the throat usually more extensive and the buff less evident. The crown is usually grayer and the median coverts whiter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In natal down and juvenal plumage females are indistinguishable from males. The first winter plumage is acquired by a complete moult, and is similar above to that of the male, more washed with buff below and without the black throat and chestnut postauricular patches. The first nuptial plumage is acquired by wear, the buff being largely lost and later plumages differ very little from each other, the only renewal being at the postnuptial moult.

It would be interesting to know whether this species on its "native heath" goes through the same sequence of plumages and moults although there is no reason for supposing them to have been modified through acclimatization since it was imported into this country.

Carpodacus purpureus (Gmel.). Purple Finch

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Plate IV, fig. 1 shows a juvenal plumage crown feather.

Above, wood-brown, broadly streaked with olive-brown and showing whitish streaks if the feathers be disarranged so as to expose a lighter portion. Below, dull white streaked with paler olive-brown, least on the chin, throat and middle of abdomen and crissum, the last two areas often unmarked. An indistinct whitish superciliary line. Wings and tail deep olive-brown, edged with pale buff deepest and broadest on tertiaries and wing coverts. Bill and feet pinkish buff, sepia-brown when older.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning the end of August, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Differs in general effect very little from the last, but the streaks are bolder, the brown usually with a greenish yellow tinge merging into the buffy edgings.

Plate IV, fig. 2 shows a crown feather of this plumage newly grown ; **fig. 3,** a similar feather after about eight months of wear. When to apply the term first nuptial to this feather is a matter not easy to determine.

4. First Nuptial Plumage acquired by wear through which most of the buffy tints are lost, the edgings becoming whitish. Males are brown streaked and indistinguishable from females in most cases.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning early in August all males assuming the pink plumage.

Above, pale geranium-red (often carmine or brick-red), hoary on the pileum and nape, the feathers of the back with dusky shaft lines and broad greenish buff edgings. Below, a hoary geranium-pink blending into white on abdomen and crissum, the flanks buffy with a few dusky streaks. Wings and tail clove-brown the edgings tinged with pale brick-red.

Young and old now become practically indistinguishable.

Plate VII, fig. 1 represents a crown feather of this plumage already showing wear which finally produces a feather like that seen as **fig. 2,** the adult nuptial dress.

6. ADULT NUPTIAL PLUMAGE acquired by wear which produces a plumage largely bright rosy carmine decidedly brighter to the eye than the winter dress. The explanation of this evident color change is, however, very simple. There is no pigmentary change, the brightening being wholly an optical delusion. Under a glass of even moderate power it will be seen that the whitish barbules of the reddish feathers of the winter dress especially of the head and throat have worn away, leaving the resistant carmine barbs bare and glistening. The remaining barbules show as hoary spots and in winter plumage, of course, the whole effect is hoary. This explanation, although at variance with that offered by other writers is unquestionably the correct one, and **plate VII, figs. 1 and 2** show the change unmistakably. The bases of the feathers of this species are dusky, and often show when the plumage is much worn or even disarranged. Wear is considerable by the end of the breeding season and loss of edgings helps intensify the reddish tints.

In captivity pink adults assume golden or bronzed feathers at their first moult, never reassuming the pink dress. It is probable that some ingredient of their food when in the wild state is lacking and a deficiency of pigment results.

Female.—In natal down, juvenal, first winter and first nuptial plumages indistinguishable from the male and later plumages are brown streaked like the immature male. The moults correspond to those of the male.

Loxia curvirostra minor (Brehm). AMERICAN CROSSBILL

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult

Above, streaked with olive-brown, the feathers with whitish edgings, an olive-green tinge on the back and pale buff on the rump. Wings and tail clove-brown the feathers faintly edged with pale buff sometimes greenish tinged. Below, dull grayish white thickly streaked with olive-brown. Bill and feet olive-gray, black when older. The mandibles do not cross at first but in about three weeks deflect as they grow to the right or left indifferently.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult which involves the body plumage but neither the wings

nor the tail. Birds in considerably worn juvenal dress taken in New Brunswick, Canada, June 29th, July 21st and July 23d, show a few new feathers of this plumage.

Everywhere a mottled mixture of bright yellows, greens and reds, the former predominating and the reds dull, but individual variation is great. The colors are brightest on the head, rump, throat and sides of abdomen. The posterior part of the abdomen and under tail coverts may be red tinged or yellowish or they may fail to moult and remain brown streaked.

4. First Nuptial Plumage acquired by wear which is marked by midsummer producing through loss of grayish barbules a brightening of the whole plumage, as already explained under *Carpodacus purpureus*. A worn reddish breast feather of this plumage is shown on **plate VII, fig. 4**. In a year the feather (**fig. 3**) which actually grew beside this one would also lose its barbules and appear a brighter red, like **fig. 4**.

5. Adult Winter Plumage acquired by a complete postnuptial moult in September. The brick-red body plumage with vermilion rump is acquired at this moult as shown by a specimen taken in New Brunswick, Canada, October 16th which has renewed about three quarter of the mottled dress. **Plate VII, fig. 3,** represents a new feather that had not lost its sheath and was situated next to the worn one represented by **fig. 4**. It seems probable that an entirely red plumage is not always fully acquired until the second postnuptial moult. A reddish tinge is observable in the faint edgings of wings and tail.

6. Adult Nuptial Plumage acquired by wear which through loss of barbules produces coppery and rosy reflections, to the eye, brighter than those of the previous plumage.

Female.—In natal down and juvenal plumage indistinguishable from males. The first winter plumage acquired by a partial postjuvenal moult which does not include the wings nor the tail is olive-buff indistinctly mottled or streaked with olive brown; the rump bright olive-yellow. The first nuptial plumage is acquired by wear producing little change. The adult winter plumage varies little from the first winter, the rump perhaps brighter and the breast tinged with bright olive-yellow. Old birds sometimes show dull red tints on these areas, but the brightest adults are greenish yellow as compared with the dullest young males which are orange tinged.

Of 68 specimens of both sexes in my collection, the upper mandible crosses to the right in 38 and to the left in 30.

Loxia leucoptera Gmel. White-winged Crossbill

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Whole plumage dull grayish white thickly streaked with clove-brown, the feather edgings grayish, but buffy on back, rump and abdomen. Wings and tail dull black, the primaries, secondaries and tertiaries narrowly, the tertiaries and wing coverts broadly, edged with buffy white forming two distinct wing bands at tips of greater and median coverts. Bill and feet brownish black.

This description is taken from two females in my collection secured in eastern Canada, June 29th and July 16th. The birds are decidedly blacker than *L. c. minor* in corresponding plumage.

3. First Winter Plumage acquired by a partial postjuvenal moult, probably in September, which involves the body plumage, but neither the wings nor the tail.

The head, back, rump, throat and breast are varying shades of chrome-yellow with an occasional dash of dull red, the scapularies and upper tail coverts black. Lores, orbital region and forehead dull black.

4. First Nuptial Plumage acquired by wear which to the eye brightens the yellow by loss of the barbules of the feathers. The mouse-gray basal portion of the body feathers is somewhat in evidence.

5. Adult Winter Plumage acquired by a complete postnuptial moult. It is likely nearly all young birds assume the full red adult plumage at this moult.

Rosy or hoary brick or geranium-red, the wings, tail and scapularies black. Wing bands and tertiary edgings white. Abdomen smoke-gray and under tail coverts dull white, rose tinged, both streaked with clove-brown. The colors are much pinker than those of *L. c. minor* in corresponding dress and the white wing bands distinctive.

6. Adult Nuptial Plumage acquired by wear, which, to the eye, brightens the rosy tints considerably by loss of the barbules

from a part of each barb. The general effect is that of a rosy bird mottled with whitish spots.

Female.—In natal down and juvenal plumage indistinguishable from the male, no doubt, as is the case in allied species. The first winter plumage, acquired by a partial postjuvenal moult, not involving the wings nor the tail, is olive-buff, similar to *L. c. minor*, from which it may easily be distinguished by the wing bands, and besides it is more distinctly mottled and streaked with deeper olive-brown. The first nuptial is simply the previous plumage modified by wear. The adult winter plumage is, of course, acquired by a complete postnuptial moult, and shows a certain amount of yellow scattered through it, which is somewhat brightened by wear becoming the adult nuptial plumage. Females never become pink.

Acanthis linaria (Linn.). Redpoll

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, streaked with sepia and clove-brown with whitish edgings ; rump paler but also streaked. Wings and tail clove brown with whitish or buffy edgings ; the coverts, wing bands and tertiaries edged with pale cinnamon. Below dull white streaked with clove-brown and washed with buff on throat and sides. Bill and feet of dry skin dull ochre.

Description from a specimen taken in Labrador, August 27th.

3. First Winter Plumage acquired by a partial postjuvenal moult late in August, which apparently involves the body plumage and wing coverts and not the rest of the wings nor the tail.

Above, wood-brown, sides of head and rump paler, streaked with olive-brown, the feather edgings often whitish. Crown dull crimson, usually coppery. Wings and tail deep olive-brown, the feathers with whitish edgings. Below white, washed with buff on throat, sides and flanks, streaked laterally and on under tail coverts with olive-brown. A dull brownish black chin spot.

Some young birds may assume a few rosy breast feathers, but they are characteristic of adults.

4. First Nuptial Plumage acquired by wear, through which much of the buff is lost, the birds becoming darker and whiter with the crown spot a trifle brighter to the eye, due to loss of the grayish barbules of the red barbs.

5. Adult Winter Plumage acquired by a complete postnuptial moult. The geranium-pink or rosy feathers of the breast and rump are assumed. Otherwise similar to first winter dress.

6. Adult Nuptial Plumage acquired by wear through which the rosy feathers appear brighter like the crown partly by loss of barbules and partly by loss of the whitish edgings.

Female.—The plumages and moults correspond to those of the male, but the crown spot is duller and smaller, often bronzed, and rosy breast feathers are seldom acquired.

Acanthis linaria rostrata (Coues). Greater Redpoll

The plumages and moults of this race correspond to those of *A. linaria*, the subspecific characters prevailing even in the juvenal plumage, the colors darker and the streaking somewhat heavier. The adults are large, with large bills and very white rumps, sometimes with rosy tints everywhere.

Carduelis carduelis (Linn.). European Goldfinch

The limited number of specimens examined of this introduced species, now well established in Central Park, New York City, forbids positive conclusions. I have not seen the juvenal plumage, nor do I know the extent of the postjuvenal moult, which undoubtedly takes place. Adults evidently have but one moult annually, the postnuptial, and I believe the brightening of the red frontlet in spring is due to the loss of the fuzzy barbules from brighter colored barbs. Descriptions from textbooks are unsatisfactory in solving the problems of moult, but they seem to indicate the usual sequence of plumages and moults in this species.

Spinus tristis (Linn.). American Goldfinch

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above wood-brown, grayer on crown, yellowish on forehead. Below, including sides of head primrose-yellow brightest on chin, washed on sides and flanks and across the throat with deep buff. Wings and tail dull black whitish edged; secondaries, tertiaries, and wing coverts including two wing bands edged with ochraceous buff the outer greater coverts usually partly white. Bill and feet pinkish buff, becoming dusky with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning late in September which involves the body plumage but not the wings nor the tail.

Similar to previous plumage but a deeper brown above and the yellow below replaced (except on the chin which is a brighter yellow) by pale olive-gray, darkest on the throat and washed with wood-brown on the sides. The crissum and middle of the abdomen are white. Dull black, brownish or yellowish edged lesser coverts (the "shoulders") distinguish young birds from adults which have them bright yellow, the black of the wings and tail is besides less intense, the wing bands are browner and the chin duller yellow.

4. First Nuptial Plumage acquired by a partial prenuptial moult during April and early May which involves the entire body plumage but neither the wings nor the tail. The bright canary and black dress is assumed, old and young distinguishable only by the brownish "shoulders," and the duller and more worn wings and tail of the young bird. It is interesting to note that the black wings and tail are assumed with the juvenal plumage, the black crown at the prenuptial moult. The effects of wear are marked, for the white edgings due to fading are lost by abrasion before the end of the summer so that the edges of the tertiaries and secondaries become scalloped out, and very little if any white remains when the postnuptial moult occurs. This is illustrated by **plate II, figs. 4 and 5.**

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning about the middle of September. Similar to first winter but a richer deeper brown above, the crown, throat and sides of breast more distinctly yellow, the edgings of the wings and tail (which are jet black) paler and most important of all the "shoulders" bright canary-yellow instead of brown. Young and old now become indistinguishable.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves, as in the young bird, the whole body plumage but not the wings nor the tail. Distinguishable from first nuptial chiefly by the yellow "shoulders."

Female.—Females have plumages and moults exactly corresponding to the males, but the plumages are regularly much duller and the prenuptial moults much less extensive. The wings and tail are browner and there is no black upon the crown. I have a large series of this species taken every month in the year including many specimens showing both sexes in various stages of the double moult they regularly undergo.

Spinus pinus (Wils.). Pine Siskin

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, olive-brown with buff tinged, or yellowish feather edgings and streaked with clove-brown. Wings and tail deep olive-brown, basal portion of the remiges and rectrices canary-yellow, the edgings of the primaries and secondaries paler yellow, their tips whitish, the edgings of the rectrices faintly olive-yellow, the wing coverts edged with ochraceous-buff forming two wing bands, the tertiaries broadly edged with buff. Below primrose-yellow, palest on chin, thickly streaked with clove-brown. Bill and feet pinkish buff, dusky when older.

This plumage is worn a long time, probably two months, the postjuvenal moult beginning early in August as shown by a specimen from eastern Canada, August 8th. It becomes considerably worn and the buffy tints as well as the yellow below are nearly lost before the moult begins.

3. First Winter Plumage acquired by a partial postjuvenal moult in August in eastern Canada which involves the body plumage but not the wings nor the tail.

Differs very little from the previous plumage, birds being a paler brown above and altogether without the yellow tinge below. They are dull white below with a faint buffy tinge anteriorly and laterally and streaked with olive-brown; the buffy wing coverts rapidly fade to dull white.

4. First Nuptial Plumage acquired by wear which produces a dingy white, brown-streaked bird.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Differs very little from first winter dress. The wings and tail will average darker with more yellow and the wing coverts have less buff and often a tinge of yellow.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—Females have plumages and moults corresponding to those of the males. They are indistinguishable from them in natal down and juvenal plumage except that the extent and intensity of the yellow in the wings and tail is less in most specimens in juvenal dress. In later plumages this difference holds and besides the birds are usually less heavily streaked and paler than the males.

Plectrophenax nivalis (Linn.). Snowflake

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head mouse-gray streaked faintly on the head, more broadly on the back with dull black. Wings dull black ashy edged, secondaries, basal part of primaries and wing coverts pure white, the tertiaries broadly edged with Prout's-brown. Tail chiefly white, the central rectrices wholly clove-brown the others merely edged with it terminally. Below, dull white, the throat, breast and sides mouse-gray, a brownish wash in the flanks. Bill pinkish flesh, feet dull black.

This description is taken from Greenland specimens.

White primary coverts terminally dusky distinguish young males from adults, in which they are wholly white.

3. First Winter Plumage acquired by a partial postjuvenal moult early in August in Greenland which involves the body plumage, but apparently not the wings nor the tail.

Above, wood-brown often russet tinged, darker on the crown, completely veiling the black basal portions of the dorsal feathers and the white portions of those of the head. Below pure white, a jugular band and the sides russet, its extremities and the auriculars Vandyke-brown.

4. First Nuptial Plumage acquired chiefly by wear which produces during the breeding season a plumage almost wholly

black and white. The feather edgings of the back are gradually lost down to the black area, the individual feathers thereby becoming sagittate instead of rounded, while abrasion and fading remove the browns that conceal the white. I do not find that the black area of any feather corresponds, except approximately, to the points where the barbules of adjacent barbs last cross as figured by CHAPMAN ('96) and STONE ('96, pp. 118–119). I am inclined rather to believe that chemical disintegration proceeds faster in the less pigmented extremities of the barbs which certainly are not provided with heavier barbules at the point where the feather tips cease to break away. Besides wear, there is some renewal of feathers on the chin, throat and sides of the head during February and March, as in many other species, but this perhaps scarcely deserves to be called a moult.

5. ADULT WINTER PLUMAGE acquired in Greenland by a complete postnuptial moult late in July and in August. The wings and tail are usually blacker than in first winter dress, the edgings richer with less brown and more gray, the tertiaries edged with a deeper brown, the primary coverts wholly white; elsewhere the brown is paler especially on the crown and jugular band.

6. ADULT NUPTIAL PLUMAGE acquired chiefly by wear and partly by moult as in the young bird. Plumage wholly black and white.

Female.—In juvenal plumage the female is similar to the male, but with less white on the wings and tail, the greater coverts brown, the primary coverts wholly dusky, and the secondaries with dusky edgings. Subsequent plumages and moults correspond to those of the male. The wings and tail are regularly duller, and the white of the wing restricted and mixed with dull black. The chief differential character is found in the feathers of the head and nape which are dull brownish black basally. In winter plumages this black is veiled with rich brown, but wear produces a streaked appearance in nuptial plumages. The jugular band is usually faint in females. The characters given distinguish females in any plumage from males, whether adults or young birds.

Calcarius lapponicus (Linn.). Lapland Longspur

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head rich buff or clay-color streaked heavily with black. Wings and tail deep clove-brown, tertiaries and greater coverts edged with Mar's-brown, white tipped, lesser coverts with white, primaries and tail with pale cinnamon, outer rectrices terminally buffy white. Below, dull white, washed with buff across the throat: the chin, throat and sides streaked with black. Bill and feet of dried skin dusky clay-color.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning in Greenland early in August which involves the body plumage, part of the wing coverts and not the rest of wings nor the tail. Young and old become practically indistinguishable in many cases.

Similar to the previous plumage. Above, wood-brown and cinnamon streaked with clove-brown, the nape and sides of neck chestnut concealed by wood-brown edgings; lesser coverts edged with wood-brown. Median crown stripe superciliary line and anterior auriculars buff, posterior auriculars black. Below, white, the feathers everywhere dusky basally, the sides of chin and a crescentic area on the throat jet black veiled almost completely by long white edgings; the sides and flanks streaked with black.

4. First Nuptial Plumage acquired by a partial prenuptial moult beginning in March in the United States which involves the anterior parts of the head, chin and throat. The black feathers of these areas and the creamy white ones of the sides of the head are acquired by moult contrasting with the chestnut collar which is assumed by loss of feather edgings. This moult does not usually extend to the posterior portion of the black throat patch where old black feathers with partly worn-off edgings are regularly found. Wear produces a distinctly black and white streaked appearance above with the collar clear chestnut as if unveiled.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable in many cases from first winter dress, but the black on the chin and throat is more extensive, and the colors richer and deeper, especially the wing edgings.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male, but the black throat patch is never so extensive and usually merely outlined with dull black streaks. The juvenal plumage is indistinguishable from that of the male. The first winter plumage is much veiled and streaked above with clove and cinnamon brown, the nape vinaceous ; below it is white obscurely black on the sides of the chin and with a small throat patch, the sides and flanks black streaked. The first nuptial plumage is chiefly the result of wear, a few white feathers being acquired by moult on the chin. The adult winter plumage is like the first winter dress with perhaps more black on the throat.

Calcarius ornatus (Towns.). Chestnut-collared Longspur

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above clove-brown, the feathers edged with dull white and wood-brown producing a streaked appearance. Wings, sepia-brown, the primaries terminally dusky, the coverts edged with white forming a band at tips of the greater, which with the tertiaries, secondaries and middle rectrices are edged with pale cinnamon, the primaries with buff; tail largely white, the outer rectrices with only a terminal shaft line of sepia. Bill and feet dusky pinkish buff, becoming darker.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage, lesser wing coverts and usually not more of the wings nor the tail.

Similar to previous plumage. Above, sepia edged with pale wood-brown concealing black feathers on the crown and chestnut ones on the nape and sides of neck; a partly streaked effect elsewhere. Lesser wing coverts black veiled with whitish edgings. Below, throat and breast black much veiled with buffy white edgings, the chin, flanks and crissum white tinged with buff. Auriculars wood-brown, the posterior ones concealing black ; superciliary line and lores whitish.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March which involves chiefly the head and throat. The chin, auriculars and lores are renewed by moult, becoming clay-colored and also part of the black area on the throat and forehead, the rest of it becoming black by loss of the feather edgings. The black portion of the auriculars and the chestnut collar is exposed by wear, the superciliary line becoming whiter,

the abdomen paler and the back more distinctly streaked by the same influence. There are few species in which the same color, black, is produced by moult and by wear, but this one illustrates it beautifully and the lines of demarcation between old and new feathers vary according to the individual. When only part of the chin is renewed by moult, the clay-color may be divided from the black by a white band of worn faded feathers. Young and old become practically indistinguishable.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult. Differs from the first winter dress chiefly in the larger areas of black, which often include the chin, and in the richer darker colors especially wing edgings.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male from which the female is first distinguishable in first winter plumage which is plain wood-brown streaked everywhere with clove-brown, the wing coverts and tertiaries with whitish edgings. The prenuptial moult is limited and in later plumages very little if any of the black throat of the male is acquired.

Poocætes gramineus (Gmel.). VESPER SPARROW

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including sides of head, wings and tail clove-brown, the effect, streaked owing to the body feathers and wing coverts being dark centrally, bordered with buffy, grayish and whitish edgings. The edgings of the tertiaries and the lesser coverts ("shoulders") are Mar's-brown, those of the greater coverts paler and the feathers tipped with white, those of the secondaries still paler, those of the outer primaries and rectrices dull white; the outer rectrix largely white. Below, dingy white streaked with clove-brown, heaviest on the jugulum, merely flecked on chin and crissum. Feet and bill pinkish buff darkening little with age.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult beginning the latter half of August which involves the body plumage but not the wings nor the tail, young becoming practically indistinguishable from adults.

Similar to the previous plumage. Above, sepia-brown streaked with clove-brown and tinged with walnut. Below, dull white, clearer on the chin, washed on throat and sides with pinkish buff and streaked broadly on throat and sides with clove-brown, walnut tinged and veiled with whitish or buffy edgings; the chin flecked; the breast, abdomen and crissum white.

4. First Nuptial Plumage acquired by wear which is marked and produces a brown-streaked plumage. The buffs and browns are largely lost. A few new feathers may be assumed about the chin in spring, but there is no evidence of a moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning in mid-August. Practically indistinguishable from first winter dress, sometimes paler below, the tertiary edgings rather darker.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically alike in all plumages, although the colors will average duller in the female, and the moults are the same.

Ammodramus princeps (Mayn.). Ipswich Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, buff, palest on the back, streaked narrowly on the pileum, nape and rump, and broadly on the back with deep clove-brown. Below, pale yellowish buff, palest on chin, abdomen and crissum; narrowly streaked on sides of throat, across jugulum, on sides, flanks and thighs with clove-brown. Wings and tail clove-brown the quills and coverts with whitish or pale cinnamon edgings, becoming russet on the tertiaries the proximal one white edged. Bill and feet pinkish buff, the former becoming dusky, the latter slightly browner with age.

This description is based upon nine specimens in my collection taken on Sable Island, Nova Scotia, in July and August.

3. First Winter Plumage acquired by a partial postjuvenal moult in August which involves the body plumage, and apparently the wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to the previous plumage. Above, chiefly drab-gray which edges feathers clove-brown centrally bordered by a zone of Vandyke-brown so that the streaking above is suffused. The nape and median crown stripe are yellowish. The edgings of the wing coverts, secondaries and tertiaries are of a vinaceous cinnamon which rapidly fades. Below, white, buff tinged on sides of head, across throat and on sides, streaked on sides of chin, across jugulum and on sides and flanks with russet bordered by clove-brown which is veiled by overlapping whitish feather edgings. Superciliary line ashy gray. No yellow above the eye.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves the head, throat, and part of the breast, and a few stray feathers of the other tracts but neither the wings nor the tail. The chin and throat become whiter, the streakings on them darker and the yellow of the superciliary line is acquired. Elsewhere the buffy tints fade out and the streakings become more prominent owing to the abrasion which exposes the darker colors beneath the veiling. The prenuptial moult begins in February lasting through March in the vicinity of New York city, young birds and old becoming practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Indistinguishable with certainty from first winter dress but usually grayer or more hoary above, the russet deeper on tne wings and everywhere less suffused with buff. Some specimens are tinged with yellow above the eye.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The sexes are practically indistinguishable although females will average rather browner and duller; and the moults are identical, the prenuptial of the female however more limited than that of the male.

Ammodramus sandwichensis savanna (Wils.).
Savanna Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult. Similar in pattern and coloration to *A. princeps*, but everywhere darker. Above clay-color or deep buff prevails with dark streaking, darkest on pileum; the wing feather edgings are darker than those of *princeps* the secondaries and tertiaries being walnut-brown. Below, and to a certain extent above, and about the head, a buff suffusion replaces the paler yellowish tints of *princeps*.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in August, which involves the body plumage, and the wing coverts, but not the rest of the wings nor the tail. Young and old become practically indistinguishable, the young usually with more buff tints.

Similar to *A. princeps*, but dark brown instead of gray prevailing above, the crown, back and wing edgings much darker. Below with more buff on the throat and about the head, the streakings decidedly broader and blacker.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March and April which involves the head, throat, breast, often the anterior part of the back, the tertiaries and stray feathers elsewhere even on the thighs, the abdomen, the lumbar tracts and the tail coverts, but not the remiges nor rectrices. The buffy winter tints are replaced by grayish ones and the yellow of the superciliary line is acquired. Wear is soon marked.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Differs little from first winter plumage, the buffiness less pronounced and the tertiary edgings a deeper brown. Superciliary line sometimes tinged with yellow.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The sexes are practically indistinguishable, although usually, the yellow of the superciliary line is less bright in the female and there is more buffy suffusion.

Ammodramus savannarum passerinus (Wils.).

Grasshopper Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, mottled and streaked with olive-brown, the edgings of the nape and median crown stripe grayish, those of the back and rump buffy, the scapularies tipped with spots of russet. Wings and tail olive-brown, edged with wood-brown or pale cinnamon, the wing coverts and tertiaries tipped with white. The central rectrices have a peculiar fused barring along the shafts. Below, white, streaked across the jugulum and faintly on the sides with olive-brown. Edge of wing white or faintly yellow. Bill and feet pinkish buff, the former becoming dusky, the latter deep brown when older, and dull ochre-yellow in dried skins. (**Plate II, fig. 1**, shows a new tertiary of this plumage.)

This plumage is worn a long time and is much frayed and faded when the postjuvenal moult begins about the middle of August.

3. First Winter Plumage acquired by a complete postjuvenal moult in August.

The pattern of nearly all the feathers is changed from that of the juvenal plumage, the streaking of the pectoral band being lost, the barring of the tail replaced by uniform brown, and the plain brown tertiaries acquiring apical sepia-brown spots. (Plate II, fig. 2, shows a tertiary of this plumage and fig. 3 the effect of wear upon it.) The feathers of the back are black with apical chestnut spots edged with pearl-gray; the nape lacks most of the black, and the pileum most of the gray, of the previous plumage. The median crown stripe and the edgings of the tertiaries and wing coverts are rich buff, of the wing quills and tail olive-gray, the bend of the wing bright lemon. The wings and tail are darker. Below, including sides of head and superciliary line, rich buff, deepest on jugulum, very obscurely streaked with pale cinnamon, the middle of the abdomen pure white.

4. First Nuptial Plumage acquired by a partial prenuptial moult at the south in April, which involves chiefly the chin, sides of head and crown and a few scattering feathers of the other tracts; but not the wings nor the tail. The yellow superciliary spot is acquired. Wear is more marked than is the slight moult, which perhaps does not deserve the name, fading removing a large part of the buff tints and abrasion fraying the feathers, so that by the end of the breeding season even the terminal spots of the tertiaries become gouged out as shown on plate II, fig. 3.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs very little from first winter dress, the buff less obvious and the colors deeper.

6. Adult Nuptial Plumage acquired apparently by a partial prenuptial moult as in the young bird.

Female.—The sexes are practically indistinguishable and have corresponding moults and plumages.

Ammodramus henslowii (Aud.). Henslow's Sparrow

1. Natal Down. Smoke-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above clay-color, streaked on head and back with black, the feathers with rounded central spots bordered with the clay-color. Wings and tail clove-brown edged with clay-color, secondaries and tertiaries with russet, alulæ with white. Below, faint primrose-yellow, buffy on chin and throat, unstreaked or an occasional streak at sides of throat. Bill and feet of dried skin raw umber brown sometimes dusky and paler in spring specimens.

3. First Winter Plumage acquired by a complete postjuvenal moult so far as may be judged from limited material for comparison.

Pileum and nape yellowish olive-buff, lateral crown stripes and flecking of nape black; back chestnut, streaked with black the edgings pearl gray; rump tawny olive veiling black streaks. Below, dull white washed on sides of head, breast, flanks and on crissum with clay-color, a jugular band of narrow black streaks which extend broader on the flanks. Orbital ring pearl-gray. Wings and tail darker than in previous plumage, the edgings largely russet or chestnut, the alulæ edged with drab. The tail is darker, the dusky stripes along the shafts bordered with chestnut.

4. First Nuptial Plumage acquired probably by a partial prenuptial moult confined chiefly to the head and chin. In species so much affected by wear it is not easy to be sure of a moult without specimens which actually show it. The freshness of many feathers in spring indicate it.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter, usually whiter below, of a greener tint about the head and the edgings of the back grayer.

6. Adult Nuptial Plumage acquired probably by a partial prenuptial moult as in the young bird.

Female.—The sexes are practically indistinguishable, and the moults correspond.

Ammodramus caudacutus (Gmel.). Sharp-tailed Sparrow

1. Natal Down. Grayish wood-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Everywhere rich buff brightest on superciliary and malar stripes and on jugulum; the back broadly, the jugulum and sides narrowly streaked with clove-brown. Crown and wings nearly black, wing coverts and tertiaries broadly edged with ochraceous buff, the secondaries with russet, the primaries and their coverts with greenish tinged olive-gray, the alulæ with white. Tail olive-brown with clove-brown shaft streaks and indistinct barring. Auriculars dusky. Bill and feet pinkish buff the former becoming dusky, the latter sepia-brown with age.

This plumage is worn from June to September when the postjuvenal moult takes place in worn and faded birds.

3. First Winter Plumage acquired by a partial postjuvenal moult during September and early October which involves almost the entire plumage except the primaries, their coverts, and the secondaries, and apparently these also in some vigorous individuals.

Unlike the previous plumage; the upper parts resembling *A. marit mus.* Above, dull brownish olive-green, an orange tinged patch on the nape, the feathers of the back edged with pearl and cinereous gray, the crown rich sepia faintly streaked with clove-brown, an indistinct median stripe cinereous gray. The tertiaries are edged with buff, the secondaries and greater coverts with russet, the lesser coverts with olive-yellow; the edge of the wing is bright lemon-yellow. The new tail has more olive and is less barred than the old. Below, dull white washed on chin, across jugulum and on sides, flanks and crissum with ochraceous buff, superciliary and malar stripes deeper buff; streaked on jugulum, sides and crissum with clove-brown veiled by overlapping feather edgings. Auriculars cinereous.

The buff everywhere fades rapidly and abrasion is soon marked bringing the throat streaking into prominence. Birds become much grayer above and much whiter below by fading and by actual loss of the veiling feather tips. Several albinistic specimens in my collection are in this plumage mottled with white.

4. First Nuptial Plumage acquired by a complete prenuptial moult which occurs in March and April. I have seen several specimens with the remiges partly grown, but this is usually accomplished before the birds reach us although many show renewal in the body feathers. A careful examination under the glass shows that birds in May are in as fresh plumage even to the wings and tail as when they leave us late in October and November and it would be safe to infer a moult even if there were no actual proof of it. Wear soon produces a faded ragged bird dull brown above and dingy white below with dull streaks, only the superciliary and malar stripes showing any buff.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning late in August. Practically indistinguishable from first winter dress the colors averaging richer.

6. Adult Nuptial Plumage acquired by a complete prenuptial moult as in the young bird.

Female.—The sexes are practically indistinguishable and the moults identical.

Ammodramus caudacutus nelsoni Allen. Nelson's Sparrow

Ammodramus caudacutus subvirgatus Dwight. Acadian Sharp-tailed Sparrow

The plumages and moults of these two races correspond exactly to those of *A. caudacutus.* I have indicated their differences of plumage in another paper (Auk, XIII, 1896, pp. 271–278) and need only add that all these birds undoubtedly have two complete moults every year, judging by a large amount of material illustrating all plumages except the natal and juvenal of *A. c. nelsoni* which is unknown in collections.

Ammodramus maritimus (Wils.). Seaside Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and the tail, olive-brown narrowly streaked on pileum, nape and upper tail coverts and more broadly on the back with clove-brown. Wings dull black, primaries edged with olive-gray, secondaries with russet, coverts and tertiaries with buff, alulæ with white. Below, dull white washed with buff on sides of chin, on jugulum, along the flanks and on crissum and narrowly streaked on jugulum and along the sides with clove-brown. The supraloral space is greenish. Bill and feet pinkish flesh, the former becoming slaty and the latter sepia-brown.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning the latter part of August when the juvenal plumage has become worn and faded as a result of fully two months' wear. Young and old become indistinguishable.

Unlike the previous plumage, less definitely streaked. Above, including sides of head, wings and tail olive-green. pileum and back cinereous from the olive and pearl-gray edgings, median crown stripe pure cinereous gray bordered by two lateral stripes of olive-green obscurely streaked with black. The primaries are edged with olive-green, the outer with white, the secondaries, tertiaries and greater coverts with rich russet, the lesser with olive-yellow, the alulæ with white. The edge of the wing is bright lemon and a yellow spot is acquired in the supraloral space, the superciliary line greenish. Below, dull white washed across jugulum, on sides and crissum with buff, and broadly and rather indistinctly streaked (except on chin and mid-abdomen which are pure white) with olive-gray.

4. First Nuptial Plumage acquired by wear. The plumage of these birds when they reach the latitude of New York in May is already ragged, and by the end of the breeding season the feathers are in shreds, the plumage becoming a dingy brown above and a mottled gray below the only distinctive markings being a dirty white chin and yellow supraloral spots. The tattered condition of this species illustrates how unfortunate it is to base specific descriptions on breeding plumages.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning in mid-August. The fresh plumage assumed is in sharp contrast to the ragged one doffed and differs very little from first winter except in the richness of the tints, being a trifle darker and grayer with less buff.

6. Adult Nuptial Plumage acquired by wear as in the young bird. It is rather surprising that a species living in the same environment as *A. caudacutus* and suffering equally from abrasion due to coarse marsh grasses and reeds should have but one moult in the year, while the latter has two.

Female.—The plumages and moults are identical, the colors averaging somewhat duller.

Chondestes grammacus (Say). Lark Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep olive-brown, including wings and tail, the feathers edged with pale buff and dull white, producing a streaked effect on the back and head; the greater coverts are edged with buff, the primaries and secondaries with pale vinaceous cinnamon, an area of this color at the bases of the primaries forming a spot beneath their coverts; the rectrices broadly tipped with white. Below, dull white, the chin, throat, breast and sides flecked and streaked with deep olive-brown. Superciliary stripes pale buff flecked with dull black; suborbital region white; loral and rictal streaks and posterior auriculars black; anterior auriculars sepia-brown. Bill and feet pinkish buff. the upper mandible becoming dusky, the lower, and the feet dull clay-color.

3. First Winter Plumage acquired by a complete post-juvenal moult beginning in Kansas the middle of July, young and old becoming practically indistinguishable.

Similar to previous plumage, but unstreaked below. Above, wood-brown, streaked with black, the pileum laterally chestnut, anteriorly black, divided by a buff median stripe, palest anteriorly. Wings and tail deep clove-brown, with cinnamon edgings deepest on the tertiaries, palest on the indistinct wing bands. Below, white, washed with wood-brown on sides, flanks and crissum, the sides of the chin and a central spot on the throat, with rictal and loral streaks, black; auriculars largely chestnut; malar, suborbital and superciliary stripes white, the latter buff tinged.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March which involves the anterior parts of the head, the chin and throat. This renewal supplies fresh feathers similar to those they replace and the line of demarcation is obvious on the throat by contrast of the clear white feathers next the old, and only less obvious on the head. The chestnut of the auriculars seems to be richer and the superciliary line whiter. Wear, which is marked in this species, removes much of the wing edgings, and the spot at the base of the primaries fades where unprotected by their coverts.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July in Kansas. Practically indistinguishable from first winter dress, the colors, especially of edgings, averaging deeper.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird. As all available spring specimens appear to show fresh feathers, semiannual moult in both old and young is the natural inference.

Female.—The plumages and moults correspond to those of the male. The juvenal plumage is indistinguishable from the male. The first winter plumage is rather duller and the auriculars less distinctly chestnut. In later plumages the sexes are practically alike.

Zonotrichia leucophrys (Forst.). White-crowned Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *Z. albicollis* but with paler brown on the lateral crown stripes, paler edgings, lack of chestnut and less heavily streaked below with duller black. Above sepia-brown streaked with black the edgings of the back pale buff, the central crown stripe and indistinct superciliary lines dingy white. Below, grayish white, faintly washed with wood-brown on breast, sides and crissum-streaked on throat, breast, sides and flanks with dull black. Wings and tail deep olive-brown edged with Mar's-brown, the coverts and inner tertiary tipped with pale buff. Auriculars grayish. Feet clay-color and bill slaty in dried skin.

3. First Winter Plumage acquired by a partial postjuvenal moult, probably in August on its breeding grounds, which apparently involves the body plumage and the wing coverts partly but not the rest of the wings nor the tail.

Above bistre, this effect from broad Vandyke-brown stripes which are chestnut laterally and bordered with wood-brown; median crown stripe wood-brown bordered by burnt-umber stripes. (A few black feathers on the crown stripes are occasionally acquired.) Wing coverts and tertiaries clove-brown edged with Vandyke-brown or russet and tipped with yellowish white forming two wing bands. Below, including sides of neck pale smoke gray nearly white on chin and abdomen and washed on flanks and crissum with wood-brown. Auriculars wood-brown. Indistinct superciliary line dull buffy gray. The bill is pinkish buff, drying darker. The feet dull flesh color.

4. First Nuptial Plumage acquired by a partial prenuptial moult beginning the end of March which involves chiefly the head and chin and a few scattering feathers elsewhere. The black and white crown is assumed which soon shows nearly as much wear as the rest of the plumage. This becomes grayer and the stripes clearer. Old and young become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs from first winter dress in having a black and white crown, lacking buff about the auriculars and being everywhere grayer and scarcely different from nuptial dress.

6. Adult Nuptial Plumage acquired apparently by a partial prenuptial moult as in the young bird. This dress differs so very little from the adult winter that perhaps there is no regular prenuptial moult in adults; but occasional new feathers are to be found and unless more material proves the contrary there is reason for believing in the moult.

Female.—The female has corresponding plumages and moults and is practically indistinguishable from the male in all plumages, acquiring the black and white crown at the first prenuptial moult.

Zonotrichia albicollis (Gmel.). White-throated Sparrow

1. Natal Down. Pale clove-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, chestnut-brown, darkest on the head, streaked with dull black, median line and superciliary line olive-gray buff tinged, the feathers of the back edged with buff. Wings and tail deep olive-brown, the coverts and tertiaries chestnut edged and buff tipped, the secondaries and rectrices edged with paler brown, the primaries with brownish white; edge of wing white. Below, dull white, washed with buff on throat and sides and thickly streaked with clove-brown, the whiter chin merely flecked, the abdomen and crissum unmarked. Bill slaty brown, feet pinkish buff, both darker when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning in eastern Canada early in August, which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Unlike previous plumage except above. The back is more broadly striped and edged with buff, the crown nearly black divided by a dull brownish or olive-gray median line. Superciliary line dull white buff tinged, lemon-yellow anteriorly; edge of wing pale yellow. Below, the chin is pure white with black rictal and submalar streaks, the throat and breast ashy gray obscurely vermiculated with clove-brown, a darker concealed central breast spot. Abdomen white, the flanks and crissum washed with wood-brown and duskily streaked.

The more precocious young birds become indistinguishable from adults, and there is great individual variation among them, the whiteness of the chin patch, the grayness of the throat, and the black and white of the crown showing all degrees of intensity. As a rule, however, young birds are browner with duller crown stripes and less purely gray breasts.

4. First Nuptial Plumage acquired by a partial prenuptial moult during April which involves more or less of the body plumage, but usually confined chiefly to the head, throat and breast and not involving the wings and tail. The black crown and the postocular streak with pure white median and superciliary stripes and bright yellow supraloral spot are acquired above; the white chin bordered by clear cinereous gray being the chief feature below. The breast spot and vermiculation are lost if in-

volved by the moult, but frequently they are not reached, nor is the posterior part of the crown nor the back and rump in most cases. In some birds the moult seems to be almost wholly suppressed and they breed in worn autumnal dress. Young and old as a rule now become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Differs from first winter in being of a clearer gray on the throat with less buff and the vermiculations more obscure, the crown and superciliary stripes whiter. The breast spot is less obvious.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves the same areas as in the young bird, and produces a similar plumage richer with age and grayer on the throat. As all spring specimens show signs of moult it is probably that both old and young moult twice a year. It is impossible to tell them apart in every case in the spring, and hence the difficulty in affirming a double moult after the first year.

Female.—The plumages and moults of the female correspond to those of the male. In juvenal plumage males and females are indistinguishable ; in first winter plumage females usually have much paler brown crown stripes, the gray of the breast brownish and streaked rather than vermiculated. The prenuptial moult may be almost wholly suppressed in young birds or so extensive that they assume the same first nuptial plumage as the male. Older, the sexes are practically indistinguishable, females probably averaging duller in general color.

Spizella monticola (Gmel.). Tree Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, streaked with sepia and clove-brown with tinges of chestnut on crown and back. Wings and tail, deep olive-brown edged with grayish white, the coverts and tertiaries with pale buff. Below dull white, grayish on the throat, yellowish on abdomen and crissum, the sides washed with pale cinnamon, streaked (except on abdomen and crissum) with dull black. Bill and feet dull sepia-brown in dried specimens.

Description from a bird taken August 31st in Labrador.

3. First Winter Plumage acquired by a partial postjuvenal moult in August in Labrador which involves the body plumage but apparently not the wings nor the tail, young and old becoming indistinguishable.

Pileum chestnut, faintly edged in median line with buff, feathers of back black bordered with zone of chestnut, the edgings rich buff, rump Isabella-color, often grayish. White wing bands, the greater coverts and tertiaries (white tipped) are edged with chestnut, the lesser wing coverts wholly olive-gray. Below, dull white, the chin, throat, breast, sides of head and neck and superciliary line pale French-gray, the sides washed with wood-brown, a conspicuous clove-brown central breast spot.

4. First Nuptial Plumage acquired by wear, the buff edgings of the back becoming grayish and the chestnut everywhere slightly paler. New feathers regularly grow on the chin in March but apparently not in the other tracts and their appearance indicates, as in some other species, renewal rather than moult, for they are very few in numbers.

5. Adult Winter Plumage acquired by a complete postnuptial moult and indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are indistinguishable and the moults are the same.

Spizella socialis (Wils.). Chipping Sparrow

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, wood-brown, grayish on nape and rump, heavily streaked with dull black, faintly tinged on scapularies and crown with chestnut. Wings and tail dull black, rectrices and primaries ashy edged, the secondaries and tertiaries chestnut edged, wing coverts and tertiaries terminally edged with buff. Ill-defined superciliary stripe, dull grayish white spotted with black. Auriculars wood-brown. Dusky loral and postocular streak. Below, white, streaked except on abdomen and crissum, with dull black. Bill and feet pinkish buff, the former growing dusky and the latter wood-brown with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning the middle of August, which involves the body plumage, and the wing coverts but not the rest of the wings nor the tail.

Similar above to the previous plumage, but with the chestnut crown veiled with buff edgings and narrowly streaked with black. Below, uniform grayish white, unstreaked, washed with buff on throat and sides. Superciliary line dull white buff tinged. Loral, postocular and indistinct submalar streaks black.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March and April, which involves chiefly the forehead, crown, sides of head, chin and throat, little else of the body plumage, and not the wings nor the tail. The chestnut crown, bordered by the white superciliary lines, the white chin and the adjacent cinereous gray are acquired by moult, abrasion bringing the streaking of the back into prominence, the buff and chestnut everywhere paler from gradual fading. Young and old become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning in mid-August. Indistinguishable in many cases from first winter dress, the tertiaries usually chestnut edged to their tips, not buff, the greater coverts more often white tipped, less buff about the head; the grays and chestnuts generally richer, and somewhat less streaking on the crown.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird. The line of demarcation between old and new feathers can be made out in *all* birds in the spring and summer, and all the new crown feathers are chestnut without the terminal black spot characteristic of the winter plumage, therefore, the prenuptial moult must occur regularly in adults as well as young.

Female.—The sexes are practically alike in all plumages, and the moults are similar, the prenuptial being more limited. The first winter plumage is usually more washed below with brown, the chin with more dusky edgings and the crown is less distinctly chestnut and more streaked, these streaks more frequently remaining posteriorly than in the male after the prenuptial moult.

Spizella pusilla (Wils.). Field Sparrow

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Resembles *S. socialis*, but the crown practically unstreaked and the streaking below duller and restricted to throat and sides; the loral and postocular streaks are lacking, the wing edgings are richer and deeper; and the lower parts are washed with pale buff or brown. The orbital ring is not conspicuous. The upper mandible is usually paler than in *S. socialis*.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning early in September, which involves the body plumage, and the wing coverts but not usually the rest of the wings nor the tail, although the middle pair of rectrices is occasionally renewed. Old and young becoming practically indistinguishable.

Above, including auriculars, walnut-brown, a faint grayish median crown stripe, the back streaked with black, the edgings buff or pale cinnamon; rump hair-brown. Orbital region and sides of neck ashy, the orbital ring conspicuously buff. Below dull white, jugular band and sides washed with pale cinnamon.

4. FIRST NUPTIAL PLUMAGE acquired by wear. All the cinnamon below is lost except a faint pectoral band, the sides of the head and neck become clear ashy, and the upper parts bright hazel with whitish edgings on the back, the wing bands white. There is some renewal of feathers on the chin in April but apparently not enough to deserve the name of a moult.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult beginning late in August. Practically indistinguishable from first winter.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male, the sexes being practically indistinguishable.

Junco hyemalis (Linn.). SLATE-COLORED JUNCO

1. NATAL DOWN. Slate-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, drab, plumbeous on crown; sides of head and nape streaked with dull black, the feathers especially of the back edged with bistre. Wings and tail slaty black edged with olive-gray, the tertiaries and wing coverts with dull cinnamon, the greater coverts tipped with buff. Two outer rectrices pure white. Feet pinkish buff, dusky when older. Bill dusky pinkish buff, flesh-color when older and in dried specimens becoming dull ochre-yellow.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult in August and September, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Above, including wing coverts, sides of head, throat, breast and sides slaty gray, darkest on the crown and veiled with bistre edgings, especially on the back, more faintly with paler brown or ashy gray on the throat. Abdomen and crissum pure white, sometimes faintly washed with vinaceous cinnamon.

4. FIRST NUPTIAL PLUMAGE acquired by wear through which the brown and ashy edgings are finally lost, birds becoming ragged but not much faded by the end of the breeding season. A few new feathers are acquired on the chin early in April, but no regular moult is indicated.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult beginning the middle of August. Practically indistinguishable from first winter, but the tertiaries usually edged with gray instead of faded cinnamon, the wings and tail blacker and showing everywhere fewer brown edgings.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in first nuptial from which practically indistinguishable.

Female.—In natal down and juvenal plumage not distinguishable from the male. The moults are the same. The first winter plumage is similar to that of the male, but the gray much paler and everywhere the plumage more veiled with brown. The adult winter plumage is grayer than the first winter dress and resembles the young male at like season, but is much browner with the gray paler.

Melospiza fasciata (Gmel.). SONG SPARROW

1. NATAL DOWN. Sepia-brown.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Resembles *Z. albicollis*, but lacks chestnut above, paler on crown and less streaked below.

Above, including sides of head, wood-brown or sepia broadly striped on back, narrowly on crown, nape and rump with dull black, the feathers centrally black with a narrow zone of walnut and wood-brown and grayish edgings. Indistinct median crown and superciliary stripes dull olive-gray with dusky shaft streaks.

Rictal and submalar streaks black; orbital ring buff. Wings dull black with walnut edgings, the wing coverts and tertiaries buff tipped. Tail olive-brown broadly edged with walnut and indistinctly barred. Below, dull white washed with pale or yellowish buff deepest on the throat and flanks and streaked on sides of chin, throat, breast and sides with dull black. Feet and bill pinkish flesh, becoming dusky with age, the lower mandible remaining partly flesh-color.

Twenty-seven specimens in this plumage show a good deal of individual variation in the yellowness of the lower parts and the amount of streaking. This plumage is worn several months and fades considerably.

3. First Winter Plumage acquired by a partial, sometimes complete, postjuvenal moult during August, September and October which involves the body plumage and the tail and very often, part at least, of the remiges. The renewal of five or six outer primaries occurs in nearly all young birds of this species and is very likely characteristic of the first brood. This fact throws light on the moult of the Indigo Bunting (*Passerina cyanea*) and some others which have this peculiarity. The secondaries are rarely found in moult, the tertiaries, alulæ and wing coverts regularly so. I have a series of eighty-one birds at this stage, besides the twenty-seven in juvenal dress, showing all stages of the postjuvenal moult. With a few specimens only the renewal of primaries, secondaries and even of rectrices, might easily be overlooked as the new feathers are nearly of the same pattern and color as the old and not in contrast as with the Indigo Bunting. My large series shows that the postjuvenal moult begins in some birds, presumably those of first broods, by the middle of August while others may show no signs of moult before the last of September. The middle of September will find the former in full first winter dress, while the latter will still show new feather growth late in October or even November. It is worth noting that the whole period of moult does not cover much over two months in the great majority of cases.

This plumage resembles the previous, but is whiter below and richer in chestnut streakings both above and below. The lateral crown stripes are distinct with black streaks, the median and superciliary stripes distinctly olive-gray. Below, white washed with pale vinaceous cinnamon on sides of head, across jugulum and on sides, and streaked, except on chin and mid-abdomen, with clove-brown bordered with chestnut, the streaks becoming confluent at sides of chin and on mid-throat forming three nearly black spots.

Old and young become absolutely indistinguishable in most cases, young birds with the wing edgings perhaps a trifle duller and with a yellowish tinge.

4. First Nuptial Plumage acquired by wear which is marked and by the end of the breeding season the birds are in tatters. The buff is lost and the streaking below comes out in strong contrast on a white ground.

5. Adult Winter Plumage acquired by a complete post-nuptial moult beginning usually about the middle of August and completed before the end of September. Old and young cannot be told apart with any certainty, adults however with wing edgings that may perhaps average darker and browner and the throat markings blacker. My series of twenty-three moulting adults shows that age can only be determined with certainty by osteological characters.

6. Adult Nuptial Plumage acquired by wear as in the young bird with the same results.

Females.—The sexes are practically alike and the moults identical. In first winter plumage females are apt to be more washed with brown or to have a yellowish cast when compared with males in like dress. Females average later in their moult than males. I have one taken September 22d that has little more than begun the postnuptial moult.

Melospiza lincolnii (Aud.). Lincoln's Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *M. fasciata*, the wings and tail, especially the edgings and the crown, a little darker; but not so dark as *M. georgiana* and the chin faintly streaked.

Above, wood-brown the crown Mar's-brown divided by an indistinct dull olive-gray median line, streaked with black. Wings and tail black edged chiefly with Mar's-brown, the wing coverts and tertiaries with wood-brown. Below, white faintly yellow tinged, washed with pale buff across throat and on sides, flanks and crissum, and streaked with black except on the abdomen, the chin also flecked. Superciliary stripe indistinct and dull olive-gray with dusky shaft streaks. Bill and feet pinkish buff becoming dusky and drying to a dull clay-color, the upper mandible slaty.

The description is from two specimens secured by me in New Brunswick, Canada, July 12th, with tails about one-third grown.

3. First Winter Plumage acquired by a partial postjuvenal moult in August in eastern Canada which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Extremely like the previous plumage but with a greenish tinge above, the edgings and median crown stripe paler. Below, whiter, the throat band deep pinkish buff, a like tint on the malar bands which are bordered by black rictal and submalar streaks, the sides, flanks and crissum grayer buff. The streakings below are narrow and black, merely flecking the white chin and not reaching the white of the breast and abdomen. The superciliary line is deep olive-buff extending on the sides of the neck.

4. First Nuptial Plumage acquired by wear which produces very little effect. Birds become slightly grayer and of a paler brown above and the streakings below are a little more prominent, the buff fading a little.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter dress, the tertiary edgings perhaps darker and all the colors richer.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable in all plumages, and the moults are the same in both sexes.

Melospiza georgiana (Lath.). Swamp Sparrow

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *M. fasciata* but darker especially on the crown, more washed with buff below and more narrowly streaked with deeper black on the throat.

Above, cinnamon-brown, dull chestnut on the crown, streaked with black. No obvious median crown stripe. Superciliary line olive-gray duskily spotted. Wings and tail black, edged largely with chestnut, the wing coverts and tertiaries paler. Below, dull yellowish white washed with deep buff on sides of chin, across jugulum, on sides, flanks and crissum and narrowly streaked with black except on the chin and mid-abdomen. Bill and feet pinkish buff, the former becoming dusky, the latter sepia-brown.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult beginning the end of August which involves the body plumage and the wing coverts, but usually not the rest of the wings nor the tail.

Above, similar to the previous plumage, the back and the lateral crown stripes showing more chestnut; a grayish nuchal band. Below, unlike previous plumage, grayish white, cinereous on throat obscurely streaked with a darker gray, washed on the flanks and often on the breast with olivaceous wood-brown obscurely streaked or spotted with clove-brown. Rictal and submalar streaks black bordering a grayish or yellow tinged chin. Superciliary line clear olive-gray or yellow tinged; postocular streak black; auriculars bistre.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves chiefly the crown, chin and throat, but not the wings nor the tail. The amount of renewal varies according to individual, and may be quite extensive; a few feathers of most of the body tracts are usually renewed. Early April specimens from the south show the prenuptial moult in progress. The chestnut cap with black forehead, white chin, and clear cinereous gray of the throat, sides of head and neck are assumed, and a nearly complete renewal is indicated in some cases judging by the freshness of the feather borders.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in August and September. Practically indistinguishable in many cases from first winter, but usually with more chestnut on the crown, the superciliary line and sides of neck a clearer darker gray, the chin not yellow tinged but white and a grayer cast of plumage everywhere perceptible.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird. It seems to me that unless the crown feathers are renewed by moult, more specimens would show the black terminal spot which on feathers of the winter plumage reaches to the forking of the first pair of barbs. It is not an easy point to determine in species showing great wear, although the line of demarcation between areas of old and new feathers is usually marked.

Female.—The sexes are practically indistinguishable in all plumages, but the female is usually duller and browner, the crown with less chestnut and more streaked especially in the autumn. The prenuptial moult is more limited.

Passerella iliaca (Merr.). Fox Sparrow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired no doubt by a complete postnatal moult. I have been unable to obtain any specimens at this stage, but judging by *P. iliaca unalaschensis* the plumage probably resembles the first winter dress, being browner with paler edgings and more streaks above, and darker with heavier dusky streaking below. The wings and tail (as seen in the next plumage) are clove-brown with walnut-brown edgings, the wing coverts probably with more buff than in first winter plumage.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Above, olive-brown, streaked broadly with burnt-umber, the wing coverts walnut-brown, darker on inner webs and tipped faintly with pale buff. Below white, the sides of the chin, the breast, the sides and flanks broadly streaked with walnut-brown, the streaks coalescing on the sides of the chin and mid-throat; the anterior part of the abdomen with dusky spots.

4. First Nuptial Plumage acquired by wear which produces slight changes. A few new feathers are usually acquired about the chin in March, possibly the beginning of a more extensive moult. My latest spring specimen is April 8th.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike and the moults correspond although females may average duller in colors.

Pipilo erythrophthalmus (Linn.). Towhee

1. Natal Down. Pale clove-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, cinnamon-brown (often darker) somewhat obscurely striped, broadly on the back, more narrowly on the crown, with deep olive-brown. Wings dull black, the primaries with edgings and a patch at their bases white, the tertiaries with broad edgings of buff and walnut-brown, the innermost white edged, the wing coverts with buff or pale cinnamon edgings. Tail deeper black than the wings, the three outer rectrices with subterminal areas of white. Below, dull white, strongly washed with buff or pale yellow, cinnamon tinged on breast, flanks and crissum, and streaked on the throat and sides with dull black. Bill and feet pinkish buff, the former becoming slaty black, the latter dusky sepia-brown. Iris, sepia-brown becoming deep red during the winter.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of August, which involves the body plumage, the wing coverts, the tertiaries and the tail but not the primaries, their coverts, and the secondaries. Young and old become almost indistinguishable except by the browner primary coverts of the young birds.

Whole head, throat, breast, back, rump, wing coverts and tertiaries jet black; abdomen pure white, the sides and flanks rich chestnut, the crissum cinnamon. The upper tail coverts are usually edged with cinnamon and the back sometimes has obscure Vandyke-brown edgings. The tertiary endings are pale buff with walnut, those of the inner tertiary nearly white.

4. First Nuptial Plumage acquired by wear which is marked by the end of the breeding season producing a ragged plumage, but the black areas do not fade perceptibly and the chestnut flanks fade but very little. The brown primary coverts are the distinguishing feature of young birds.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning early in August. Differs from first winter dress chiefly in the blacker wings, especially the primary coverts and deeper wing edgings. Old and young now become indistinguishable.

6. Adult Nuptial Plumage acquired by wear and differing from first nuptial by black instead of brown primary coverts. A few feathers may be assumed by moult on the chin and elsewhere, but they are insignificant in numbers.

Female.—In juvenal plumage olive-brown wings and tail replace the black ones of the male. The first winter plumage, acquired by a moult of similar extent to that of the male, differs in having the head, back, throat and breast, brown instead of black. Adult and young females cannot be distinguished in this plumage. The first nuptial is acquired by wear and the adult winter by a complete postnuptial moult. Subsequent plumages do not differ, females never assuming the black areas of the male.

Cardinalis cardinalis (Linn.) CARDINAL

1. NATAL DOWN. Mouse-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, sepia-brown, wings darker and suffused with dull dragon's-blood and brick-red, the tail, crest and forehead largely brick-red, traces of black on lores and chin. Below wood-brown, cinnamon tinged on throat, sides and flanks. Bill and feet pinkish buff assuming when dry a dusky clay-color.

3. FIRST WINTER PLUMAGE acquired by a complete post-juvenal moult beginning about the middle of August.

The scarlet plumage, practically indistinguishable from the adult, is assumed, but it is usually much veiled with olive-gray. The bill assumes the reddish color of the adult later.

4. FIRST NUPTIAL PLUMAGE acquired by wear which produces little difference in the color except that the red is more prominent through loss of the gray edgings.

5. ADULT WINTER PLUMAGE acquired by a complete post-nuptial moult. Practically indistinguishable from first winter dress, but with less veiling, and a reddish bill.

Female.—The moults and plumages correspond to those of the male, but after the juvenal plumage, in which the sexes are alike, is put aside, females are distinguishable by their brownish dress brightened with dull red. The black of the head is always dull.

Habia ludoviciana (Linn.). ROSE-BREASTED GROSBEAK

1. NATAL DOWN. White.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including sides of the head, olive-brown with cinnamon and whitish edgings. Wings and tail darker, a white area at the base of the primaries, the rectrices faintly buff tipped, the coverts edged with buff forming two nearly white wing bands. Below, pure white usually a few olive-brown streaks on the sides of the chin and throat. Broad superciliary lines and central crown stripe white, buffy tinged. The edge of the wing is of a pale rose-pink; under wing coverts duller, salmon tinged. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning the middle of August, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Above, raw umber streaked with clove-brown darkest on the pileum which has a central buff stripe, the feathers white at their bases. Below, ochraceous buff, white on chin and abdomen, streaked on throat, breast and sides with clove-brown; a geranium-pink area on the jugulum veiled with ochraceous buff. Auriculars sepia bordered with clove-brown. Superciliary stripe and suborbital region white, tinged with buff, the lores grayish buff. The under wing coverts bright geranium-pink, those of the edge of the wing black spotted, the lesser coverts or "shoulders" with a carmine tinge. Two wing bands buff.

4. First Nuptial Plumage acquired by a partial prenuptial moult, late in the winter as indicated by South American specimens, which involves the body plumage, the tertiaries, most of the wing coverts and the tail, leaving often only the brown and worn primaries, their coverts and the secondaries.

Above, including sides of the head and neck, wing coverts, tertiaries and tail, black the body feathers with broad buff or wood-brown edgings, the coverts and tertiaries tipped with white, the three outer rectrices with large white terminal spots. The throat has a large geranium-red or pale crimson patch extending into the chin and down the middle of the throat. Less vigorous individuals may assume a body plumage largely veiled with brown, a small area of crimson, and only stray rectrices or wing coverts here and there are replaced by black ones.

The individual variation is great and all sorts of mixed plumages may be seen, the brown, worn wings and other left-over feathers showing such specimens to be young birds.

5. Adult Winter Plumage acquired by a complete postnuptial moult early in August. Easily distinguishable from first winter dress by the jet black wings and tail. Adults are less veiled, the brown deeper and the carmine more extensive often covering the whole throat and breast and invading the abdomen and the crown. A few black spots laterally replace the streaking of the young bird. The wing edgings are whiter than those of the first winter dress. Young and old become practically indistinguishable except that some of the less vigorous individuals may be deficient in depth of color.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves the body plumage but not the wings nor the tail. Distinguishable from first nuptial by the black wings and worn tail. The retained tertiaries and secondaries become much worn and the terminal spots are gradually lost often leaving gaps in their place.

Female.—The female is streaked with brown and possesses salmon-colored or cadmium-yellow under wing coverts in all plumages. In first winter plumage, lacking the pink throat of the male ; the under wing coverts, regularly cadmium-yellow. The nuptial plumages are acquired by wear alone or by a very limited prenuptial moult.

Guiraca cærulea (Linn.). Blue Grosbeak

1. Natal Down. Brownish mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, bistre, grayish on the rump, russet tinged on the pileum, the feathers with wood-brown or russet edgings. Wings and tail dull clove-brown, with wood-brown edgings, two indistinct wing bands and narrow tipping of the tail buff. Below rich clay-color, pale buff on the chin, abdomen and crissum. Bill and feet dusky pinkish buff becoming darker

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in August, which involves body plumage and wing coverts but not the rest of the wings nor the tail.

Similar to the previous plumage the browns everywhere darker and richer especially noticeable on the median wing coverts which become deep hazel, the crissum which becomes cinnamon or dusky-streaked and the lores which are dull sepia-brown.

Further material may show that a few blue feathers are assumed by some young males, at this moult.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves a variable amount of the brown body plumage and wing coverts, the tail wholly or in part and apparently the outer primaries in some cases. A mixture of brown and blue results, the key to the age of a specimen being the retained brown primary coverts. The moult must occur in midwinter judging by the worn condition of spring specimens.

5. Adult Winter Plumage acquired by a complete postnuptial moult. The full blue plumage is assumed, veiled with cinnamon feather tips on the head and back, a deeper band across the throat, these edgings very pale elsewhere below. The wings are black with blue edgings, those of the lesser and median coverts rich chestnut, of the greater coverts paler, of the tertiaries still paler; the tail darker than the wings and with deeper blue edgings, the outer pair of rectrices narrowly tipped with white. The lores are black.

6. Adult Nuptial Plumage acquired by wear through which the veiling is usually wholly lost, birds becoming almost completely blue except the wings and tail. The prenuptial moult of the first year is evidently not repeated.

Female.—The plumages and moults correspond but the female never acquires much blue, remaining in a brown plumage like the male first winter. In first winter plumage the female is pale cinnamon-brown darkest on the head and palest below and on the rump; the wings and tail deep olive-brown; the wing bands pale chestnut, the one at tips of greater coverts paler. The first nuptial plumage, assumed almost wholly by wear, is paler, the brown fading. The adult winter plumage usually shows a bluish tint in the wing edgings, the wings and tail being darker than in first winter dress. More mature birds may show blue feathers on the rump, crown, sides of head, sides of throat and across the jugulum but do not often acquire a plumage as bright as that of the male in first nuptial plumage.

Passerina cyanea (Linn.). Indigo Bunting

1. Natal Down. Brownish mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, dark sepia-brown, wings darker, the primaries and secondaries edged with pale wood-brown, the coverts and tertiaries with pale cinnamon. Tail pale clove-brown, more or less faintly edged with greenish or glaucous blue. Below, dull white, washed with raw umber-brown on breast, sides and crissum and narrowly streaked with sepia on the breast and sides. Bill and feet pinkish buff, the former becoming dusky, the latter dull black with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning late in August which involves the body plumage, the wing coverts, sometimes the tail and sometimes five or six distal primaries.

Similar to previous plumage but with very indistinct streaking and whiter below, and not so brown above. Above, bistre often washed with Mars-brown, the rump and upper tail coverts often dull blue, brown edged, the wing coverts edged with cinnamon or russet, the lesser often with a bluish tinge, the others nearly black, blue tinged. Below, dull white, washed on breast, sides and crissum with wood-brown, often russet tinged and indistinctly streaked with olive-gray.

The renewal of the tail and primaries is a fact shown by several specimens in moult and can probably be laid to individual precocity of southern-bred birds. Mr. Wm. Palmer has loaned me two young birds (Nos. 3283, Sept. 17th, and 3655, Oct. 2d) taken at Washington, D. C., both showing a postjuvenal moult in the remiges and rectrices nearly completed, and I have seen a few other similar birds.

Dull blue feathers veiled with brown edgings are found sparingly on the chin and throats of some specimens, these birds also showing precocity by bluer wing coverts. At this moult the tail and part of the flight feathers sometimes acquire their blue edgings, although this renewal is apt to be deferred till late in the winter. A similar moult takes place in some Song Sparrows (*M. fasciata*) but never deferred till winter. A new body feather and a worn one of this plumage are figured (**plate VI, figs. 1 and 2**) as they appear under the microscope, but owing to difficulties in reproduction, **fig. 2** does not resemble **fig. 1** as closely as the feathers themselves resemble each other.

4. First Nuptial Plumage acquired by a partial prenuptial moult chiefly in February and March which involves a varying number of body feathers, the tail, five or six of the distal primaries sometimes all (but not their coverts except in some cases the first), most of the wing coverts, the tertiaries and perhaps a stray secondary, less often all of them. Two specimens (U. S. Nat. Mus., Nos. 107844 and 107845) taken March 11th in the Bahamas shows actual moult of the body plumage, coverts, primaries and tail, the brown primary coverts remaining, and a number of other specimens (many unfortunately without dates on

the labels) from Central and South America and the West Indies, show abundantly the growth of new feathers, at the prenuptial moult, when the greatest complications of plumage regularly arise, not only in this species but in many others. In precocious individuals the renewal may be nearly complete except usually the primary coverts, secondaries and abdominal feathers and there is an almost unbroken series to individuals that have only renewed a feather here and there. This moult produces a variety of birds, *all with brown primary coverts*, some specimens being as bright blue as are adults; usually, the new blue body feathers, unworn and of peculiarly slender barbs sometimes white tipped, are mixed in with the bleached much abraded feathers of the first winter plumage. One of them is figured on **plate VI, fig. 3.** Abrasion of the lower parts brings into view the dull blue or gray bases of the old feathers, the buff edgings of which become faded and nearly white. Two kinds of blue feathers are therefore found not only here but on the rump and head, one bright and new the other dull and worn. The renewal of the wing coverts is very often incomplete and a mixture of blue and brown results. The most surprising renewal is that of the distal primaries *without their primary coverts*, four to six being renewed sometimes asymmetrically in the two wings by quills that have blue edgings of various depth of color in contrast to the older and more worn ones adjacent. Five or six seems to be the usual number replaced, and their color is regularly darker than the old ones. A new black tail edged with blue is assumed unless it has already been acquired at the postjuvenal moult. Dull white feathers frequently appear on the chin. The bill becomes slaty. It is natural to assume that birds which acquired new wings and tail in the autumn are the worn duller specimens we find in May, while the brighter less worn birds are those which have acquired these feathers at a more recent date. Both classes show recent growth of the blue body feathers, and the slenderness of the barbs of nuptial feathers as compared with the blunter ones of the winter dress ought effectually to dispose of the superfluous idea that color change without moult can take place in this species.

5. Adult Winter Plumage acquired by a complete postnuptial moult.

Strikingly different from first winter dress in the depth and richness of the brown and the marked blueness of the wings and tail. Above, Mars- or mummy-brown conceals the dull blue bases of the feathers except where these are less broadly tipped as on the rump and upper tail coverts. Below, the brown is paler and chiefly on the breast and sides, veiling bases that are cerulean-blue. The chin, abdomen and crissum are almost white displaying better the concealed blue. The wings and tail are black, edged with blue, the tertiaries and coverts with Mars-brown, and the lesser coverts are almost wholly bright blue, the others tinged with a darker shade; the primary coverts are black, edged with blue which is apparently pale in the less precocious birds and deeper in those more vigorous.

Adults and young become practically indistinguishable. The birds with the brighter wing edgings are probably birds more than one year old or possibly more vigorous individuals.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage, part of the wing coverts and tertiaries, but not the rest of the wings nor the tail. The less vigorous birds retain old worn wing coverts or stray feathers scattered especially on the abdomen and crissum, elsewhere assuming a greenish blue plumage purplish on the head. The structure of these feathers differs from those assumed at the postnuptial moult as may be seen under the microscope, but does not differ from those acquired at the first prenuptial moult (see **plate VI, fig. 3**). The blue of the head is always deeper than elsewhere, and the feathers of the lores and interramal space are black. Wear of adult birds has very likely given rise to the idea of a color change without moult, as they do become preceptibly bluer in a cage from gradual loss of the brown autumnal edgings which conceal the blue beneath.

Female.—The plumages and moults of the female correspond to those of the male, the prenuptial moult, especially the first, apparently limited or sometimes suppressed. In juvenal plumage practically indistinguishable from the male, but with little or no greenish or bluish tint in the tail. In first winter plumage browner than the male and lacking the blue tinge usually present. In first nuptial plumage (which is in many cases apparently the result of wear) a greenish tail and few greenish edged primaries are assumed together with a few whitish feathers below. In adult winter plumage, similar to first winter, but with the wings and tail greenish edged, and lower parts less obviously streaked. The adult nuptial plumage is attained chiefly by wear.

It is scarcely necessary to add there is not the slightest evidence of the color change without moult that has been claimed in this species. I have examined large series which show the transition stages from one plumage to another and such evidence of an abnormal color change as has hitherto been offered does not accord with the simple facts.

Passerina ciris (Linn.). Painted Bunting

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, olive-brown. Wings dull clove-brown with sage-green edgings, brownish on the coverts. Tail dull olive-green. Below, pale grayish drab washed with buff most marked posteriorly. Orbital ring pale buff. Bill umber-brown, the upper mandible darker. Feet dark sepia in dried specimens.

3. First Winter Plumage acquired by a postjuvenal moult which seems to be complete, one specimen from South Carolina taken October 13th being in this dress.

Above, bright olive-green or oil-green. Wings and tail deeper brown than in juvenal dress, the coverts wholly oil-green and the remiges and rectrices edged with a slightly paler shade. Below, olive-yellow becoming maize-yellow posteriorly and dull lemon anteriorly. Orbital ring lemon-yellow.

Judging by spring specimens the individual variation is considerable, some being yellower and some greener, a few acquire a blue feather or two about the head and others even a few reddish feathers below.

4. First Nuptial Plumage acquired by wear. Young males at this stage resemble the average adult female but may usually be distinguished from them by browner more worn primary coverts which do not show greenish edgings and are possibly the retained juvenal coverts.

5. Adult Winter Plumage acquired by a complete postnuptial moult. The brilliant colors of this species are assumed

by both young and old, but it is probable that year-old birds do not acquire remiges and coverts wholly claret tinged like adults. This accounts for the green feathers mixed with the others in many specimens in which all the feathers are equally worn. The claret and the greenish remiges and the body plumage are equally fresh in November birds. The claret tinged tail is first assumed at this moult.

6. Adult Nuptial Plumage acquired by wear. It is probable that all birds with stray green remiges are birds of the second nuptial stage, those with all of the remiges claret tinged of the third nuptial. The primary coverts are usually claret tinged at both stages and unlike the brown ones of the first nuptial period. The full adult dress is certainly assumed at the second postnuptial moult and in some cases, if not many, probably at the first.

Female.—The moults and plumages correspond to those of the male. In juvenal plumage the wings and tail are duller ; in first winter dress, relative dullness prevails but the sexes scarcely differ, and the first nuptial assumed by wear is characterized by worn brown primary coverts as in the male. At the first postnuptial moult females assume bright green edged remiges, rectrices and primary coverts and are even greener above and yellower below than males in first winter dress. At the second postnuptial moult or later ones birds tend toward the plumage of the male developing blue or dull red feathers where brighter areas occur in the male.

It follows that many males cannot be certainly distinguished from females by plumage characters, but the absence of mixed plumages of old and new feathers, as found in *Passerina cyanea*, disproves any semiannual moult as in the latter species.

Spiza americana (Gmel.). Dickcissel

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, clay-color, a few broad dull black stripes on the back, the crown bordered laterally with obscure black stripes. Wings and tail dull black, the primaries and rectriees with whitish, the secondaries with cinnamon, the tertiaries and coverts (including two paler wing bands) with clay-colored edgings. Below, cream-buff, clay-colored across throat, on sides and crissum. Superciliary stripe ochraceous buff, auriculars sepia-brown; lores, rictal and submalar stripes dusky. Bill and feet pale pinkish buff becoming dusky with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning in Kansas early in July which involves the body plumage, wing coverts and tertiaries, but not the rest of the wings nor the tail.

Similar to previous plumage. Above, including auriculars sepia or wood-brown narrowly and obscurely streaked on the pileum and broadly on the back with black; the tertiaries edged with cinnamon; the wing coverts almost entirely cinnamon-rufous or rich russet. Below, the chin and abdomen pale buff, the throat, sides and crissum deep wood-brown with obscure narrow black streaks, two more distinct streaks bordering the chin laterally. Superciliary and malar stripes and usually the jugulum dull ochre-yellow sometimes brighter, "edge of the wing" lemon-yellow; lores and subocular streak grayish.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March and early April in Texas which involves the head, throat and breast, but not the rest of the body nor the wings and tail.

The grayish pileum tinged anteriorly with yellow, the plumbeous auriculars and bright lemon of the superciliary and malar stripes and of the breast and mid-abdomen, the white chin and the black throat patch are acquired by moult, the browns of the winter dress becoming gray from marked wear. The amount of black and of yellow is variable; I have seen two specimens with the throat patch Mars-brown. Young and old become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs from first winter chiefly in possessing a veiled black throat patch smaller than in nuptial dress. Adults have more yellow and richer grayer wing edgings than young birds.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage females are indistinguishable from males. The first nuptial is acquired by a limited prenuptial moult. In subsequent plumages the throat remains pale brown with lateral black chin streaks without the black patch of the male and the colors elsewhere are regularly duller.

Calamospiza melanocorys (Stejn.) LARK BUNTING.

1. NATAL DOWN. Mouse-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, clove-brown, the feathers with broad wood-brown edgings which are darker on the crown and rump and form an indistinct median stripe on the crown. Wings deep olive-brown, the outer primaries usually dull black, everywhere rather broadly edged with white, including the secondaries and the primary coverts; the greater coverts largely pinkish buff, forming a broad wing band. Tail dull black tipped with white spots, the outer pair of rectrices edged with white, the the others with cinnamon. Below, white, tinged with cream-buff and streaked, except on the abdomen, with dull clove-brown. Auriculars and lores dusky. Bill and feet in dried specimen, clay-color.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult which involves the body plumage and wing coverts, but not the remiges nor rectrices.

Above, olive-brown with darker streakings. Below, white, streaked with clove-brown, least on crissum, abdomen and throat, but the streaks aggregating into a blotch on the breast. The chin dull black, entirely veiled with broad white edgings. The greater coverts pale cinnamon forming a broad wing band. The tertiaries and other wing coverts are edged with deep cinnamon.

Some young birds become indistinguishable from adults.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult in April in Arizona which involves most of the body plumage, tertiaries and wing coverts but not the rest of the wings nor the tail. The jet-black dress is assumed, relieved by white bands on the wings. Browner and more worn remiges with traces of the edgings partly worn off distinguish young birds from old, this feature being especially marked among the primary coverts.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult occurring during September in Mexico.

The wings and tail are much blacker than the first winter dress and lack almost wholly the edgings of this period. The edgings of the throat are less extensive and consequently the chin is distinctly black, the color extending to the breast more or less. The wing bands are a deeper cinnamon and so too the edgings of the tertiaries.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage as in the young bird from which it may be distinguished by the blacker remiges and rectrices with absence of edgings.

Female.—The moults and plumages correspond to those of the male. Practically indistinguishable from the male in juvenal and in first winter plumage, although rather duller, and with narrower wing bands. All later plumages resemble that of the male in first winter dress, but some of the older birds are much blacker and with broader streakings.

TANAGRIDÆ

The Tanagers are peculiar in their moults as might be expected with such highly colored birds. *P. erythromelas* acquires the full red plumage at the first prenuptial moult, goes back to a greenish dress at the postnuptial and continues to undergo a semi-annual moult regularly from green to red in spring and from red to green in fall. *P. ludoviciana* also moults twice every year. *P. rubra*, on the other hand, has but one prenuptial moult, a mere scattering of red feathers very often, and afterwards continues in the red plumage renewed only at the postnuptial moult.

Piranga ludoviciana (Wils.). Louisiana Tanager

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, yellowish green obscurely streaked. Wings and tail dull black, edged with olive-yellow, forming on the coverts two wing bands. Below, pale yellow with dusky streaks on the breast, similar to the young of other Tanagers.

3. First Winter Plumage acquired by a partial postjuvenal moult, in July in California, which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Differs from previous plumage in being unstreaked and brighter colored. Above, olive-yellow, brownish on the back, the wing bands strongly tinged with lemon-yellow, the one at tips of greater coverts palest. Below, clear lemon-yellow, a slight orange tinge often on forehead and chin.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage, tail, wing coverts and tertiaries. The coverts as in other species are irregularly renewed, the brown worn primaries, their coverts, the alulæ and secondaries in contrast to the new coverts and tertiaries which are black, edged with canary-yellow and white respectively. The back is black with smoke-gray edgings and the rest of the plumage canary-yellow of variable depth according to individual variation, the forehead and chin more or less bright with cadmium-orange.

5. Adult Winter Plumage acquired by a complete postnuptial moult and similar to first winter dress but of a richer yellow with jet-black wings and tail, the back black, with bright olive-green edgings, the head and chin usually more deeply tinged with orange, sometimes with dusky edgings on sides of the chin and jugulum. Young and old become indistinguishable.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves the same body areas as in the young bird but not the wings nor the tail, consequently old and young may be told apart during the breeding season by the brown wings of the young bird, black ones of the old. An undated specimen from Orizaba, Mexico (Coll. Am. Mus. Nat. Hist., No. 40842) shows new nuptial feathers pushing from their sheaths on the crown, throat and back, the wings proving it to be an adult.

Female.—The plumages and moults correspond to those of the male. The juvenal dress is practically indistinguishable from that of the male. The first winter plumage is rather duller, being browner above and paler below. The first nuptial plumage is acquired by a very limited prenuptial moult, such wing coverts as are acquired being duller than those of the male and the few orange-tinged feathers paler, the whole bird paler and grayish. The adult winter plumage is brighter than the first winter, and in adult nuptial plumage a few orange feathers may appear acquired by prenuptial moult.

Piranga erythomelas Vieill. SCARLET TANAGER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, olive-yellow, including sides of head and neck, the back greener with dusky edgings. Wings and tail dull brownish black, the secondaries, wing coverts, tertiaries and rectrices edged with olive-yellow, whitish on the tertiaries and primaries. Below, dull white, sulphur-yellow on the abdomen and crissum, broadly streaked on the breast and sides with grayish olive-brown. Bill, pinkish buff, slate-black when older. Feet pinkish olive-gray, dusky when older. Differs from *P. ludoviciana* in the crown being darker and lacking distinct wing bands.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult beginning the middle of August which involves the body plumage, and the wing coverts, but not the rest of the wings nor the tail.

Differs from previous plumage chiefly in being unstreaked. Above, including sides of head deep olive-yellow or pale olive-green. Below, citron-yellow. The wing coverts are jet-black edged with olive-yellow, but frequently only a part of them are renewed.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult probably in March and April which involves the body plumage, wing coverts, tertiaries and the tail but not the primaries, their coverts, the secondaries and usually not the alulæ. The body plumage becomes scarlet vermilion varying in intensity sometimes pale or mixed with orange, usually paler but often indistinguishable from the adult. The tibiæ become black and red often retaining a few old greenish feathers. Black tertiaries and black wing coverts without edgings are assumed in sharp contrast to the worn brown flight feathers which mark adults in nuptial dress. It is not unusual for only a part of the wing coverts or tertiaries to be renewed and as a freak, scarlet coverts are occasionally assumed. Greenish feathers of the first winter dress left over are comparatively infrequent on the body, the moult usually being quite complete.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult beginning early in August. Year-old as well as adult birds acquire jet-black wings and tail which distinguish them from first winter birds, and usually the yellow green is deeper.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves the same body areas as in the young bird from which easily distinguishable by the completely black wings. The greater wing coverts are not renewed as at the first prenuptial moult. The tails show some wear as compared with those of young birds. The vermilion body plumage will probably average deeper.

Female.—The plumages and moults of the female apparently correspond to those of the male, but the color is greenish at all seasons. In natal down and juvenal plumage the sexes are indistinguishable. In first winter plumage the female is greener with less yellow and duller than the male and without black wing coverts. The first nuptial plumage is yellowish and so fresh that a prenuptial moult is indicated, probably more limited than that of the male. At the postnuptial moult an orange tinged adult winter plumage is acquired and sometimes black wing coverts appear, seen in the adult nuptial plumage in which only the body feathers are renewed by a limited prenuptial moult.

Piranga rubra (Linn.). Summer Tanager

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, ruddy or yellow tinged sepia-brown with darker edgings and feather centres producing a faintly streaked appearance. Wings deep olive-brown with olive-yellow or greenish edgings, usually reddish tinged on the outer primaries, the coverts duller, the tertiaries paler. Tail bright olive-green or olive-yellow often reddish tinged basally, the shafts sepia-brown. Below, dull white tinged with sulphur-yellow on abdomen and crissum, distinctly and broadly streaked on the throat, breast and sides with deep olive-brown. Bill and feet pinkish buff becoming dusky clay-color, the feet darker.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning in the South early in July which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Unlike previous plumage, unstreaked. Above pale olive-green with a strong orange tinge, reddish in many specimens. Below chrome-yellow often strongly tinged with orange especially on the crissum and "edge of the wings." The wing coverts are edged with olive-green strongly tinged with yellow or orange according to individual vitality. The orbital ring is usually chrome-yellow or paler.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves portions of the body plumage, wing coverts, tertiaries and the tail. There is an unusual amount of individual variation in the extent of this moult accentuated by the contrast of the new vermilion or poppy-red feathers among the old greenish or yellow ones. Some birds become entirely red except for the old greenish primaries, their coverts and the secondaries and there are all sorts of intermediates ranging down to those with a mere sprinkling of red feathers. The central quills only of the tail may be renewed, sometimes only part of the tertiaries and wing coverts, but in every case it is easy to see that the process of moult has stopped at points where the checking of its normal advance would produce the varied plumages found. The freshness of the red feathers compared with the green ones is also easily demonstrable. I have also seen two undated specimens, one from Guatemala, showing red feathers still in their sheaths here and there among the brown ones.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in August. The full red plumage including the wings and tail is acquired at this moult. It will be observed that this species does not revert to the greenish dress of the first winter like *P. erythomelas*.

6. ADULT NUPTIAL PLUMAGE acquired by wear which is not very perceptible even on close examination of the feathers. The color of breeding birds is pinkish or geranium-red when compared with *P. erythomelas*. There appears to be no second prenuptial moult in this species.

Female.—The plumages and moults correspond to those of the male, but the plumage remains similar to that of the male in first winter and the first and only prenuptial moult is mostly suppressed. Adult females may be red tinged, but regularly they are even yellower than the male in first winter dress.

HIRUNDINIDÆ

The Swallows, like the Flycatchers, afford in their moulting, some problems that existing material scarcely suffices to solve, for with the exception of *T. bicolor*, they migrate southward in the autumn before acquiring their winter dress, so that a mere handful among hundreds of specimens examined, show signs of moult before they have passed beyond the borders of the United States. A few specimens from Mexico and Central America show that both adults and young birds reach these countries in worn nuptial and worn juvenal plumages respectively and two or three more afford evidence of a mid-winter moult, the occurrence of which has been previously affirmed by other observers.

From these meagre facts and from the study of the feathers, which, on account of the metallic colors and the aërial habits of the Swallows, show little evidence of wear, we may not draw positive conclusions, but two at least may be reached with considerable certainty. The first is that adult Swallows undergo a complete postnuptial moult late in the fall, either while on their southward journey or at its conclusion; and the second is that young Swallows undergo a complete postjuvenal moult (or prenuptial perhaps in point of time) later than the postnuptial of the adult. More specimens are needed to fix the limits of these two moults, but I am of opinion that mid-winter birds in moult will all prove to be young ones. It may perhaps be expedient to call this a prenuptial moult and consider the postjuvenal suppressed, but this is only a matter of convenience and would not alter the facts nor disturb my scheme of plumages and moults which has been devised so as to give clear expression to the facts. These may be found discussed under each species, and I hope a much larger fund of material may accumulate within a few years now that I have pointed out the deficiencies in that at present available for study.

Progne subis (Linn.). Purple Martin

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including wings and tail, sooty or clove-brown, the forehead and a nuchal band grayish, the feathers of the head and back indistinctly dull steel-blue. Feathers of the wings with very narrow whitish edgings. Below, white, mouse-gray on chin, throat, breast, sides and tibiæ, the feathers of the chin, lower breast and abdomen with narrow dusky shaft streaks. Bill and feet brownish black.

This plumage is worn a long time and is still retained when the birds leave for the south early in September.

3. First Winter Plumage acquired probably by a complete postjuvenal moult. Similar to the previous plumage but darker, the throat browner while scattered patches of steel-blue feathers are acquired. A specimen (U. S. Nat. Mus., No. 122944, ♂, August 3d, Maryland), which from the date might be a year-old bird, has partly renewed two proximal primaries, an outer rectrix and some of the body plumage.

4. First Nuptial Plumage acquired apparently by wear alone. It is impossible to estimate just when the feathers of this plumage are assumed, because all the Swallows show very little wear owing to their habits and to the structure of their feathers. The immature mixed blue and gray plumage is peculiar to the first breeding season.

5. Adult Winter Plumage acquired by a complete postnuptial moult after the species has departed south. A specimen in my collection (J. Dwight, Jr., No. 560, ♂, Connecticut, August 16th) shows the proximal primary of each wing just sprouting and a bird, perhaps *P. s. hesperia* (U. S. Nat. Mus., No. 128306, ♂, September 13th, Nicaragua) has renewed two proximal primaries and a few body feathers. The steel-blue plumage is assumed and old and young become indistinguishable. A white patch is exposed if the posterior feathers of the humeral tracts be disarranged.

6. Adult Nuptial Plumage acquired by wear which produces practically no effect on the previous dress even late in the summer. Florida specimens of March 11th to 14th are in fresh plumage but show no direct evidence of recent moult.

Female.—The female has similar plumages and moults, but is always duller than the male, lacking most of the steel-blue above and all of it below. In juvenal plumage the gray collar is much browner than that of the adult female and the under tail coverts are grayish white with dusky shaft streaks instead of smoke-gray with whitish edgings. The lines on the breast are broader. Later plumages are alike but females show more wear than males.

Petrochelidon lunifrons (Say). Cliff Swallow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult. Above, including wings and tail clove-brown, the pileum and back greenish with obscure metallic reflections, each feather edged with drab, a nuchal band drab ; the whole rump and usually the forehead (on which are often scattered a few white feathers), cinnamon. The tertiaries are broadly and some of the wing coverts narrowly edged with cinnamon. Below, dull white, strongly washed on the throat, sides, and crissum with vinaceous cinnamon ; the chin and forepart of the throat showing a curious mixture of white, dull black and cinnamon-rufous feathers, sometimes one color and sometimes the other predominating, the white perhaps entirely absent and replaced by black. Lores and auriculars dull black. Feet dull sepia. Bill dull black.

This plumage is worn for some time, part of the edgings being lost and it is not replaced before the birds depart southward the end of August or early in September. Several specimens from Central America still retaining this plumage, are dated October 20th.

3. First Winter Plumage acquired probably by a complete postjuvenal moult in the winter habitat so far as may be estimated from the changes found in the plumage on the return of the species in May. Wear is somewhat evident even in the wings and tail although the resistant metallic feathers show little of it. At all events the glossy blue of the head and back and the rich chestnut of the chin and auriculars with the black throat spot are acquired. The breast and throat feathers now have shaft streaks and the cinnamon crescent on the forehead is conspicuous.

4. First Nuptial Plumage acquired, in all probability, wholly by wear.

5. Adult Winter Plumage acquired by a complete postnuptial moult after the species has departed south. Evidently indistinguishable from the first winter dress. An adult female (Am. Mus. Nat. Hist., No. 40264) in worn nuptial dress, taken

in Brazil and without other data, retains only two old primaries, the others and part of the body plumage being in process of growth at the usual points.

6. ADULT NUPTIAL PLUMAGE acquired by wear.

Female.—The sexes are practically alike, although the female usually has less black on the chin, and the moults are undoubtedly similar.

Chelidon erythrogastra (Bodd.). BARN SWALLOW

1. NATAL DOWN. Smoke-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, dull iridescent green (less often blue), browner on the pileum, the forehead russet and a faint nuchal band grayish. Wings and tail dull greenish black, rectrices with large subterminal white spots, the *outer pair with broad, rounded apices reaching less than one inch beyond the central pair.* (See **plate II, fig. 20.**) Below, pale cinnamon often vinaceous, the chin and throat much deeper and russet tinged, a broad incomplete slate-black band across the jugulum. Lores and auriculars dull black. Feet sepia. Bill dusky except a pinkish lower mandible, wholly black when older.

This plumage is still worn, its pink tinge somewhat lost when the birds leave for the south about the end of August.

3. FIRST WINTER PLUMAGE acquired probably by a complete postjuvenal moult.

It is evident, as with the other species of Swallows, a complete moult occurs before this species returns to our latitude in the spring. Two specimens from South America, taken in February, show primaries and tails with adherent sheaths and fresh body plumage, but it is impossible to say whether they are adults or young birds; and two others from Corumbá, on the boundary between Brazil and Bolivia, March 23d (Amer. Mus. Nat. Hist., Nos. 31164 and 31166), are also in fresh new plumage. The new attenuated lateral rectrices (**plate II, fig. 21**) extend fully one and one-quarter inches beyond the middle pair. Greenish wings are acquired together with the metallic purplish feathers of the jugular band. The chin and throat become chestnut and the lower parts darker cinnamon. Old and young become indistinguishable.

4. First Nuptial Plumage acquired apparently by wear which produces little effect on the iridescent feathers, or possibly by a complete prenuptial moult (if the postjuvenal is considered as suppressed), as indicated by the specimens to which reference has just been made.

5. Adult Winter Plumage acquired by a complete postnuptial moult, after departure for the south. Probably indistinguishable from first winter dress although I have seen no birds identified as adults after the postnuptial moult. A specimen (Amer. Mus. Nat. Hist., No. 28100, ♀, October 3d, Arizona) is still in worn nuptial dress.

6. Adult Nuptial Plumage evidently acquired by wear.

Female.—The sexes are practically indistinguishable in all plumages, although the female in nuptial dress is often if not regularly much paler below than the male.

Tachycineta bicolor (Vieill.). Tree Swallow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and neck, wings and tail sooty brown the tertiaries slaty with faint grayish edgings. Below, pure white, a very faint incomplete sooty collar on the jugulum. Lores dull black. Bill dull black. Feet pinkish buff becoming dusky with age.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning late in August and extending into October, as shown by large series, young and old becoming practically indistinguishable.

Unlike previous plumage. Above, iridescent green, sometimes with steely blue reflections. Wings and tail deep bottle-green slightly iridescent, the tertiaries broadly tipped with white. Below, pure white slightly smoky gray on the sides.

A tertiary of this plumage is figured on **plate II, fig. 6,** and the effect of wear may be seen by **fig. 7.**

4. First Nuptial Plumage acquired by wear only obvious in the entire loss of the white tips of the tertiaries, one of which is figured on **plate II, fig. 7.** The wings become a trifle browner as the summer advances.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult beginning the middle of August. Practically indistinguishable from first winter dress, possessing the same white tipped tertiaries, but usually the head and back show blue rather than green metallic reflections. This is the only one of our Swallows that completes its moult before migrating southward. It breeds early and moults early as compared with the others.

6. ADULT NUPTIAL PLUMAGE acquired by wear through which the white tips of the tertiaries are lost as in young birds, specimens thus becoming wholly steel-blue above.

Female.—The female has corresponding plumages and moults, but is usually duller with less iridescence and browner wings and tail until the adult winter plumage is assumed which is usually indistinguishable from that of the male.

Clivicola riparia (Linn.). BANK SWALLOW

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including sides of head, brownish mouse-gray, most of the feathers edged with pale drab. Wings and tail dull brownish black, the wing coverts and tertiaries edged with pale cinnamon, the rectrices with grayish white. The tail is rounded, only slightly forked and without the indistinctly barred or "watered" effect usual in the adult. Below, white, a broad pectoral band mouse-gray, or dull clove-brown with cinnamon edgings, the chin tinged with cinnamon, and flecked with faint dusky dots. Lores dull black. Bill dull black. Feet sepia becoming black.

Birds migrate southward in this plumage before September, some of the edgings having been lost by wear. A specimen from Tehuantepec, Mexico, October 13th, still retains this dress.

3. FIRST WINTER PLUMAGE acquired probably by a complete postjuvenal moult. The new tail is more deeply forked and is indistinctly barred. The chin is pure white without spots and the collar is darker. Young and old evidently become indistinguishable.

4. FIRST NUPTIAL PLUMAGE acquired evidently by wear, which is very marked in this species as compared with the Swallows of iridescent plumage. The wings and tail are darker

than those of the juvenal plumage, and this points to their having been completely renewed during the winter absence.

5. Adult Winter Plumage acquired by a complete postnuptial moult. This dress is assumed after the birds have moved southward in the autumn.

6. Adult Nuptial Plumage acquired by wear.

Female.—The sexes are indistinguishable in all plumages, and the moults are probably identical.

Stelgidopteryx serripennis (Aud.). Rough-winged Swallow

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep sepia-brown, edged with cinnamon-rufous. Wings and tail clove-brown, the coverts, secondaries and tertiaries edged with cinnamon-rufous. The outer edge of the first primary is without hooklets and therefore not rough to the touch. Below, dull white, the breast and throat vinaceous cinnamon. Bill and feet dusky flesh-color, becoming black.

There is some fading and loss of feather edgings before the birds leave us in the autumn.

3. First Winter Plumage acquired by a complete postjuvenal moult after the birds have migrated southward in September, or very likely while they move leisurely along in flocks. One young female (Am. Mus. Nat. Hist., No. 71520, October 24th, Key West, Florida), shows six new primaries partly grown in each wing and a few new body feathers. Judging by spring specimens taken in May the plumage when fresh must be deep sepia-brown, darker on the pileum, with dusky shaft streaks and slightly paler, indistinct edgings. Wings and tail darker than in juvenal dress, males acquiring the saw-toothed outer primary. Below dull white with a brownish mouse-gray pectoral band.

4. First Nuptial Plumage acquired by wear which is much more marked than in Swallows having iridescent plumage.

5. Adult Winter Plumage acquired by a complete postnuptial moult after the birds have migrated southward. An

adult male (Am. Mus. Nat. Hist., No, 53251, September 20th, Arizona), has just begun the postnuptial moult, having renewed three primaries of each wing and a few of the body feathers.

6. Adult Nuptial Plumage acquired by wear.

Female.—The sexes are practically alike and the moults, no doubt, correspond. The first primary is usually less distinctly rough-edged.

AMPELIDÆ

Both species of Waxwings moult in the same way, having only a single annual moult, young birds assuming their body plumage by a postjuvenal moult which is partial.

Ampelis garrulus Linn. Bohemian Waxwing

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including lesser and median coverts, grayish hair-brown tending below to heavy streaking on breast and abdomen which are grayish white centrally. Crissum pale vinaceous cinnamon. Chin grayish with obscure dusky spotting and bordered by dusky lateral lines. Lores and circumocular region black. Wings dull black, the secondaries and primary coverts broadly tipped with white, the inner primaries tipped with primrose-yellow on the outer web, the outer two or three with white. The secondaries usually have about four waxy, vermilion appendages, smaller and fewer than in adults. The crown feathers are lengthened into an insignificant crest. Tail drab-gray, black subterminally with a narrower terminal band of canary-yellow. Bill and feet black.

The wing pattern, much grayer tints and cinnamon crissum distinguish young birds from those of *A. cedrorum* in corresponding plumage. The description is from two birds taken on the Yukon River, N. W. T., and kindly loaned me by Dr. L. B. Bishop.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts, but not the remiges nor rectrices.

Everywhere rich drab, grayer below and on rump, fawn-color about the head. A large black chin patch, the black extending to lores and forehead and bordered everywhere by rich walnut-brown.

4. First Nuptial Plumage acquired by wear which is not marked.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Adults are somewhat grayer than young birds, the primaries are edged with bright lemon-yellow and tipped with white so as to form a sort of a terminal L and the waxy appendages are more numerous, larger and better formed. Young and old become indistinguishable.

6. Adult Nuptial Plumage acquired by wear.

Females.—The moults and plumages correspond to those of the male. In juvenal dress the spots on the primaries are paler than in the male and often wholly white, and the appendages few or none. The black chin patch of later plumages is apt to be smaller and duller than that of the male and the appendages fewer, with paler spots on the primaries.

Ampelis cedrorum (Vieill.). Cedar Waxwing

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head and wing coverts, olive-brown. Below, paler with darker broad fused stripes on the throat, breast, sides and flanks, the chin paler, the abdomen and crissum dull white often yellow or buff tinged. A crest not well marked is found on the crown. Anterior frontal feathers, lores and partial orbital ring dull black; posterior quadrant of orbital ring, submalar streak and narrow superciliary line white or pale buff. Chin bordered laterally by dull black. Wings and tail slate-black, the primaries ashy edged, occasionally some of the secondaries tipped with bright vermilion wax-like appendages, the tail terminated with a lemon-yellow band, the rectrices also occasionally but infrequently tipped with similar red appendages. Bill and feet sepia, becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning in September which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Similar to previous plumage, but the brown much paler and the streaking absent. Above, including sides of head and throat silky drab merging into plumbeous gray on the rump and paling on the crown where the feathers are basally white. The crest marked. The abdomen and flanks are pale canary-yellow; the crissum white. Chin black merging into the brown throat. Narrow submalar stripe and part of orbital ring white. Forehead at nostrils, lores, superciliary stripe and part of orbital ring black.

4. First Nuptial Plumage acquired by wear which scarcely shows in the soft, silky plumage till late in the autumn when fading becomes apparent.

5. Adult Winter Plumage acquired by a complete postnuptial moult usually begun in September. Practically indistinguishable from first winter dress, the red wing appendages perhaps more frequent.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically alike in plumages and moults, but the female usually has less black on the chin and the wax-like tips probably less frequently develop.

LANIIDÆ

Our two Shrikes appear to moult the same, apparently having a semiannual renewal in both young and old birds. Young acquire full adult body plumage at the first prenuptial moult, retaining the immature remiges until the first postnuptial.

Lanius borealis Vieill. Northern Shrike

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, brownish mouse-gray with indistinct dusky vermiculations, especially on the rump. Wings black, a white area at bases of the primaries ; the coverts, tertiaries and secondaries edged with wood-brown, or pale cinnamon mottled from irregular extension of the color, and similar tipping on the rectrices which are black, the lateral ones largely white. Below mouse-gray, nearly white on mid-abdomen, indistinctly vermiculated, more marked on sides and crissum. Bar though eye dull clove-brown ; lores grayish. Bill and feet dusky wood-brown in dried skin.

Description from a bird taken in Labrador.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage, and wing coverts, but not the rest of the wings nor the tail.

Above, French gray washed with brownish gray, the rump grayish white. Lesser coverts cinereous gray, the median black, the retained greater coverts dull black buff tipped. Below grayish white with distinct dusky vermiculations except on the chin, abdomen and crissum. Tail black, the three outer rectrices with much white. Lores grayish. Bar through eye dusky.

4. First Nuptial Plumage acquired by a partial prenuptial moult in March which involves the anterior part of the head, chin and throat. A whiter chin and black lores are acquired, young and old becoming practically indistinguishable. A good deal of the vermiculation is lost by wear of the feather edges.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs from first winter in having a white wing band on the greater coverts, the tertiaries and secondaries with white edgings, the wings and tail jet-black, including all the coverts. The back is grayer without the brownish tint of the young bird.

6. Adult Nuptial Plumage acquired apparently by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male. Usually browner, especially the wings and tail and with a brown transocular bar until the adult winter plumage is assumed.

Lanius ludovicianus (Linn.). Loggerhead Shrike

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, drab-gray, faintly vermiculated and with pale buff edgings; rump slightly paler. Wings and tail black, a white area at the bases of the primaries, the coverts and tertiaries buff tipped, palest on the tertiaries; the outer rectrices largely white, the central ones buff, with terminal mottling. Lores, orbital region and auriculars dull black. Below, dull white on chin, abdomen and crissum, washed on breast and sides with very pale buff or drab, vermiculated with dusky subterminal bands on each feather. Bill and feet dusky becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult in September and October, which involves the body plumage, tertiaries, wing coverts and tail, but not the rest of the wings.

Similar to previous plumage but grayer above and the vermiculations absent or very indistinct on the breast. Above, plumbeous gray, paler on rump, the posterior scapularies white. Wings and tail black except for the brown juvenal primaries, secondaries and primary coverts, the lesser coverts plumbeous, white tips to the new tertiaries and white terminal spots on the lateral rectrices. Below, dull white with dusky vermiculations sometimes faintly indicated. A broad, black bar through the eye.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult in February and March, which involves chiefly the chin, throat and head, and a few scattering feathers elsewhere, but neither the wings nor the tail. The whiter throat is the most marked change produced. The wings and tail have become brownish and show considerable wear.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in September. Practically indistinguishable from the first winter dress, but the wings and tail will average blacker.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird.

Female.—The sexes are practically alike in all plumages, but the black bar through the eye is usually duller in females, and brownish until renewed at the first prenuptial moult.

VIREONIDÆ.

The Vireos all have a single annual moult, and in arboreal species suffer very little from wear. *V. noveboracensis* is peculiar in having a complete postjuvenal moult, although I am not sure this occurs in all specimens. Young birds become practically indistinguishable from adults at the postjuvenal moult although they do not assume adult wings and tail as a rule until the first postnuptial.

Vireo olivaceus (Linn.). RED-EYED VIREO

1. NATAL DOWN. Pale drab-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult. Above, including lesser wing coverts, drab. Wings and tail olive-brown, edged with bright olive-green, brightest on the secondaries and tertiaries. Below, silky white, faintly tinged on the sides and crissum with primrose-yellow. Superciliary stripe dull white; lores and postocular streak dusky. Bill and feet pinkish buff, becoming slaty. Iris walnut-brown.

3. First Winter Plumage acquired by a partial postjuvenal moult in August and September which involves the body plumage, the wing coverts (often the tertiaries) but not the rest of the wings nor the tail.

Similar to the previous plumage but olive-green replaces the drab and a gray cap is assumed. Above, including sides of neck and edgings of wing coverts and auriculars olive-green, the pileum slate-gray bordered by two lateral dull black stripes. Superciliary line broad, grayish or buffy white. Transocular streak dusky. Below, grayish white faintly washed on the sides with olive-green and on the crissum with primrose-yellow.

In plumage young and old are practically indistinguishable in the autumn, but the iris of young birds is brown while they remain with us.

4. First Nuptial Plumage acquired by wear which is scarcely appreciable owing to the soft long-barbed feathers and the habits of the species. Some fading is apparent late in the season. The iris becomes dull red before the birds return in the spring.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter except by the red iris but possibly will average richer olive-green above with a grayer pileum, and less washed with buff below.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—The sexes are alike in plumages and moults, the females in winter dress often browner and duller than the males.

Vireo philadelphicus (Cass.). Philadelphia Vireo

1. Natal Down. Pale drab-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *V. olivaceus* and *V. gilvus*, but darker above and distinctly yellow below. Above, wood-brown, darker and olive tinged on the back and wing coverts. Wings and tail clove-brown with olive-green edgings. Below primrose-yellow, auriculars, orbital ring, and superciliary stripe buff-yellow. Lores and postocular streak dusky. Feet pinkish buff, drying to dusky wood-brown. Bill pale bistre, the under mandible pinkish, drying to a yellowish raw umber-brown. When older the bill dusky and feet slaty. Iris deep hazel-brown.

3. First Winter Plumage acquired by a partial postjuvenal

moult beginning the end of July which involves the body plumage and wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similiar to the previous plumage but greener with a grayer crown, and brighter yellow below. Above, dull olive-green, slate-gray on the pileum. Below pale canary-yellow, whiter on middle of abdomen. Sides of head pale greenish or grayish buff, superciliary stripe paler ; transocular streak dusky.

4. First Nuptial Plumage acquired by wear. The back fades a little and becomes grayer, the yellow below, paler.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress, the yellow below usually paler with a larger area of white on the abdomen.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike and the moults are the same.

Vireo gilvus (Vieill.). Warbling Vireo

1. Natal Down. Pale wood-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *V. philadelphicus* but paler. Above wood-brown, very pale on pileum and nape, darker and faintly tinged with olive on the back. Wings and tail pale clove-brown edged with dull olive-green. Below, white, the crissum tinged with pale primrose-yellow. Auriculars, orbital ring and superciliary line white. Bill and feet pinkish buff, becoming dusky and slate-gray respectively when older. Iris deep hazel-brown.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in August which involves the body plumage and the wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to the previous plumage but greener above. Above, grayish olive-brown, the pileum mouse-gray. Below, buffy white, palest on chin and abdomen, washed on the sides and flanks with greenish primrose-yellow. Superciliary line, suborbital region and orbital ring very pale buff. A dusky transocular streak. Auriculars drab.

4. First Nuptial Plumage acquired by wear which is slight. The whole plumage becomes paler below and grayer above, the buff tints being lost.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter, but with less buff in some cases.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—The sexes are alike and the moults are identical.

Vireo flavifrons Vieill. Yellow-throated Vireo

1. Natal Down. Drab.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, smoke-gray. Wings and tail black, edged with olive-gray, the secondaries and tertiaries with olive-green (the two inner tertiaries white edged), the greater and median coverts with dull white forming two wing bands. Below, silky white, the chin, throat and sides of head pale canary-yellow, the orbital ring, ocular region and superciliary stripe still paler. Bill and feet pinkish buff becoming dusky and slate-gray when older. Iris deep hazel-brown.

3. First Winter Plumage acquired by a partial postjuvenal moult in August, which involves the body plumage and the wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage but greener above. Above, including auriculars and sides of neck, bright olive-green, scapularies and rump, olive-gray. The lesser wing coverts are edged with dull olive-green, the median and greater with pure white, forming two broad wing bands. Below, bright canary-yellow extending to orbital region and superciliary stripe; abdomen and crissum white, the flanks faintly washed with olive-gray.

4. First Nuptial Plumage acquired by wear, the olive above fading a little, the yellow below hardly at all.

5. Adult Winter Plumage acquired by a complete postnuptial moult, and practically indistinguishable from first winter dress, the wing edgings, especially of the lesser coverts and of the scapularies grayer.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes and moults are alike.

Vireo solitarius (Wils.). Blue-headed Vireo

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, drab, tinged with green, pileum and auriculars drab-gray. Wings and tail clove-brown edged with olive-green, the tertiaries with white, two wing bands at the tips of the median and greater coverts white, yellow tinged. The outer rectrices partly white. Below, pure white, tinged on flanks and crissum with primrose-yellow. Obscure superciliary stripe, loral and orbital regions white; a dusky anteorbital streak. Bill and feet pinkish buff, the former becoming slaty, the latter plumbeous gray.

3. First Winter Plumage acquired by a partial post-juvenal moult in August which involves the body plumage and the wing coverts but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

Similar to the previous plumage but greener above and with a gray cap. Above, olive-green (often mixed with gray), the pileum, nape, sides of head and tibiæ slate-gray. Below, pure white, strongly washed on the sides and flanks with olive-yellow mixed with gray. Lores and orbital region conspicuously white. Orbital ring interrupted anteriorly by deep slate-gray.

4. First Nuptial Plumage acquired by wear which produces little effect, the back becoming a shade grayer.

5. Adult Winter Plumage acquired by a complete post-nuptial moult. Practically indistinguishable from first winter dress, the gray above clearer and where the orbital ring is interrupted, darker.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The female is apt to be duller especially in first winter plumage, the head browner and with a buffy wash below; but many birds are indistinguishable from males. The moults are identical.

Vireo solitarius plumbeus (Coues.). Plumbeous Vireo

This remarkably distinct subspecies, characterized by extreme paleness in all plumages, enjoys the same sequence of plumages and of moults as *V. solitarius.* In northern Mexico and in Arizona the juvenal dress is acquired chiefly during July. The postnuptial moult is completed early in August as indicated by several adults.

Vireo noveboracensis (Gmel.). White-eyed Vireo

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull brownish olive-green. Wings and tail deep olive-brown edged with bright olive-green, the tertiaries with pale buff, the greater and median coverts with straw-yellow forming two distinct wing bands. Below, dull grayish white, buffy on the throat, strongly washed on the sides and crissum with sulphur-yellow (sometimes buffy). Auriculars pale écru-drab; supraloral and orbital regions pale canary-yellow, a dusky loral streak. Bill pinkish buff, becoming dusky; feet paler, becoming plumbeous gray. Iris mouse-gray, becoming white by the following spring.

3. First Winter Plumage acquired by a complete postjuvenal moult beginning about the middle of August. The juvenal dress is worn much longer than that of the other Vireos, becoming rapidly ragged from the thicket-loving habits of the species and thus probably its complete renewal is a necessity.

Differs very little from the previous plumage. The olive-green is brighter above, markedly edged on the pileum and neck with smoke-gray contrasting with the back. The wings and tail are darker, the edgings of the wing coverts and tertiaries pale straw-yellow. The throat is grayer and the yellow wash of the sides brighter and greener.

Young and old become practically indistinguishable except by the gray iris of the young bird.

4. First Nuptial Plumage acquired by wear which is marked. The back becomes browner, and the gray is confined to the neck, but the yellow below shows little change.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress, but the yellow about the head is apt to be richer and the gray clearer. The iris is white.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike in all plumages and the moults are the same.

MNIOTILTIDÆ

Many of our Warblers undergo a semi-annual moult which is often extensive at the time of the prenuptial moult. *S. ruticilla* is perhaps unique among them in having a limited first prenuptial moult which is apparently not repeated, although I suspect a similar peculiarity may be found to prevail among several others. The prenuptial period of moult seems to be a protracted one, beginning even in November and extending into May. As most of the species are in the tropics at this time we do not know much about the changes in plumage except as we may judge from somewhat worn specimens when they reach us in the spring, and from a few extra-limital specimens. The types of moult are numerous in this large family, but with one possible exception (*Icteria virens*) the remiges and rectrices are retained until the first postnuptial moult. The renewal at the prenuptial moult varies greatly in amount and when confined to a few feathers of the head and chin is very difficult to determine. As a rule adult winter plumages and adult nuptial plumages are not very different. The juvenal plumage is quickly replaced by the first winter which is apt to resemble closely the female adult winter dress. In many species the first prenuptial moult renders old and young practically indistinguishable although such feathers of the old plumage as remain throw much light upon the age of doubtful specimens. Great confusion has existed as to the first winter or "immature" plumage of many species and still less has been known of the adult winter dress.

Mniotilta varia (Linn.). Black and White Warbler

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, wood-brown streaked with dull olive-brown, the upper tail coverts dusky; median crown and superciliary stripe dingy white. Wings and tail dull black, edged chiefly with ashy gray, the tertiaries (except the proximal which is entirely black) broadly edged with white, buff tinged on the middle one Two buffy white wing bands at tips of greater and median wing coverts. The outer two rectrices with terminal white blotches of variable extent on the inner webs.

Below, dull white, washed on the throat and sides with wood-brown, obscurely streaked on throat, breast, sides and crissum with dull grayish black. Bill and feet pinkish buff, becoming dusky with age.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in July which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Similar to previous plumage but whiter and definitely streaked. Above, striped in black and white, the upper tail coverts black broadly edged with white; median crown and superciliary stripe pure white. The wing bands white. Below, pure white streaked with bluish black on sides of breast, flanks and crissum, the black veiled by overlapping white edgings; the chin, throat, breast and abdomen unmarked.. Postocular stripe black; the white feathers of the sides of the head tipped with black.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves a large part of the body plumage except posteriorly, but not the wings nor the tail. The black streaks of the chin and throat are acquired, veiled with white, and the loral, subocular and auricular regions become jet-black. The brown primary coverts distinguish young birds and the chin is less often solidly black than in adults.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the first of July. Differs from first winter dress in having the chin and throat heavily streaked with irregular chains of black spots veiled with white edgings, the wings and tail blacker and the edgings a brighter gray.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird from which the blacker primary coverts and sometimes solidly black chin will serve to distinguish it. A specimen (Am. Mus. Nat. Hist., No. 50374, February 18th, Tehuantepec, Mexico), evidently an adult, shows renewal on the chin; also an undated bird (Am. Mus., No. 39634, Yucatan).

Female.—The female has corresponding plumages and moults, the first prenuptial moult often very limited or suppressed. In juvenal dress the wings and tail are usually browner with duller edgings and the streaking below obscure. In first winter plumage the streakings are dull and obscure everywhere, a brown wash conspicuous on the flanks and sides of the throat. The first nuptial plumage is gained chiefly by wear through which the brown tints are largely lost, the general color becoming whiter and the streaks more distinct. The adult winter plumage is rather less brown than the female first winter, the streakings less obscure and the wings and tail darker. The adult nuptial plumage, acquired partly by moult, is indistinguishable with certainty from the first nuptial.

Protonotaria citrea (Bodd.). PROTHONOTARY WARBLER

1. NATAL DOWN. Brownish mouse-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, dull brownish olive-green, yellowish on the back ; in very young birds a strong wash of Vandyke-brown prevailing which fades to gray. Wings and tail slate-black, edged chiefly with plumbeous gray, the tertiaries (and sometimes the other quill feathers) with olive-green ; the coverts edged with yellowish or greenish wood-brown palest at their tips. The rectrices are largely white. Below, wood-brown, primrose-yellow on abdomen and crissum, rapidly fading to brownish gray and white. Bill and feet pinkish buff becoming black.

Twelve specimens of various ages in my collection show remarkable variations in the depth of the brown.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult in July which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

Entirely different from the previous plumage. Chiefly of a bright lemon-yellow deepest on the crown, olive-yellow on the back merging into white on abdomen and crissum and into plumbeous gray on rump and upper tail coverts. Wing coverts plumbeous gray edged with olive-green which color also veils the yellow crown.

4. FIRST NUPTIAL PLUMAGE acquired by wear which produces very little apparent effect except by loss of some of the edgings.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress, but the wings and tail usually blacker and the edgings clear bluish plumbeous gray especially noticeable on the primary coverts.

6. ADULT NUPTIAL PLUMAGE acquired by wear and indistinguishable from the first nuptial.

Female.—The sexes are alike, although the female is apt to be of a paler yellow and the moults correspond.

Helinaia swainsonii Aud. Swainson's Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including wing coverts, pale cinnamon-brown. Below, paler cinnamon. Wings and tail olive-brown edged with olive-green. Crown with two indistinct lateral stripes pale brownish gray. A dusky transocular streak. Bill and feet pale pinkish buff. Scarcely differs from *Helmitherus vermivorus* but rather paler.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts but not the remiges nor rectrices. Young and old become practically indistinguishable.

Above, bistre, greener on the back. Below, yellowish white, shading to olive-buff on sides and flanks. Superciliary line indistinctly white ; a dusky line through the eye.

4. First Nuptial Plumage acquired by wear. The head becomes Mars-brown in contrast to the olive back, and below the plumage is somewhat paler.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The moults and plumages correspond to those of the male, and females are hardly distinguishable except by a duller line through the eye.

Helmitherus vermivorus (Gmel.). Worm-eating Warbler

1. Natal Down. Brownish mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Whole body plumage and the wing coverts cinnamon, palest on the abdomen. Wings and tail olive-brown edged with olive-green. Two indistinct lateral crown stripes brownish mouse-gray. A transocular streak dusky. Bill and feet pinkish buff remaining quite pale later.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July, which involves the body plumage and wing coverts but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

Resembles the previous plumage. Above, grayish olive-green, the lateral crown stripes and the postocular streak black, the median stripe and the superciliary lines pale buff-yellow or deep cream-color. Below, cream-color washed on the throat with buff-yellow and on the flanks with olive-buff.

4. First Nuptial Plumage acquired by wear which is not obvious, the tints fading slightly.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning about the first of July. Adults are indistinguishable from young birds although sometimes paler.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike in all plumages and the moults are identical.

Helminthophila pinus (Linn.). Blue-winged Warbler

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Entire body plumage olive-yellow darkest on the back and throat. Wings and tail slate-gray largely edged with plumbeous gray, the tertiaries and coverts with olive-yellow; the greater and median coverts tipped with white, yellow tinged. Rectrices largely white. Lores dusky. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July, which involves the body plumage and wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to the previous plumage. Above, bright olive-green, lemon-yellow on the crown veiled by greenish tips. Below, bright lemon-yellow, the crissum white or merely tinged with yellow. Transocular streak black. Wing coverts plumbeous gray, edged with olive-green, the greater and median tipped with white, yellow tinged, forming two broad wing bands.

4. First Nuptial Plumage acquired by wear which produces little change except to expose the concealed yellow of the crown by loss of the greenish feather tips.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter dress, the yellow of the crown rather more conspicuous and the yellow below a trifle deeper.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—Indistinguishable from the male in juvenal plumage; in later plumages distinguished by the duller black of the transocular streak and by very little yellow on the crown.

I am able to throw little additional light on the supposed hybrids *H. leucobronchialis* and *H. lawrencei*. Of two specimens in my collection from the same brood and fed by a typical *H. pinus* one (No. 4434, ♀, June 28th, New Jersey) is in the juvenal dress of this species with many new yellow feathers of the first winter plumage appearing, the other (No. 4433, ♂), is in similar juvenal dress, but is acquiring on the throat the black feathers of *H. lawrencei*.

Helminthophila chrysoptera (Linn.). Golden-winged Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, grayish or brownish olive-green. Wings and tail slate-black edged chiefly with bluish plumbeous gray, the coverts and tertiaries with olive-green. Below, pale olive-yellow, the throat dusky. Transocular streak dusky. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Unlike previous plumage. Above, plumbeous gray veiled with olive-green edgings; the crown bright lemon-yellow veiled posteriorly only. Below, grayish white, with yellow edgings here and there, the chin, jugulum, lores and auriculars jet-black veiled slightly with pale buff. Broad submalar stripes joining at angle of the chin, and superciliary lines white. Outer half of median and greater coverts bright lemon-yellow forming an almost continuous wing patch, lesser coverts plumbeous gray, edged with olive-green.

4. First Nuptial Plumage acquired by wear, through which the buff edgings of the black areas, the olive edgings of the back and the yellow edgings below are almost completely lost, the plumage becoming clear gray, white, yellow and black.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from the young bird, the veiling usually less marked or absent, and black occupying the whole interramal space which is white in the first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—In juvenal plumage the sexes are alike. In first winter and other plumages olive-gray, dusky on the lores and auriculars, replaces the black areas of the male, and olive-yellow marks the crown. Above, the plumage is greenish ; the submalar stripes are grayish.

Helminthophila ruficapilla (Wils.). Nashville Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Pileum hair-brown, back darker, olive-tinged, and rump olive-green. Below, pale yellowish wood-brown, straw-yellow on abdomen and crissum. Wings and tail olive-brown broadly edged with bright olive-green, the median and greater coverts tipped with pale buff-yellow forming two wing bands. Lores and auriculars mouse-gray, the orbital ring pale buff. Bill and feet pinkish buff, dusky when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail. Young and old become practically indistinguishable in many cases.

Above, grayish hair-brown becoming bright olive-yellow on the rump and wing coverts; a variable, small area of chestnut on the crown concealed by the feather tips. Below, canary-yellow, brightest on the throat, breast and crissum, slightly veiled by grayish feather tips, the flanks washed with brownish olive-buff. Sides of head and neck smoke-gray. Conspicuous orbital ring buffy white.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the crown, sides of head and throat, but not the rest of the body plumage nor the wings and tail. The head becomes plumbeous gray, the edgings only half concealing the rich chestnut of the crown. The orbital ring is white and conspicuous. Wear is marked, bringing the gray of the nape into contrast with the greenish back, later exposing the chestnut of the crown.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July, and practically indistinguishable in many cases from first winter dress, but usually the chestnut area on the crown is larger and the color deeper, the gray areas darker and the yellow below brighter.

6. Adult Nuptial Plumage acquired probably by a partial prenuptial moult as in the young bird. It does not seem probable that by wear alone the brownish gray tips of the chestnut crown feathers and the brownish gray tints of the head in autumn can become so decidedly plumbeous by spring, and besides the most worn spring birds show comparatively little wear.

Female.—The plumages and moults correspond to those of the male. The sexes are alike in juvenal plumage. In first winter plumage, the chestnut of the crown is lacking or a mere trace. In first nuptial plumage, acquired partly by a limited prenuptial moult, the chestnut is increased although new feathers both with and without chestnut grow on the crown. Two specimens from Jalapa, Mexico, April 7th (Am. Mus., Nos. 68548 and 68549), show pin-feathers on the crown and throat. The adult winter plumage is practically like the male adult winter and later plumages are very similar to those of the male, the gray and yellow usually duller.

Helminthophila celata (Say). Orange-crowned Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, brownish olive-green. Wings and tail olive-brown, broadly edged with bright olive-green, the median and greater coverts tipped with buff. Below, greenish buff paler and yellower on abdomen and crissum. Lores and auriculars grayish buff. Bill and feet pinkish buff, dusky when older.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Above, bright olive-green, mostly concealed on the pileum and nape with pale mouse-gray edgings that blend into the green. The crown brownish orange concealed by greenish feather tips. Wing coverts broadly edged with dull olive-green, sometimes the greater coverts with faint whitish tips. Below, pale olive-yellow, grayish on the chin and sides of neck with very indistinct olive-gray streaking. A dusky anteorbital spot. Lores, orbital ring and indistinct superciliary stripe mouse-gray.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the anterior part of the head and the chin. A richer, half concealed, orange crown patch is acquired; the lores and adjacent parts become grayer, the anteorbital spot darker. Wear makes birds greener above and slightly yellower below. Young and old become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs chiefly from first winter dress in possessing a larger, more distinct crown patch. The color below is uniform and paler.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult, as in the young bird. Several March specimens, apparently adults, show pin-feathers on the throat and head.

Female.—The sexes and the moults are practically alike, although the female is usually a little duller. In first winter plumage, however, the crown patch is usually wholly lacking, and the first prenuptial moult is more or less suppressed.

Helminthophila peregrina (Wils.). Tennessee Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Similar to *H. ruficapilla* but lacking the brownish cast and with a faint dusky transocular stripe. Above dull grayish olive-green, the rump brighter. Wings and tail clove-brown, the primaries whitish edged, the secondaries tertiaries and wing coverts greenish edged with two yellowish white wing bands. Below grayish buff rapidly fading when older to a greenish gray; abdomen and crissum pale straw-yellow. Trace of dusky transocular streak. Bill and feet pinkish buff, dusky when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning about the middle of July in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Resembles the previous plumage. Above, bright olive-green, gray tinged on the pileum. Below, olive-yellow darker on the flanks, the abdomen and crissum white. Superciliary line and orbital ring buff. Transocular streak dull black.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the head, chin and throat. The ashy gray cap is acquired, the chin, throat and superciliary line become white, the throat is tinged with cream-buff and the transocular streak black. The yellow tints of the feathers retained below are lost by wear.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter, but somewhat grayer above and whiter below.

6. Adult Nuptial Plumage acquired evidently by a partial prenuptial moult as in the young bird. A specimen (Am. Mus., No. 39688) from Tehuantepec, Mexico, January 14th, shows new growth of feathers about the head.

Female.—The plumages and moults correspond to those of the male. The sexes are alike in juvenal plumage. In first winter plumage differs from the male in having the lower parts more washed with olive-green. The prenuptial moult is less extensive and the crown never becomes, even in later plumages, as gray as that of the male, but always has a brown or greenish tinge.

Compsothypis americana (Linn.). PARULA WARBLER

1. NATAL DOWN. Smoke-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including sides of head, brownish olive-gray; indistinct superciliary stripe and orbital ring white, yellow tinged; faint dusky transocular streak. Wings clove-brown, the edgings chiefly olive-green, bluish on the primaries and their coverts. Two wing bands tipping coverts, white. Tail clove-brown edged with ashy blue the outer rectrices with subterminal white blotches on their inner webs. Bill and feet pinkish buff, the former becoming dusky, the latter deep sepia-brown with age.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, including sides of head, bluish plumbeous gray veiled by olive-green edgings, the back chestnut-tinged veiled by olive-yellow. Below, canary-yellow on chin and throat, veiling a pectoral band of pale chestnut, which is dusky on the jugulum and invaded by the gray of the sides of the neck. The abdomen and crissum, white, veiled slightly with edgings of canary-yellow, the sides and flanks faintly washed with cinereous gray and pale chestnut. The wing coverts are bluish plumbeous gray, broadly tipped with white yellow-tinged, forming two wing bands. Indistinct superciliary line and large suborbital spot white. A dusky transocular streak.

Young and old become practically indistinguishable in many cases, the young birds usually duller and especially lacking in chestnut on the chin.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves chiefly the head, chin and throat, but not the rest of the body plumage, the wings nor the tail. The ashy blue crown feathers faintly dusky centrally, the blackish ones of the sides of the head with a white spot above and below the eye and the yellow or chestnut-tinged chin feathers as far as the pectoral band or farther are assumed by moult. Wear brings the back into contrast with the nape and whitens the lower parts. The wings and tail are browner and more worn than in the adult, especially the primary coverts.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter

dress in some cases, but usually bluer with blacker wings and tail, with bluer wing edgings (especially the primary coverts), darker transocular streak, the edgings above more scanty, the pectoral band broader and both parts of it darker and the chin usually tinged with chestnut.

6. Adult Nuptial Plumage acquired evidently by a partial prenuptial moult as in the young bird. The bluer wing edgings and the blacker primary coverts constitute the only fairly constant differences between young and old. Differs from adult winter dress chiefly in the deeper blue of the head, blackness in loral and ocular regions with a small white spot above and below the eye, and in the unveiling of concealed tints elsewhere.

Female.—Not distinguishable from the male until the first winter plumage is assumed when the chestnut of the pectoral band is much restricted or lacking, and the upper parts are greener. The first nuptial plumage is assumed by a limited prenuptial moult, a female taken in Jamaica, West Indies, January 29th, showing actual moult on the head and throat. The colors assumed are duller than those of male in first nuptial dress but similarly distributed. The adult winter plumage resembles the male in first winter dress but the primary coverts are usually bluer and the chestnut more restricted. The adult nuptial plumage differs little from this and later plumages are always duller than those of the male.

The separation of northern birds into a subspecies known as *usneæ* is based upon extremely slender characters, the variation between individuals being greater than the differences described. The first prenuptial moult usually produces *americana* especially if it does not extend to the chestnut portion of the pectoral band. Later prenuptial moults probably produce *usneæ* with the deeper colors peculiar to adults. If it were not that some young birds also acquire deep colors, the matter would be less complicated.

Dendroica tigrina (Gmel.). CAPE MAY WARBLER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, dark hair-brown, olive tinged on the back. Wings and tail black, edged chiefly with dull brownish olive-green, the coverts with drab and tipped with buffy white. The two outer rectrices with subterminal white spots. Below, including sides of head, mouse-gray with dusky mottling or streaking on the breast and sides; the abdomen and crissum dingy white faintly tinged with primrose-yellow. Bill and feet pinkish buff becoming dusky.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning early in July in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Above, dull olive-green, each feather centrally clove-brown veiled with olive-gray edgings; the rump canary-yellow, the feathers basally black. Below, including sides of neck, superciliary lines and spot under eye, canary-yellow, palest on abdomen and crissum, narrowly streaked on sides of chin, on the throat, breast and sides with black which is veiled by grayish edgings; auriculars mouse-gray.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves much of the body plumage but not the wings nor the tail. The black crown, the streaks on the back, the chestnut ear-patches and the streaked yellow of the throat and breast are acquired. A specimen of January 30th from Jamaica, W. I., shows new growth on the throat.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in July. Similar to first winter plumage but the head black, the back streaked and everywhere veiled with smoke-gray edgings. Below, whitish edgings obscure the black streaks, the chestnut ear-coverts and the bright lemon-yellow areas. The wings and tail are blacker than in first winter, the back is black, either streaked or spotted, and the yellow below is deeper.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird. The change from the previous plumage is so slight as to suggest the possibility of wear alone, the amount of which is not, however, as strikingly variable in different spring individuals as might be expected if the young alone undergo a prenuptial moult. I confess I am in doubt, with so little available material.

Female.—Not distinguishable from the male until the first winter plumage is assumed, which is duller and browner above, and generally without yellow below, being dull white with gray streaking. The first nuptial shows a little yellow assumed by a limited prenuptial moult. The adult winter plumage is similar to the male in first winter dress, the yellow below rather paler and with less heavy streaking. Later plumages are duller than those of the male.

Dendroica æstiva (Gmel.). Yellow Warbler

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, pale olive-brown. Wings clove-brown broadly edged with bright olive-yellow paling at tips of the quills, the edge of the outer primary bright lemon-yellow. Tail pale clove-brown, the inner webs of the rectrices lemon-yellow, the outer edged with olive-yellow. Below, pale sulphur-yellow, unstreaked. Bill and feet pinkish buff the former becoming slaty, the latter deep sepia-brown.

3. First Winter Plumage acquired by a partial postjuvenal moult, early in July, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Similar to previous plumage but yellower and somewhat obscurely streaked below. Above, pale yellowish olive-green, the edgings of the wing coverts paler. Below, dull lemon-yellow obscurely, narrowly and sparingly streaked on the throat and sides with pale chestnut.

The paler yellow lower parts, but slightly streaked, distinguish young birds from old.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage, the wing coverts and the tertiaries, but not the primaries, their coverts, the secondaries, nor the tail. The whole plumage becomes golden lemon-yellow, greener above and brightly streaked on the throat, breast and sides with pale chestnut, somewhat veiled by the feather edgings. The forehead and crown are yellower than the back and usually chestnut tinged. The tertiaries and wing coverts are broadly edged with bright lemon-yellow. An undated specimen from French Guiana (Am. Mus., No. 39844),

with worn, narrowly streaked breast-feathers shows pin-feathers about the head, throat and back. This bird may be an adult female, but the fact of moult is proved just the same. Young and old become practically indistinguishable.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in July. Similar to first winter dress but the yellow richer, and streaked more or less heavily on throat and sides with pale chestnut veiled by the overlapping feather edges. The bill is usually darker. The primary coverts are darker and more conspicuously edged. The crown is not orange or chestnut tinged as in nuptial dress.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird, from which it is practically indistinguishable save in some marked cases by the darker wings and tail most obvious in the primary coverts. The yellowish orange forehead and the chestnut streaks below, heavier than in adult winter dress, are assumed at this moult.

Female.—Not distinguishable until the first winter plumage is assumed, which is paler and lacks the streaking of the male. The first nuptial is assumed by a limited prenuptial moult, becoming yellower than the previous plumage and acquiring a few obscure chestnut streaks below. The adult winter plumage resembles the first winter, but the yellow is deeper and there are a few chestnut streaks below, birds sometimes resembling quite closely males in first winter dress. Later plumages differ little.

Dendroica cærulescens (Gmel.). BLACK-THROATED BLUE WARBLER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including auriculars, olive-brown. Wings dull black, the primaries with a large white blotch basally and edged with bluish plumbeous gray, the secondaries, tertiaries and coverts with olive-green. Tail black with subterminal white blotches on the outer rectrices and edged broadly with clear bluish plumbeous gray. Below, dull brownish white, yellow tinged on throat and abdomen. Lores and two submalar streaks dusky; superciliary stripe yellowish white. Bill and feet pinkish buff, the former becoming black, the latter sepia.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in July in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail. Occasionally an old juvenal covert is retained and sometimes one or more black tertiaries or black-spotted back feathers are assumed.

Unlike the previous plumage. Above, bluish plumbeous gray bluest on the head, and everywhere veiled with olive-green edgings. Below, white, tinged with pale yellow or buff on the flanks; sides of head including superciliary line, the chin, throat, sides of breast and abdomen and the tibiæ black, veiled slightly with ashy gray, the interramal space usually white. The wing coverts are black, edged with bluish plumbeous gray. There are usually a few white feathers on the lower eyelid.

4. First Nuptial Plumage acquired probably by an extremely limited prenuptial moult confined to the head and chin. Blue-gray crown feathers and black interramal ones are assumed by moult, the greenish edgings above and the ashy ones of the black areas being lost by wear which is marked. Young and old become indistinguishable except by the brown worn wings and tail most noticeable in the primary coverts of the young bird. Although most of the white interramal feathers are basally black wear alone of this region could scarcely produce the uniformly black feathers found on spring birds.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs from first winter in being of a bluer gray above without greenish edgings, the back often with a few black spots, the crown with concealed dusky shaft streaks. The black below solid, including the interramal space, the veiling absent or slight, the primaries with a larger area of white. The wings and tail are blacker and the edgings bluer, showing well in the primary coverts. There is no white on the lower eyelid. Young and old become indistinguishable.

6. Adult Nuptial Plumage acquired perhaps by a limited prenuptial moult as in the young bird, wear producing no obvious changes. The less worn, blacker wings with bluer edgings distinguish adults from young in first nuptial dress. The freshness of crown and chin feathers, the former sometimes with blacker shaft streaks than in autumn, point to a moult.

Female.—The females have corresponding plumages and moults. Even in juvenal plumage a difference from the male can be observed in the dull brown wings and tail with greenish instead of bluish edgings, and the white area at the bases of the primaries is dingy and sometimes absent. In first winter plumage the bird is olive-green above, and yellowish buff below; the wings and tail olive-brown, the latter without white blotches, the superciliary line and the lower eyelid are buffy-white; the lores and auriculars are a dull drab. The first nuptial plumage is acquired apparently wholly by wear, which makes the bird grayer above and whiter below. The adult winter plumage is bluer above than the first winter, especially on the head, lesser coverts and wing edgings, and paler below, the tail showing traces of dingy blotches on the lateral rectrices. The white area of the primaries is larger and whiter. The lores and auriculars are dusky. The adult nuptial and later plumages are very similar to the adult winter.

I am of the opinion that the southern race described as *cairnsi* may prove to be untenable, as the blackness of the back might easily be due to age rather than locality.

Dendroica coronata (Linn.). Myrtle Warbler

1. Natal Down. No specimens seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, the feathers centrally dull black, edged with drab and buffy brown, producing a streaked effect. Below, much whiter but similarly streaked, a tinge of pale primrose-yellow on the abdomen. Wings and tail dull black, edged with drab, palest on primaries and outer rectrices. Two very indistinct buffy white wing bands. Upper and lower eyelids with dull white spots. Bill and feet dusky pinkish buff, the former becoming black, the latter deep sepia.

Birds at this stage (see *Auk*, XVI, 1899, p. 217, plate III), bear a striking resemblance to the young of *Spinus pinus*.

3. First Winter Plumage acquired by a partial postjuvenal moult, in August in eastern Canada, which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Entirely different from the previous plumage. Above, sepia-brown, grayer on the back and obscurely streaked with black, the rump and a concealed crown spot lemon-yellow, the upper tail coverts black, broadly edged with plumbeous gray. Wing coverts black, plumbeous edged and tipped with white tinged with wood-brown forming two wing bands. Below, dull white, washed with pale buff on the throat and sides and obscurely streaked on the breast and sides with black, veiled by whitish edgings. Sides of breast with dull yellow patches. Incomplete orbital ring and faintly indicated superciliary stripe white or buffy.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage and wing coverts, occasionally a tertiary but not the rest of the wings nor the tail. The black and gray of the upper surface, the white wing bars and the yellow crown and rump are new, some of the old upper tail coverts and a part of the feathers of the abdomen and crissum being retained in many cases and less often those of the back and elsewhere. Young and old become practically indistinguishable although the young usually have browner and more worn wings and tails, obvious in the primary coverts, but the differences are not absolute.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning late in July. Differs little from the first winter dress, but the wings and tail are blacker with brighter gray edgings, noticeable especially in the primary coverts. The back is usually grayer and the lower parts whiter, with broader streakings above and below.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult, as in the young bird from which the adult is usually distinguishable by blacker wings and grayer edgings, especially of the primary coverts.

Female.—The female has plumages and moults corresponding to the male, from which she is not distinguishable until the first winter plumage is assumed, and then not in all cases. The black streaking of this dress is less obvious both above and below than in the male, the plumage everywhere is browner, and the crown patch very obscure. The first nuptial plumage is assumed by a restricted moult, leaving behind many brown feathers. The brown feathers of the lores and auriculars are assumed by moult. The adult winter plumage is little different from the first winter, the wings and tail rather blacker, the edgings grayer and the streakings more obvious resembling the male in first winter dress. The adult nuptial is acquired both by moult and by wear. The most highly colored females are almost always duller than the dullest males in corresponding plumages. A large series of specimens taken every month in the year shows clearly the changes by moult and by wear in the plumages of this Warbler, which is the only one that ever passes the winter in this latitude.

Dendroica maculosa (Gmel.). MAGNOLIA WARBLER

1. NATAL DOWN. Sepia-brown.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, dark sepia-brown, soon fading, usually paler on the crown and obscurely streaked with clove-brown. Wings and tail dull black, chiefly edged with ashy or plumbeous gray, the secondaries, tertiaries and wing coverts with drab, two wing bands pale buff; the rectrices white on inner web of basal half. Below, pale sulphur-yellow, dusky or grayish on the throat and streaked or mottled except on the abdomen and crissum with deep olive-brown. Lores and orbital region ashy brown. Bill dusky pinkish buff, black when older. Feet pinkish buff, pale sepia when older.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning early in July, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Entirely different from the previous plumage. Head and nape chiefly mouse-gray, the back olive-yellow veiling black or dusky spots; rump lemon-yellow, upper tail coverts black, with broad plumbeous edgings. Below, bright lemon-yellow, white on abdomen and crissum, with an ashy pectoral band and streaked obscurely on sides of breast and on the flanks with black, veiled by overlapping yellow edgings. Wing coverts black, edged with gray or olive-green and tipped with white forming two distinct wing bands. Broad orbital ring buffy white.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves most of the body plumage, the wing coverts and sometimes a few tertiaries, but not the rest of the wings nor the tail. Young and old become practically indistinguishable except by the wings and tail, especially the primary coverts, all of which are usually browner and more worn than in adults.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Similar to the first winter dress but the streaking below broader, and the wings and tail blacker with grayer edgings ; but none of these differences are constant, and a dull adult may easily be mistaken for a high-colored young bird. Spotting on the back is more extensive and a solid patch of black may be assumed.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves the same areas as in the young bird with similar results. Black edging on the nape and a more solid black patch on the back may be acquired, with less of the greenish edgings that are common to young birds. The wings and tail being blacker, show less wear.

Female.—The plumages and moults of the female correspond to those of the male, the prenuptial moult always more restricted as is regularly the case with females of all species. The juvenal plumage is the same as that of the male, the wings and tail and their edgings duller. The first winter plumage is browner above, especially on the pileum than that of the male, the yellow rather paler below and the streaking scanty and obscure. The first nuptial plumage resembles the previous dress but the throat is distinctly streaked with black, the auriculars are blackish instead of gray, tne orbital ring whiter and posterior part of the superciliary line white. The adult winter plumage differs but slightly from first winter, the wing edgings grayer and the streaks broader, but duller than the male first winter. The adult nuptial plumage has the pileum browner than in nuptial male plumage, the streaks fewer and the black of the back merely streaks, never solid.

Dendroica cærulea (Wils.). Cerulean Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, drab with rather darker edgings. Wings and tail dull brownish black edged largely with bice-green, the primaries with bluish cinereous gray, the tertiaries with grayish white, the coverts with drab, two wing bands white. Below, grayish white, faintly tinged with primrose-yellow. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Above, deep bice-green, partly concealing cinereous gray which is conspicuous on the rump and upper tail coverts, the latter and the feathers of the back often black centrally. The wing coverts with bluish cinereous gray edgings; two wing bands white, faintly tinged with canary-yellow. Below, white, strongly washed except on chin, abdomen and crissum with primrose-yellow, the sides and flanks streaked obscurely with dull black. Superciliary line primrose-yellow; lores and orbital regions whitish; a dusky transocular streak.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves much of the body plumage and wing coverts, but not the rest of the wings nor the tail. The grayish cerulean blue, the black streaks on the back and the white wing bands are acquired; below, the plumage is white with a narrow bluish black band on the throat and the sides distinctly streaked. Young and old become practically indistinguishable, except by the duller wings and tail of the juvenal dress.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs from first winter in being much bluer and whiter, the wings and tail blacker and the edgings a bluer gray. Resembles the adult nuptial, but rather grayer on the back and the throat band incomplete.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the edgings of the wings and tail are greener tinged than those of the male. In first winter plumage the green above is duller and the black of the back and tail coverts is lacking; below there is more yellow and the side streaks are obscure. The first nuptial plumage is acquired by a moult limited chiefly to the head and throat which become bluer and whiter respectively. Later plumages are brighter, but green always replaces the blue of the male.

Dendroica pensylvanica (Linn.). Chestnut-sided Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dark raw umber-brown, obscurely streaked or spotted on the back with dull black. Wings and tail dull black, chiefly edged with ashy or plumbeous gray; the secondaries, and tertiaries with olive-yellow, the coverts with buff forming two wing bands yellow-tinged. Below, pale umber-brown, grayer on the throat and sides of head, the abdomen and crissum dull white. Bill and feet dusky pinkish buff, becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in June, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, bright olive-yellow concealing black spots on the back and rump, the upper tail coverts black, tipped with cinereous gray and olive-yellow. The wing coverts black, edged with olive-yellow, two broad wing bands canary-yellow mixed with white. Below, grayish white, pearl-gray on sides of head, throat, breast and flanks, a trace of chestnut striping the flanks terminating in a lemon-yellow spot. Conspicuous white orbital ring.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage and the wing coverts, but not the rest of the wings nor the tail. Young and old become practically indistinguishable, save for the browner wings and tail of the young bird. The yellow crown, the black and white about the head, the streaking of the back and the lateral chestnut stripes of the throat and sides are acquired.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs from first winter dress only in the broad deep chestnut stripes on the sides, the greater amount of black on the back and the slightly blacker wings and tail, with brighter edgings.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male, from which it is first distinguishable in first winter plumage when the white below is duller the sides grayer and the chestnut stripes altogether lacking. The first nuptial plumage, acquired by a limited moult, resembles that of the male in like dress but is lacking in intensity of the colors. The adult winter plumage resembles the first winter, but is brighter and with a trace of the chestnut stripes like the male first winter dress. In adult nuptial plumages, the black on the sides of head and throat is regularly duller and the chestnut striping less heavy than in the male.

Dendroica castanea (Wils.). BAY-BREASTED WARBLER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, including wings, tail and wing coverts, clove-brown, edged with pale bistre; two wing bands dull white. Below, white, thickly spotted with dull black. Bill and feet pinkish buff becoming dusky.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, in July and August in eastern Canada, which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Similar to previous plumage but unspotted. Above, yellowish olive-green with dusky streaks on the crown, a few concealed black spots on the back, the upper tail coverts cinereous gray. Wing coverts edged with olive-green and two broad wing bands white tinged with yellow. Below, cream-color washed with straw-yellow on the throat and with a very little chestnut on the flanks.

Resembles *D. striata* but a yellower olive above, a buffier yellow below and a wash of chestnut on the flanks, with less definite streaking above and none below.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult which involves most of the body plumage and wing coverts but not the rest of the wings nor the tail. The deep chestnut crown, paler throat and lateral stripes, black sides of the head and forehead, olive-gray back streaked with black, the rich buff patches on the sides of the neck and the black wing coverts, plumbeous-edged and white-tipped, are all assumed. Young and old become practically indistinguishable, adults usually with darker wings and tail noticeable in the primary coverts.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in July. Similar to first winter dress, but the crown, nape and back distinctly streaked with black, creamier tints below and the flanks striped distinctly with chestnut, the

wings and tail blacker and the edgings grayer rather than greener as in the young bird ; a few chestnut feathers sometimes appear on the throat and the crown.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male. Distinguishable first in first winter plumage, which is a clearer green without the crown streaks of the male, the black spots on the back duller and usually even a trace of chestnut is lacking on the flanks. The first nuptial plumage acquired by a limited moult approaches in pattern and color that of the male, but is much duller and the chestnut limited. The adult winter plumage is similar to the first winter, but whiter below, with a a wash of chestnut on the flanks and with crown streaks and the dorsal spots better defined, resembling closely the male first winter dress, although usually rather duller. The adult nuptial plumage is practically indistinguishable from the first nuptial, the older birds with richer colors, but the chestnut is at most merely a crown patch, a pectoral band and a wash on the sides.

Dendroica striata (Forst.). Black-poll Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, olive-gray obscurely streaked or mottled with dull black. Wings and tail clove-brown edged with dull olive-green, whitish on the tail, tertiaries and wing bands. Two rectrices with white terminal spots on the inner webs. Below, dingy white mottled with dull black. Bill and feet pinkish buff, the former becoming dusky, the latter sepia.

3. First Winter Plumage acquired by a partial postjuvenal moult, in July and August in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings and the tail.

Similar to previous plumage but unspotted. Above, including sides of head, olive-green, olive-gray on tail-coverts, rather obscurely streaked, chiefly on the back, with black. The wing coverts clove-brown edged with olive-green and tipped with white, yellow-tinged. Below, very pale canary-yellow, white on abdomen and crissum with a few obscure grayish streaks on the throat and sides. A narrow and obscure superciliary line and orbital ring pale canary yellow; the lores whitish, a faint dusky transocular stripe. One or two black crown feathers are occasionally assumed.

Resembles *D. castanea* and *D. vigorsii* but distinguishable from either of them by the streaked back and duller colors.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage, the wing coverts and tertiaries, but not the rest of the wings nor the tail. Young and old become practically indistinguishable. The black cap and black and white plumage are assumed, at first evidently, somewhat veiled by whitish edgings. The early beginning of the prenuptial moult is indicated by a specimen labeled Roraima, British Guiana, November 1st, which shows active moult in progress on the nape, back, abdomen and sides, where black and white feathers are replacing yellowish ones.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Similar to first winter dress but whiter below, the streaking often distinctly black and extending to the chin, which is spotted here and there; above the crown is decidedly streaked or marked with stray black feathers; the wings and tail are blacker and the edgings darker and grayer especially on the tertiaries. The slight sprinkling of black feathers is like that found in *Dolichonyx orizivorus* and some other species in the autumn.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The plumages and moults correspond to those of the male from which it is first distinguishable in first winter plumage, but not in every case. Females are then a little greener above and yellower below including the crissum, the streaks on the sides extremely faint. The first nuptial plumage acquired by moult is a little paler than the first winter, the head, back and sides with distinct black streaks; resembles the male in first winter dress but more decidedly streaked. The adult winter plumage is practically indistinguishable from first winter but rather paler and with the wing edgings darker. The adult nuptial plumage much resembles the male in adult winter dress and is merely tinged with yellow and streaked on crown, back, sides of chin, throat, and sides with black. The black cap and broad streaking of the male are never acquired.

Dendroica blackburniæ (Gmel.). Blackburnian Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dark sepia-brown obscurely streaked on the back with clove-brown. Wings and tail clove-brown edged with olive-buff, the tertiaries and coverts with white forming two wing bands at tips of greater and median coverts; the outer three rectrices largely white. Below, white, washed with wood brown or buff on breast and sides, spotted, except on chin, abdomen and crissum, with dull sepia. Superciliary stripe cream-buff, spot on upper and under eyelid white; lores and auriculars dusky. Bill and feet pinkish buff, becoming dusky later.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in August in eastern Canada, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, deep yellowish olive-gray, flecked on the crown and streaked on the back with black; obscure median crown stripe straw-yellow; rump and upper tail coverts black, edged with olive gray. Wing coverts clove-brown edged with olive-gray and tipped with white forming two broad wing bands. Below, straw-yellow brightening to orange-tinged lemon on the throat, fading to buffy white on the crissum and narrowly streaked on the sides with black veiled by yellow edgings. Superciliary stripe and postauricular region lemon-yellow orange-tinged. Auriculars, rictal streak and transocular stripe olive-gray mixed with black. Suborbital spot yellowish white.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves most of the body plumage (except posteriorly), the wing coverts and sometimes the tertiaries but not the rest of the wings nor the tail. The full orange and black plumage is assumed, young and old becoming practically indistinguishable, the orange throat equally intense in both, the wings and tail usually browner in the young bird and the primary coverts a key to age.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs little from the first winter dress, but the yellow more distinctly orange, the transocular and rictal

streaks, the crown and auriculars distinctly black, veiled with orange tips, the streaking below heavier and broader, the wings and tail blacker and the edgings grayer.

6. ADULT NUPTIAL PLUMAGE acquired by a partial prenuptial moult as in the young bird. Two specimens, apparently adult males judging from blackness of the primary wing coverts and other characters show this moult. One Am. Mus. Nat. Hist., No. 39748, from Bogotá, Colombia, shows many feathers in their sheaths; with No. 30330 from Quito, Ecuador, the moult is less advanced.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the wing edgings are usually duller the first winter plumage being similar to that of the male but browner, the yellow tints nearly lost and the streakings obscure and grayish. The first nuptial plumage assumed by a more or less limited prenuptial moult, is grayer above and paler below, except on the chin and throat where new pale orange feathers contrast with the worn and faded ones of the breast. The adult winter plumage is practically the same as the male first winter, the auriculars and transocular stripe usually duller. The adult nuptial plumage is brighter below than the first nuptial and with more spotting on the crown, but the black head and bright orange throat of the male are never acquired.

Dendroica dominica (Linn.). YELLOW-THROATED WARBLER

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above olive-brown with dull black streaking. Below, dull white, streaked with clove-brown chiefly anteriorly. Wings and tail dull black, edged with hoary plumbeous gray, the tertiaries with olive-gray. Outer rectrices with white spots. Bill and feet brownish black.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, early in June in Florida, which involves the body plumage and wing coverts, but not the remiges nor rectrices.

Above, smoke-gray veiled with sepia-brown edgings, the feathers of the forehead basally black. Below, white with black streaking laterally, the chin and throat lemon-yellow, bordered with black which extends to auriculars, lores and forehead. Superciliary stripe white, anteriorly tinged with lemon-yellow; white postauricular patch. Wing coverts black, the greater and middle tipped with dull white forming two wing bands.

4. First Nuptial Plumage acquired by wear which is considerable, birds becoming much grayer above and clearer white below. Young birds have browner and more worn primary coverts than do adults.

5. Adult Winter Plumage acquired by a complete postnuptial moult, beginning near Washington, D. C., late in July. Adults are grayer above with more black on the head and whiter below, while the primary coverts are blacker than in young birds. Young and old now become absolutely indistinguishable.

6. Adult Nuptial Plumage acquired by wear.

Female.—The plumages and moults correspond to those of the male, females, however, being duller in colors, much washed in autumn with brown above and below, and the black about the head dull.

Dendroica virens (Gmel.). Black-throated Green Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, sepia-brown or drab. Wings and tail dull black, edged with ashy or olive gray; two wing bands white; the outer three rectrices largely white. Below, dull white, dusky on the throat, spotted on the breast and sides with dull olive-brown. Indistinct grayish white superciliary line. Dusky transocular streak. Bill and feet pinkish buff becoming black with age.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, greenish olive-yellow, the upper tail coverts ashy or plumbeous gray edged with olive-yellow. The feathers of the crown and back especially have concealed black shaft streaks. The wing coverts are black, edged with olive-green; two broad white wing bands tipped faintly with yellow. Below, faint primrose-yellow, white on the crissum; the breast and a spot on the flanks canary, the chin, sides of head and neck and superciliary line bright lemon-yellow ; a variable area on the throat seldom including the chin, black, veiled by long yellow edgings, the sides and flanks broadly streaked and similarly veiled. Transocular and rictal streaks dusky ; lores grayish.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult, which involves chiefly the head, chin and throat and not the rest of the plumage. The black chin is assumed and the forehead becomes yellower by moult, wear removing the edgings everywhere so that the streakings below and the throat become jet-black. Young and old become practically indistinguishable, except that the wings and tail of the young bird will average browner and more worn with the edgings duller.

5. ADULT WINTER PLUMAGE acquired by a complete post-nuptial moult in July. Differs somewhat from the first winter, the black of the throat extending uninterruptedly to the apex of the chin, further down on the throat, and in broader stripes on the sides ; the wings and tail are blacker and the edgings grayer, especially on the tertiaries ; the concealed black of the back more extensive. The veiling is conspicuous on the throat.

6. ADULT NUPTIAL PLUMAGE acquired apparently by wear, through which the veiling is almost completely lost, the yellowish tips of the winter plumage barbs breaking off down to the black portion or very near to it. As *all* the black feathers of the chin in adult autumnal birds are broadly tipped with yellow, and *some* of these feathers in spring show unbroken black tips when they are examined under a glass, it is logical to assume a limited replacement which scarcely deserves the name of a moult.

Female.—The plumages and moults of the female correspond to those of the male. In juvenal plumage the sexes are practically alike. In first winter plumage the female is browner than the male, without the black throat and the side streaks obscure ; some specimens with much black may, however, easily be mistaken for dull first winter males. The first nuptial plumage differs very little from the first winter, wear bringing out the streaking, while a few feathers are assumed by moult on the chin. The adult winter plumage resembles the male first winter and may have considerable black on the throat, and even the chin. The adult nuptial plumage is, in extreme examples, hardly distinguishable from the male, but usually the black is much restricted and the chin yellow, merely spotted with black.

Dendroica vigorsii (Aud.). Pine Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, drab, shading to hair-brown. Wings and tail deep olive-brown the secondaries and rectrices with greenish gray edgings, the tertiaries and wing coverts edged with drab; two dull white wing bands. Below, olive-gray washed with drab on the throat and sides and indistinctly mottled with deeper gray. Orbital ring white. Bill and feet dusky pinkish buff becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in July, which involves the body plumage and wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Entirely different from the previous plumage. Above bright olive-green veiled with drab-gray edgings, the upper tail coverts grayer. Wing coverts black, edged with greenish olive-gray; two white wing bands. Below, including superciliary stripe and orbital ring bright lemon-yellow, fading to dull white on abdomen and crissum, veiled with whitish edgings, the flanks washed with drab-gray, a few concealed dusky streaks on the sides of the breast. Lores and post-ocular spot dusky.

4. First Nuptial Plumage acquired by wear which is excessive, birds becoming greener above and a greener yellow below by loss of the edgings, the breast streaks being also exposed.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July and August. Practically indistinguishable from first winter dress, but usually yellower, the streaking more abundant, the veiling diminished above, the wings and tail darker on an average and the edgings darker and grayer.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male from which the female is first distinguishable in first winter plumage which is much browner than that of the male, being olive-brown above and pale wood-brown below with scarcely a tinge of yellow. The first nuptial plumage is grayer and shows much wear. The adult winter plumage is much yellower than the first winter, and resembles the male first winter. The adult nuptial is the same as the previous plumage plus marked wear.

Dendroica palmarum (Gmel.). Palm Warbler

The plumages and moults correspond to those of *D. p. hypochrysea*, described below, a relative paleness and lack of yellow being found in all the plumages. If the limited prenuptial moult were to extend over the whole body this subspecies could hardly be told apart from *hypochrysea*, the new feathers being equally yellow in both and the chestnut cap of the same tint.

Dendroica palmarum hypochrysea (Ridgw.). Yellow Palm Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull sepia-brown, streaked with clove-brown. Wings and tail clove-brown, edged chiefly with dull olive-green, the coverts and tertiaries with drab cinnamon-tinged; the outer two rectrices with terminal white blotches on the inner webs; no definite wing bands. Below, including sides of head, dull white with dusky spots and streaks; chin and crissum faintly tinged with yellow. Orbital ring dull white; transocular streak dusky. Bill and feet pinkish buff, the feet darker and blacker than the bill when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, in August in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, yellowish sepia-brown, yellowish olive-green on the rump and upper tail coverts, obscurely streaked with dull clove-brown, the crown merely tinged with concealed chestnut. Wing coverts clove-brown edged with olive-green and tipped with cinnamon *not* forming wing bands. Below, canary-yellow brightest on the crissum, obscurely streaked on throat and sides with dusky chestnut everywhere veiled by overlapping whitish edgings. Superciliary line canary-yellow, orbital ring buffy white; transocular streak dusky.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the crown, sides of head, chin and throat and not the rest of the plumage. It is interesting to note that a very few new feathers are acquired on nearly all of the tracts except the alar. If they were in color contrast the effect would be not unlike *Piranga rubra* or *Icterus spurius.* A rich chestnut cap is assumed, contrasting sharply with the worn feathers of the occiput, the lores become dull black, the auriculars chestnut and the yellow of the chin and breast becomes brighter with rich chestnut streaks on the sides of the throat and breast. The streaking of the sides of the chin and across the jugulum are darker. Elsewhere a few stray feathers are acquired, as shown by a large series in actual moult, but most of the plumage of the posterior parts of the body shows a great amount of wear, as might be expected in a species of terrestrial habits. I have seen birds in moult in December and January, from Jamaica, W. I., and I have taken similar birds in Florida and Georgia in March and April and near New York city late in April.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Differs little from the first winter dress, but of a richer brown above with darker wing edgings, the chestnut more abundant on the crown and the streakings below more conspicuous.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult as in the young bird.

Female.—The sexes are very similar in all plumages, females usually a little browner and with less yellow. In first winter plumage with very little or no chestnut on the crown and later practically indistinguishable, but undergoing the same moults as the male, the prenuptial more limited.

Dendroica discolor (Vieill.). Prairie Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull olive-green, browner on the pileum. Wings and tail clove-brown edged with dull olive-green; two wing bands buff. Below, dull brownish white, pale straw-color on the abdomen. Sides of head drab; eyelids white. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Unlike, the previous plumage. Above, grayish olive-green, an area of concealed chestnut on the back. Wing coverts black, edged with olive-green; two wing bands white. Below, pale canary-yellow, streaked on the sides of the throat and breast with dull black veiled by yellowish edgings. Malar stripe and transocular streak grayish black; orbital ring, suborbital region and obscure superciliary stripe white, yellow tinged; auriculars mouse-gray.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the crown, sides of head, chin and throat but not the rest of the body plumage the wings nor the tail as shown by specimens taken in Jamaica, W. I., November 27th, December 30th, January 3d, 13th, 19th, 24th and 31st. The early date at which the prenuptial moult takes place is interesting and explains in a measure why it is so difficult to determine by examination of the feathers whether a moult has taken place. The few feathers replaced suffer from wear almost as much as those adjacent and when we first see such birds in May the evidences of moult are often completely masked. The black auriculars and transocular stripe and the yellow feathers of the superciliary stripe, the chin and throat are assumed, wear bringing the chestnut of the back into prominence. Young and old become practically indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Similar to first winter dress, but with more chestnut on the back and the streaks below broader and extending to the chin. The transocular stripe and auriculars are darker; the orbital region and superciliary line yellower.

6. Adult Nuptial Plumage acquired apparently by a partial prenuptial moult as in the young bird. Several specimens taken in Florida in March and early April show pin feathers on the head and throat. These birds, judging by the amount of chest-

nut on the back and the streaks on the sides of the throat, appear to be adults.

Female.—The plumages and moults correspond to those of the male. Indistinguishable from the male until the first winter plumage is assumed, which is browner above and paler below with fainter streaking; the auriculars and transocular streak being grayer, the chestnut on the back a mere trace; the wings and tail are duller. The first nuptial plumage, acquired by renewal of a few feathers about the head and by abrasion of the rest of the plumage with fading, differs very little from the first winter. The adult winter plumage is similar to the first winter, but yellower about the head, more distinctly and broadly streaked below, and with more chestnut on the back; very like the male first winter. The adult nuptial plumage, acquired partly by moult, resembles the male adult nuptial, differing in paler yellow, less extensive streaking, fainter chestnut of the back and grayish instead of black lores and malar stripes.

Seiurus aurocapillus (Linn.). Oven-bird

1. Natal Down. Pale sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, cinnamon-brown, sparingly spotted with olive-brown, the dusky lateral stripes faintly indicated on the crown. Wings and tail olive-brown with olive-green edgings, the coverts slightly tipped with pale cinnamon. Below, pale cinnamon, yellowish white on abdomen and crissum, faintly spotted or streaked on the sides of the chin, on the breast and on the sides with olive-brown. Bill and feet pale pinkish buff becoming very little darker when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the end of June, which involves the body plumage, the wing coverts, and rarely the tertiaries, but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

Unlike the previous plumage. Above, brownish olive-green including wing coverts and tertiaries; the crown dull orange-ochraceous concealed by brownish edgings and bordered by two black stripes extended on the nape. Below, pure white sometimes washed faintly with pale buff or olive-gray especially on the sides and flanks, the chin, abdomen and crissum sometimes faintly yellow tinged, streaked boldly on the throat, breast and sides with black slightly veiled by whitish edgings. A black submalar streak on either side of the chin. Conspicuous orbital ring, buffy white; lores grayish; auriculars obscurely dusky.

4. First Nuptial Plumage acquired by wear which is considerable but produces little effect except to expose the crown and bring the black streaks below into contrast with the white background. It may be that there is a limited prenuptial moult, but the new feathers occasionally found on April specimens are probably individual renewal scarcely deserving the name of a moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs inappreciably from first winter, the streaking below perhaps averaging blacker and the orange of the crown deeper.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable, the female in first winter plumage usually with a paler median crown stripe.

Seiurus noveboracensis (Gmel.). Water-Thrush

1. Natal Down. Deep olive-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep olive-brown with cinnamon edgings. Wings and tail darker, the coverts tipped with pale cinnamon. Below, primrose-yellow heavily streaked on the chin and less heavily on the throat, breast and sides with deep olive or clove-brown. Indistinct superciliary line and orbital ring buff; transocular stripe dusky. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July, in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

Similar to previous plumage. Above, yellowish olive-brown including wing coverts, without edgings. Below, straw-yellow palest on the crissum, the flanks washed with olive-brown, spotted on the chin and streaked, except on the mid-abdomen and crissum, with black veiled by overlapping whitish edgings. Superciliary stripe and orbital ring pale ochraceous buff; transocular streak deep olive-brown; auriculars dusky.

4. First Nuptial Plumage acquired by marked wear, birds becoming browner above and paler below, the veiling lost. It is possible there is a very limited growth of new feathers about the head, for the wear is disproportionately slight in some May specimens when we consider the terrestrial habits of the species, but the renewal hardly seems to deserve the name of a moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter, the streakings below rather broader, the wings and tail deeper in color.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike and the moults correspond.

Seiurus noveboracensis notabilis (Ridgw.). Grinnell's Water-Thrush

This darker subspecies has moults and plumages corresponding to those of *S. noveboracensis.*

Seiurus motacilla (Vieill.). Louisiana Water-Thrush

1. Natal Down. Deep olive-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep olive-brown, without cinnamon edgings. Wings and tail darker, the coverts faintly tipped with cinnamon. Conspicuous line above and behind the eye dull white. Below, yellowish white, washed on the sides and crissum with cinnamon and narrowly streaked on the chin, throat, breast and sides with dull olive-brown. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July, which involves the body plumage and the wing coverts but not the rest of the wings nor the tail.

Similar to the previous plumage. Above, deep olive-brown, much darker on the crown, which is bordered by conspicuous white superciliary stripes. The wing coverts are dark and without edgings. Below, white, buffy tinged and strongly washed on sides of the throat, flanks and on crissum with ochraceous buff. The chin is faintly flecked, the breast and sides streaked with olive-brown. Lower eyelid white ; anteorbital spot and postocular streak dusky.

4. First Nuptial Plumage acquired by marked wear through which the buff tints are largely lost, the flecks of the chin and the breast streaks diminished. Although specimens from Jamaica, W. I., in December, and from Florida in March, show a few new feathers on the chin, I doubt whether this is more than mere renewal in a species subjected to much wear. It is difficult to draw the line between moult and renewal except by the study of larger series of winter birds than are now available.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from the first winter dress.

6. Adult Nuptial Plumage acquired by wear which is marked.

Female.—The sexes are indistinguishable and the moults identical.

Geothlypis formosa (Wils.). Kentucky Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head rich olive-brown. Wings and tail rather darker, edged with deep olive-green, the wing coverts with wood-brown. Below, pale raw umber-brown, Naples-yellow on the abdomen and crissum. Bill and feet flesh-color, the former becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult in July which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Similar to previous plumage. Above, olive-green including the wing coverts. Below, including superciliary stripe, bright canary-yellow. The forehead, crown, lores and auriculars are partly black much veiled by smoke-gray edgings.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves a part of the head, chin and throat, but no other areas. The black crown with plumbeous edgings, the black lores, auriculars and a short extension on the sides of the neck are assumed, together with the yellow feathers of the chin

and superciliary stripes. Young and old become indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Differs from first winter in the crown being grayer, the black areas more defined and the edgings clear plumbeous gray, veiling the black much less.

6. Adult Nuptial Plumage acquired apparently by a partial prenuptial moult, as in the young bird, although wear alone may modify the winter plumage after the first year. The material I have examined is not conclusive upon this point.

Female.—In first winter and later plumages the female differs chiefly from the male in the black markings being duller and restricted.

Geothlypis agilis (Wils.). Connecticut Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult in all probability. Birds in this plumage have never been obtained, so far as I know, supposed ones proving to be something else. We may expect a bird most resembling *G. philadelphia*, uniformly brownish above and yellowish below, the throat and chin perhaps as dark as the back, and no streaks.

3. First Winter Plumage acquired by a partial postjuvenal moult which apparently involves the body plumage and the wing coverts and not the rest of the wings nor the tail.

Above, including wings and tail, brownish olive-green almost exactly like *G. trichas*, but usually greener and grayer. Below, unlike *G. trichas*, being canary-yellow, washed on the sides with pale olive-brown, and with broccoli-brown on the throat often concealing cinereous gray, the chin wood-brown. The orbital ring conspicuously pale buff.

4. First Nuptial Plumage acquired by a partial prenuptial moult involving much of the head and throat, which become clear plumbeous or ashy gray instead of brown, slightly veiled with olive-brown on the pileum and with drab-gray on the throat, the orbital ring white.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Differs from first winter dress in being cinereous gray instead of brown on the head and throat, palest on the chin, and slightly veiled with drab-gray on the throat, and olive-green on the crown. The back is greener and the yellow below rather brighter. The orbital ring is white. The birds with deeper plumbeous throats are probably still older. This dress differs but little from the nuptial, a fact not generally known.

6. Adult Nuptial Plumage acquired perhaps by a partial prenuptial moult as in the young bird or possibly by wear alone. Some specimens taken in spring show fresher feathers about the head than do others. Whether this denotes individual wear or only renewal in young birds, cannot be determined positively without more winter material.

Female.—In first winter plumage browner above and on the throat than the male, but often indistinguishable. The first nuptial is acquired chiefly by wear. The adult winter is similar to the first winter but rather grayer on the throat resembling the male in first winter dress. The adult nuptial and later plumages are never as gray as those of the male.

Geothlypis philadelphia (Wils.). Mourning Warbler

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Very similar to *G. trichas* but darker. Above deep olive-brown. Wings darker, edged with olive-green, the coverts faintly edged with pale cinnamon. Tail deep olive-green. Below, very deep grayish tawny-olive, abdomen and crissum pale brownish Naples-yellow. Inconspicuous orbital ring pale buff. Bill and feet pinkish buff becoming sepia-brown.

3. First Winter Plumage acquired by a partial postjuvenal moult, in August in eastern Canada, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail.

Above similar to *G. trichas* and to *G. agilis* but greener than either, with a plumbeous tinge about the head, and the yellow below brighter. There is usually a little concealed black on the throat; the chin is yellowish white. The conspicuous orbital ring and a supraloral line are pale canary-yellow, the lores dusky.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the head and throat. The plumbeous cap, the black throat veiled with cinereous, the dusky lores and the white orbital rings are assumed, the rest of the plumage showing a good deal of wear. Old feathers may be found in some cases persisting among the new.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Similar to first winter dress, but with a distinctly black chin and throat, much veiled with cinereous gray edgings.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult, as in the young bird. An undated specimen from Panama (Am. Mus., No. 39878), apparently an adult, judging by old feathers, shows new growth on the head and throat.

Female.—The plumages and moults correspond to those of the male. In first winter plumage the throat is browner and in but slight contrast to the breast, scarcely distinguishable from the male first winter dress of *G. agilis.* The first nuptial plumage is acquired chiefly by wear. The adult winter plumage resembles the somewhat grayer first winter male. The later plumages are similar, no black being assumed on the throat.

Geothlypis trichas (Linn.). Maryland Yellow-throat

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, pale olive-brown of variable depth, greenish on the upper tail coverts. Wings olive-brown edged with olive-green, the median and greater coverts faintly tipped with cinnamon. Tail bright olive-green. Below, tawny wood-brown, Naples-yellow on the abdomen and olive-yellow on the crissum. Inconspicuous orbital ring pale buff. Bill and feet pinkish buff becoming deep sepia with age.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning about the middle of July, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Unlike previous plumage. Above, deep olive-brown, greener on the upper tail coverts, the crown and forehead tinged with Mars-brown, the forehead frequently with a very few feathers black basally. The wing coverts chiefly olive-green. Below, bright lemon on the chin, throat and crissum, pale straw-yellow on the abdomen, the flanks washed with olive-brown, and a very faint buffy pectoral band. The malar and auricular regions show traces of the black "mask" varying from a few black feathers to a considerable area always veiled by ashy edgings. The black seldom invades the lores and forehead and never the orbital ring as in the adult. The orbital ring is buffy white.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the forehead, crown, sides of head and chin and not the rest of the plumage. These areas are somewhat worn, as a rule, when the birds reach New York in May, but specimens from Jamaica, West Indies, taken December 2d, January 9th, 22d and 24th and February 4th show actual moult in progress. It is not surprising that the feathers assumed then should show considerable wear before May. The black feathers of the "mask" are acquired, those of the upper margin of this area broadly tipped with pearl-gray which becomes ashy with wear. This gray band, posteriorly on the crown, has its feathers tipped with Mars-brown and the basal black gradually diminishes more posteriorly as the extent of brown on each feather increases. There is a yellow tinge in some of the feathers. The width of the band varies greatly. The bright yellow chin is also acquired and young birds and old become indistinguishable.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July and August. Differs from the first winter dress in possessing a complete black "mask," which includes the forehead, lores, orbital ring and auriculars, only the forehead and the auriculars being slightly veiled. The "mask" has a distinct cinereous posterior border veiled on the crown with Vandyke-brown. The yellow below is deeper and the brown wash on the flanks darker in most cases. Six specimens out of twenty-two in this plumage show a few white feathers in the orbital ring usually confined to the lower eyelid, and three out of twenty-three spring males show the same peculiarity which seems to be purely individual peculiar possibly to the younger birds.

6. Adult Nuptial Plumage apparently acquired by wear, although I think there must be a limited prenuptial moult if it deserves the name. I have examined specimens of this species taken every month in the year, but I have seen only a few young birds showing actual moult in February, March and April. The adult nuptial and winter plumages are so extremely similar that wear alone might convert the latter into the former, but even with the large series I have examined positive conclusions are not possible.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the sexes are alike. In first winter plumage the female is much browner, the yellow of the lower surface is wholly replaced by buff, and there is no black about the head. The first nuptial dress is assumed by a limited prenuptial moult (sometimes suppressed) illustrated by a specimen of February 4th. Later plumages differ little, except in yellowness, from the first winter dress and no black is ever assumed about the head.

Icteria virens (Linn.). Yellow-breasted Chat

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, grayish olive-brown. Wings and tail olive-brown, edged with dull brownish olive-green. Below, ashy gray washed with olive-gray across the jugulum and on the sides. Auriculars grayish and lores dusky with a trace of white above the eye. Bill and feet pinkish brown, the former becoming slaty and the latter black.

This plumage has been figured in colors (*Auk*, XVI, 1899, pp. 217–220, pl. III).

3. First Winter Plumage acquired by a complete postjuvenal moult after the middle of July. Two specimens examined show a complete moult in progress and the color and shape of rectrices in the limited material at my disposal points to this unusual moult, for this is the only Warbler known to me that renews wings and tail at this time.

Unlike the previous plumage. Above, brownish olive-green, the wings and tail darker than in juvenal plumage and with greener edgings. Below, bright lemon-yellow, somewhat veiled with olive-gray, the abdomen and crissum dull white, the sides washed with olive-brown. Lores, suborbital region and postocular stripe dull black, veiled with ashy feather tips. Superciliary, suborbital and malar stripes white.

Young and old become practically indistinguishable although young birds are rather duller.

4. First Nuptial Plumage acquired by wear which is marked, but produces little obvious effect, the browns and greens fading somewhat, the yellow very little.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter dress, the black areas about the head averaging blacker.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—Differs very little from the male and has the same moults. In first winter plumage the lores are merely dusky and the yellow below is paler, these differences usually persisting in later plumages.

Sylvania mitrata (Gmel.). Hooded Warbler

1. Natal Down. Pale sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, pale yellowish wood-brown, edged with Mars-brown, drab when older. Wings and tail deep olive-brown, edged with olive-green, brightest on the secondaries and tertiaries, the wing coverts edged with pale wood-brown, often darker. Below, primrose-yellow, washed with wood-brown on the throat, breast and sides. The three outer rectrices largely white on their inner webs. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning the end of June which involves the body plumage and the wing coverts but not the rest of the wings nor the tail. Young and old become practically indistinguishable.

The crown occiput, sides of neck, whole throat and part of the chin are jet-black veiled with narrow edgings of lemon-yellow most marked on the throat. The rest of the upper surface and the sides are bright olive-green; the forehead, sides of head, anterior part of chin breast, abdomen and crissum are rich lemon-yellow; the forehead partly veiled with olive-green or dusky tips, the lores with black ones.

The replacement of the juvenal plumage of this species has been minutely traced by Palmer, '94, and his conclusions are supported by the material I have at hand. Like many other species popularly supposed to require several years for the attainment of adult plumage, the male Hooded Warbler within a few weeks assumes a dress differing very little from the adult. Any specimens with partly black "hoods" labelled in collections as males have been incorrectly sexed. It seems to me the yellow deepens as the layers of growing feathers are superimposed rather than there being an actual deepening of color in the later bred birds as suggested by Mr. Palmer.

4. First Nuptial Plumage acquired by wear which is not very obvious, the black areas losing the veiling yellow tips. The olive-green above becomes grayer and wear brings into prominence a slight grayish collar bordering the black "hood."

5. Adult Winter Plumage acquired by a complete postnuptial moult the last of June and in July. In some cases scarcely distinguishable from the first winter but usually the yellow edgings are absent or very obscure. The black occupies the whole chin up to its apex and the yellow below is richer.

6. Adult Nuptial Plumage acquired by wear as in the young bird, from which it is usually indistinguishable. The black feathers of the adult winter plumage are more resistant to wear than the yellow-tipped ones of the first winter, the barbs of which will be found broken off near the black basal portion.

Female.—The plumages and moults correspond to those of the male, from which indistinguishable until the first winter plumage is assumed. This lacks the black of the male and is uniform olive-green above and lemon-yellow below, occasionally one or two black feathers being assumed on the crown. The first nuptial plumage acquired by wear is, of course, plain olive-green and yellow. The adult winter plumage assumed by a complete moult shows a variable amount of black about the head and throat. How much of the black is due to individual vigor and how much to successive postnuptial moults is a question not easily answerable. We know that some females in the breeding season are almost indistinguishable from males, and there are all sorts of intermediates from these mature birds down to those of the worn first winter dress, which are guiltless of black.

Sylvania pusilla (Wils.). Wilson's Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, sepia or hair-brown mottled with sepia. Wings and tail dull olive-brown edged with olive-green; wing coverts paler and indistinctly edged with buff. Below, primrose-yellow washed with pale wood-brown on the throat and sides. Bill and feet pinkish buff becoming dusky.

Resembles *S. mitrata* but darker above and on the throat, with paler abdomen; also *S. canadensis* but with darker, greener edged wings and tail; and easily mistaken for *G. tri has* but less tinged with brown.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, including wing coverts, bright olive-green the pileum black, veiled more or less with brownish olive-green feather tips. Below, including sides of head and forehead, lemon-yellow, brightest on the superciliary line and orbital ring.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the head, chin and throat. The clear black cap, sometimes with a few greenish edgings posteriorly, is assumed, the structure of the feathers differing from those of the previous plumage, and some yellow feathers are renewed on the throat. The yellow below is resistant to fading, the back becoming grayer. Young and old become indistinguishable. Several specimens from Jalapa, Mexico (Am. Mus., Nos. 68553 and 68554), taken in March, show pin-feathers on chin and crown.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Similar to the first winter, but the cap clear black, sometimes slightly veiled posteriorly, the yellow below perhaps averaging deeper.

6. Adult Nuptial Plumage acquired perhaps by a partial prenuptial moult or perhaps by wear alone. The wear of the black feathers of the crown cannot be safely estimated, and I have seen no birds while in the moult which at best is limited.

Female.—The plumages and moults correspond to those of the male. The sexes alike in juvenal plumage. In first winter plumage the cap is wholly lacking or sometimes suggested by a few black feathers laterally. The first nuptial plumage is acquired by a limited prenuptial moult, the crown becoming partly black, concealed by greenish edgings. The adult winter plumage is much like the male first winter. The adult nuptial plumage differs little from the adult male nuptial. A March bird from Mexico (Am. Mus., No. 68568), in moult, is apparently an adult.

Sylvania canadensis (Linn.). Canadian Warbler

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, sepia and, when older and faded, hair-brown. Wings and tail dull olive-brown, faintly edged with dull olive-green; wing coverts paler and indistinctly edged with buff. Below, primrose-yellow washed with pale wood-brown on the throat and sides. Bill and feet pinkish-buff becoming dusky. Practically indistinguishable from *S. pusilla* except by duller wing edgings.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in July in eastern Canada, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Above, cinereous gray, browner on the back, the crown yellow-tinged and sometimes flecked with black; wing coverts uniform with the back. Below, including supraloral line lemon-yellow, the orbital ring paler, a narrow "necklace" of small black spots on the jugulum the black extending to the auriculars and lores, slightly veiled by overlapping yellow edges; the crissum dull white.

The black is very dull and much less extensive than in the adult, some specimens hardly distinguishable from females.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves chiefly the head, chin and throat, and not the rest of the plumage. New black, ashy edged crown feathers

are assumed contrasting with the worn occipital ones, while the yellow or black ones assumed elsewhere are less obviously fresh. Wear is soon quite marked, the upper parts becoming grayer.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Quite different from first winter dress, the black "necklace" being of heavy streaks and the black area on the lores and crown larger; black feathers with broad grayish edgings are assumed on the crown, and the wing edgings are apt to be grayer and bluish instead of greenish.

6. Adult Nuptial Plumage acquired apparently by wear, although it is likely there is some new growth. It seems to me the edgings of the crown feathers of the most worn spring specimens are grayer and longer than could result from wear, which is considerable in this species. Winter material is needed to be sure which condition regularly prevails.

Female.—The plumages and moults correspond to those of the male from which the female is first distinguishable in first winter dress. This is a little paler than that of the male without black on the crown which is brownish in contrast to the back and the "necklace" consists of obscure grayish lines. The first nuptial plumage, acquired by a very limited moult, differs very little from the previous plumage which is modified by wear. The adult winter plumage differs slightly if any from the first winter; it has a bluer gray tint on the back and the crown is yellow-tinged rather than brown. The adult nuptial dress is usually marked by the "necklace" and lores being more distinctly black and frequently dusky spotting on the forehead, but the female may never be mistaken for the male except possibly in a few rare cases.

Setophaga ruticilla (Linn.). American Redstart

1. Natal Down. Hair-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of the head, deep sepia-brown. Wings and tail deep olive-brown, the basal portion of the primaries, secondaries and outer rectrices pale lemon-yellow, the secondaries and tertiaries edged with dull olive-green, the coverts with wood-brown paler at their tips. Below, pale primrose-yellow, hair brown on the chin, throat and breast. Bill and feet dusky pinkish buff darkening to brownish black when older.

3. First Winter Plumage acquired by a partial postjuvenal moult beginning early in July, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail.

Unlike the previous plumage. Above, the pileum, nape and sides of the neck mouse-gray, the back olive-green, often tinged with brownish orange, the upper tail coverts clove-brown. The wing coverts become dull olive-green. Below, dull white, ashy and pinkish buff suffusing the chin and throat, an orange-ochraceous or deep chrome-yellow area on either side of the breast, the color tingeing the breast and sides. Orbital ring, white.

4. First Nuptial Plumage acquired by a partial prenuptial moult, which involves chiefly the head and throat, where a few black feathers in patches are acquired. A few may be found scattered sparingly elsewhere and new white feathers on the chin are the rule. The prenuptial moult is late, probably in March and April, for growing feathers occur on birds taken near New York city in May. Abrasion and fading make birds paler above and whiter below. The distribution of black feathers is not unlike that of the new feathers assumed by *Icterus spurius*, *Piranga rubra* and other less conspicuously colored species like *Dendroica palmarum*, but in this species, which is unique among our Warblers during the first breeding season in wearing an immature dress strikingly different from the adult, the renewal is reduced to a minimum.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. The black and orange-red dress is assumed, the black feathers often having a faint buffy edging. Sometimes the orange basal part of the primaries or of the rectrices fails to develop and yellow, as in the first winter, takes its place. One specimen in my collection has six secondaries and the adjacent tertiary of one wing, and the rectrices with yellow; another has one secondary with yellow. Other than these I have seen no evidence of failure to attain fully adult dress at this moult.

6. Adult Nuptial Plumage acquired by wear. The abrasion of the black plumage is in places so slight that there might be some replacement by new feathers, but it is not apparent. Fading is not obvious, except of the flight feathers.

Female.—The plumages and moults correspond to those of the male. First differs in first winter plumage which is browner, the breast patches merely yellow tinged and the basal part of the rectrices much paler yellow, this color usually absent from the base of the primaries and reduced in extent on the secondaries. Some specimens are much like males. The first nuptial plumage is acquired by a very limited, sometimes suppressed prenuptial moult. The adult winter plumage is scarcely different from the first winter, a little grayer on the back and the yellow area on the wings greater. The adult nuptial plumage is apparently the previous plumage plus wear.

MOTACILLIDÆ

The only species of Wagtail found in New York undergoes a semiannual moult, the prenuptial being partial. It is a bird which from its terrestrial habits suffers a good deal by wear.

Anthus pensilvanicus (Lath.). American Pipit

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, hair-brown streaked with black, the edgings of the back pale grayish wood-brown. Wings and tail clove-brown, edged chiefly with wood-brown, Isabella-color on the greater coverts and tertiaries; the outer pair of rectrices nearly all white the next pair broadly tipped with it. Below, creamy buff, palest anteriorly, streaked on the throat and breast rather broadly and on the sides faintly with clove-brown. Indistinct superciliary line and orbital ring buffy white; auriculars wood-brown. Bill and feet clay-color in dried skin the upper mandible brownish black.

Description from an Alaskan bird.

3. First Winter Plumage acquired by a partial postjuvenal moult in August which involves the body plumage but not the wings nor the tail, young and old becoming practically indistinguishable.

Very similar to previous plumage, but darker above with less obvious streaking and deeper pinkish buff below, the streaking heavier, forming a pectoral band and extending to the flanks; an immaculate pale buff chin. The superciliary line extends behind the eye as a whitish band.

4. First Nuptial Plumage acquired by a partial prenuptial moult, in April, involving most of the body plumage which has suffered much from wear and become darker above with the buff tints nearly lost below. The extent of the fading is surprising. The new plumage is buff tinged but wear during the breeding season produces a black and white streaked bird, the buffs being wholly lost through fading.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Indistinguishable from the first winter dress, the wing edgings perhaps darker, and with less vinaceous tinge below.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult like the young bird.

Female.—The sexes are alike and the moults correspond.

TROGLODYTIDÆ

The members of this family have only an annual moult except *C. stellaris* and *C. palustris* which are exceptional in undergoing a complete (or nearly so) prenuptial moult. The juvenal remiges and rectrices are with these two exceptions worn till the first postnuptial moult. All the seasonal plumages are very much alike.

Mimus polyglottos (Linn.). Mockingbird

1. Natal Down. Pale sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, grayish sepia-brown, somewhat mottled with darker brown. Wings and tail black, the basal portion of the primaries, their coverts, and two outer rectrices white; wing edgings wood-brown, the feathers paler at tips. Below, dull white, spotted except on the abdomen and crissum, with dull olive-brown. Lores, rictal and submalar streaks faintly dusky. Bill and feet dusky pinkish buff becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult in September, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Unlike the previous plumage lacking the streaking below. Above, including sides of the head and neck mouse-gray palest on the head with faint brownish edgings on the back and rump. Wing coverts with grayish edgings, tipped with two dull white bands. Below, grayish white, pale smoke-gray on the throat and sides, the flanks and crissum tinged with pale wood-brown. Lores dusky, orbital ring white above and below.

4. First Nuptial Plumage acquired by wear which makes the plumage grayer above and dingy white below, late in the season.

5. Adult Winter Plumage acquired by a complete postnuptial moult in September. Practically indistinguishable from first winter dress, the primary coverts usually whiter and colors elsewhere clearer and deeper.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable, and the moults correspond.

Galeoscoptes carolinensis (Linn.). Catbird

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep brownish mouse-gray, a little darker on the pileum. Wings and tail nearly black, the primaries and secondaries edged with smoke-gray, the coverts browner edged; the tail with "watered" barring very indistinct. Below, pale mouse-gray indistinctly mottled with clove-brown, the throat and sides faintly tinged with sepia, the crissum faintly Mars-brown. Bill and feet dusky pinkish buff becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in August, which involves the body plumage and the wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to the previous plumage but much grayer and no mottling. Everywhere clear slate-gray, much paler below and on the sides of the head and neck; the pileum black; the crissum deep chestnut.

4. First Nuptial Plumage acquired by wear which produces little obvious change.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from the first winter ; the wings and tail perhaps averaging blacker and with grayer edgings.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable, although the females are often duller and with browner pileum, wings and tail.

Harporhynchus rufus (Linn.). Brown Thrasher

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, cinnamon-brown mottled or streaked with dull clove-brown. Wings and tail deep cinnamon-rufous or russet ; the tail with "watered" barring ; the wing edgings richer rufous ; coverts dusky terminally and tipped with pale buff forming two wing bands ; the tertiaries narrowly edged with pale buff ; the alulæ with white. Below, dull white, a buffy wash on the throat, sides and crissum, streaked broadly except on the chin and mid-abdomen with dull black. Bill and feet dull pinkish buff, the former becoming slaty, the latter dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning towards the end of July, which involves the body plumage, usually most of the wing coverts and not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage but unstreaked above Above, rich deep cinnamon-rufous ; white below, streaked with black and washed on throat, sides and crissum with ochraceous buff ; the wing coverts cinnamon-rufous, the wing-bands buffy white.

4. First Nuptial Plumage acquired by wear which is marked, although, until late in the season, the colors fade little except the buff below, the streakings coming out clear on a white ground.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July and August. Practically indistinguishable from first winter, the colors averaging darker, noticeable in the edgings of the tips of the tertiaries and in the wings and tail.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable, and the moults correspond.

Thryothorus ludovicianus (Lath.). Carolina Wren

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including wings and tail, deep russet or cinnamon-rufous, the crown darker, owing to faint dusky tips, the feathers whitish along their shafts; wings and tail with narrow dusky barring, the coverts, chiefly the lesser, buff tipped. Below, dull white, washed on the throat, sides, flanks and crissum with cinnamon tinged with wood-brown, the chin, submalar and auricular regions faintly flecked or barred with dull black. Broad superciliary line dull white bordered with dull black; postorbital stripe deep russet. Bill and feet pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, in September, which involves the body plumage, wing coverts and tail, but not the rest of the wings, young and old becoming practically indistinguishable.

Similar to previous plumage, but darker. A rich chestnut or Vandyke-brown. Above, the wing coverts with whitish terminal spots. Below deep cinnamon, except the chin, lores, sides of head and superciliary lines which are nearly white; the crissum with decided black bars. The tail darker than the juvenal and barred more irregularly.

4. First Nuptial Plumage acquired by wear, the bird becoming rather paler, especially below, and ragged later.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August and September. Practically indistinguishable from first winter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are practically indistinguishable, and the moults correspond.

Troglodytes aëdon Vieill. House Wren

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, Prout's-brown, russet tinged on the rump and deep grayish sepia on the pileum, sometimes very faintly barred. Wings and tail Prout's-brown, darkest on the wings, both with wavy, dusky barring, the palest areas on the outer primaries. Below, including sides of head, dull grayish white with dusky mottling, washed strongly with russet on the flanks and crissum. Orbital ring dusky buff. Bill and feet buffy sepia-brown, becoming darker.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in August, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage but darker and grayer with faint barring above, the wing coverts, chiefly the lesser with whitish spots; below whiter without mottling, the throat and sides obscurely barred with pale drab, the flanks and crissum boldly barred with dull black which is bordered with russet.

4. First Nuptial Plumage acquired by wear, excessive by the end of the breeding season, which brings out the barring more conspicuously and makes the bird grayer and paler, especially below.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter, perhaps averaging grayer with darker wings and tail.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike and the moults correspond.

Troglodytes hiemalis Vieill. Winter Wren

1. Natal Down. Sepia-brown.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, Mars-brown russet-tinged, the crown feathers paler centrally. Wings darker and tail ruddier, both duskily barred, alternating on the outer primaries with pale buff, the coverts with whitish terminal dots. Below, pale cinnamon with dusky and whitish mottling, the flanks and crissum deep russet. Orbital ring and faint superciliary line dull buff. Bill and feet pale sepia-brown becoming darker.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of August, which involves the body plumage and the wing coverts, and not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Above, very similar to the previous plumage, the brown usually grayer with dusky and whitish barring on the back. Below, pale cinnamon, the throat and breast obscurely streaked with white, the flanks, abdomen and crissum distinctly barred with russet, dull black and white alternating on each feather and producing a dusky appearance. Orbital ring and superciliary line clear pale buff.

4. First Nuptial Plumage acquired by wear effecting but little change in the colors except a slight paling.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter dress, perhaps grayer on an average, and more heavily barred.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are indistinguishable and the moults are alike.

Cistothorus stellaris (Licht.). Short-billed Marsh Wren

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull black on the pileum and back, the nape sepia, the rump and upper tail coverts russet ; streaked anteriorly with white, barred on the rump and wings with black, white and cinnamon, palest on the primaries ; the tail drab, mottled rather than barred with black. Below, including sides of the head, ochraceous buff palest on the chin and throat and washed strongly on the sides, flanks and crissum with cinnamon, the feathers whitish centrally and terminally. Bill and feet pinkish buff becoming deep sepia

3. First Winter Plumage acquired by a partial postjuvenal moult beginning about the middle of August which involves the body plumage and wing coverts, probably the tertiaries, but not the rest of the wings nor the tail.

Similar to the previous plumage, the forehead largely sepia-brown and conspicuous white stripes on the crown. Below, the ochraceous wash is deeper including a pectoral band and a few black and white bars occur on the flanks. The tertiaries are distinctly black, edged and barred with white, russet bordered.

4. First Nuptial Plumage acquired by a nearly complete prenuptial moult, as indicated by the relative freshness of May specimens and proved by others taken April 15th in Texas. Limited material indicates that only a few of the outer primaries are renewed in some cases, the same thing occurring in other species. This plumage is much like the last, with perhaps less barring, and shows considerable wear later.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Indistinguishable from the first winter probably averaging richer in its tints.

6. Adult Nuptial Plumage acquired by a complete or nearly complete prenuptial moult as in the young bird.

Female.—The sexes are alike and the moults are the same.

Cistothorus palustris (Wils.). Long-billed Marsh Wren

1. Natal Down. White (**plate V, fig. 2**).

2. Juvenal Plumage acquired by a complete postnatal moult.

Crown, nape and part of back brownish black, a few faint white lines on the nape; the scapularies, rump and upper tail coverts Prout's-brown often russet tinged. Wings and tail dull black, the tail barred, the tertiary edgings mostly black, the coverts and secondaries brownish edged, the primaries paler with indications of barring. Sides of head dusky; a faint whitish superciliary line. Below, white, washed on sides of breast and flanks and on crissum with pale cinnamon. Bill and feet dusky pinkish buff becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning about the middle of August, which involves the body plumages, the wing coverts, and the tertiaries, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable. This plumage may easily be mistaken for the juvenal.

Similar to previous plumage, but the brown rustier above, a brown median line dividing the black crown; the anterior part of the back is black with distinct white streaking; the superciliary line white; the tertiaries duskier and more mottled. Below, the cinnamon wash is deeper with sometimes a pectoral band and there is obscure whitish and dusky barring on the sides, the crissum distinctly barred.

4. First Nuptial Plumage acquired by a complete prenuptial moult as indicated by the relatively unworn condition of

the feathers when the birds arrive in May. Although I have no positive evidence of this moult, spring birds are in quite as fresh plumage as those of autumn and I do not believe the latter could be so little affected by wear during the winter months as not to show more of it on their return. This plumage is the same as the last, perhaps whiter below and with less obvious barring on the flanks and crissum and it becomes badly frayed before the end of the breeding season.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter but the wings and tail usually grayer, the tertiaries and wing coverts more heavily barred.

6. Adult Nuptial Plumage acquired by a complete prenuptial moult the same as in the young bird.

Females.—The sexes are alike, the female perhaps averaging a little duller, and the moults are the same.

CERTHIIDÆ

There is only the annual moult in the one species found in New York. Young birds appear to get a new tail at the postjuvenal moult retaining the remiges until the first postnuptial.

Certhia familiaris americana (Bonap.). Brown Creeper

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, streaked or mottled with bistre, sepia and wood-brown, the rump russet, the feathers centrally pale brown on the crown, whitish on the back. Wings clove-brown, reduced to a line on the outer web of the tertiaries; the coverts edged with pale buff, which also edges subterminally the secondaries and tertiaries, these as well as the primaries being crossed by a midway bar besides, and all are tipped with pale smoke-gray. Tail pale wood-brown, dusky along the shafts and narrowly barred. Below, dull white, flecked on the chin, throat and sides with pale sepia, the crissum faintly cinnamon tinged. Lores and auriculars dusky; indistinct superciliary line grayish white. Bill and feet pinkish buff, dusky later.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in August in eastern Canada, which in-

volves the body plumage, wing coverts, and the tail, but not the rest of the wings, young and old becoming practically indistinguishable.

Similar to previous plumage. Above darker, the rump much rustier, the crown and back with white shaft streaks, wing covert edgings whiter. Below, silky white, the crissum faintly cinnamon; tail olive-brown on the inner webs, Isabella-color externally, a faint barring discernible, the middle pair of rectrices more broadly and less distinctly barred than in juvenal plumage.

4. First Nuptial Plumage acquired by wear, birds becoming rather dingy below and somewhat faded above.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter, rather darker and richer.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike in plumages and moults.

PARIDÆ

All the members of this family have only the annual moult. They are peculiar in assuming a juvenal plumage closely resembling the pale nuptial plumage which results from extreme fading of the winter dress.

Sitta carolinensis Lath. White-breasted Nuthatch

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, cinereous gray with faint dull black edgings, pileum and hind neck dull black faintly edged on the nape with pale buff. Wings dull black, the primaries white basally and with a dash of white on the middle of their outer borders; the secondaries, tertiaries and coverts edged with cinereous gray, the greater coverts tipped with ashy gray. Tail jet black, the two central rectrices cinereous gray, the outer pairs with subterminal white blotches. Below, including sides of head and neck and superciliary line, grayish white usually faintly pinkish tinged; the crissum partly pale cinnamon; the loral, auricular and malar feathers with dusky tips. Bill and feet dusky pinkish buff, the bill becoming bluish slate-gray, the feet deep sepia.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body

plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to the previous plumage. The pileum and hind neck glossy greenish black, the back a brighter, bluer cinerous gray *without* dusky edgings ; the lower surface everywhere creamier and washed with pinkish buff, the flanks, crissum and tibiæ Mars-brown.

4. First Nuptial Plumage acquired by wear, the lower parts fading to dull grayish white except a tinge of pale russet on the flanks, crissum and tibiæ. Worn adults bear a striking resemblance to birds in juvenal dress.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from the first winter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male. First distinguishable from the male in juvenal plumage, the pileum being deep plumbeous gray, the hind neck dull black ; the wing coverts, edgings of the secondaries and the lower parts are strongly tinged with pale russet, the crissum with Mars-brown. The first winter plumage lacks the glossy black cap of the male, its place being taken by dull black mostly veiled with plumbeous gray ; the back is of a duller gray ; the wing coverts and secondary edgings are faintly tinged with russet ; below same as the male. Females never, even in later plumages, acquire enough black on the cap to be mistaken for males.

Sitta canadensis Linn. Red-breasted Nuthatch

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, bluish plumbeous gray, with a few faint black edgings, the pileum and transocular bands reaching the hind neck, dull black, superciliary lines extending to the hind neck, white speckled with black. Wings dull clove-brown, the tertiaries plumbeous, the alulæ black, the coverts and quills edged with pale cinereous gray, palest on the primaries. Tail black with subterminal white spots on the outer rectrices, the two central quills plumbeous. Below, pinkish buff, the crissum pale cinnamon, the breast sometimes with a few faint dusky edgings ; the chin and adjacent sides of head white with dusky edgings, especially in the malar regions Bill and feet dusky pinkish buff, the bill becoming slaty (except flesh-color at base of lower mandible), the feet becoming grayish black.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the end of July in eastern Canada, which involves the body plumage but not the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage. Above, a darker bluer plumbeous gray, the pileum and transocular stripes glossy black, the superciliary lines, sides of head and chin clear white without speckling. Below, rich tawny ochraceous buff, deepest on the sides and crissum, the under tail coverts terminally white.

4. First Nuptial Plumage acquired by wear, the fading so marked that breeding birds resemble those in juvenal dress.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Females.—The plumages and moults are similar to those of the male. In juvenal plumage the pileum is largely plumbeous instead of black. In first winter dress, the pileum becomes blacker, veiled by plumbeous edgings, and the lower parts are paler. In later plumages the cap never becomes as black as that of the male.

Sitta pusilla Lath. Brown-headed Nuthatch

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, dull slate-gray, the pileum pale mouse-gray, a partly concealed dull white spot at base of neck. Wings clove-brown, the greater coverts and tertiaries edged with wood-brown, the primaries and secondaries with dull white. Tail black, the middle pair of rectrices and tips of the outer ones plumbeous gray, a dingy white area on the outer webs of the lateral pairs. Below, dull white, a pale pinkish buff wash on the breast, abdomen and crissum. Line through eye and auriculars deep mouse-gray. Bill and feet pale sepia-brown becoming black.

3. First Winter Plumage acquired by a partial postjuvenal moult, in July in Florida, which involves the body plumage and

wing coverts, but not the remiges nor rectrices, young birds and adults becoming practically indistinguishable.

Above, deep plumbeous gray, the pileum Prout's brown, the concealed nuchal spot clear white. Below, rich deep pinkish buff, white on chin and sides of head and neck and plumbeous gray on the flanks. Line through eye and auriculars deep Mars-brown.

4. First Nuptial Plumage acquired by wear. The pinkish tint below is lost and the top of the head becomes curiously mottled, the brown remaining dark where protected by the overlapping feathers but fading to a dull white at the tips which become much abraded. The wear is far greater on the crown than in the black-headed species.

5. Adult Winter Plumage acquired by a complete postnuptial moult, beginning in Florida by the end of June. Young and adults are scarcely distinguishable, adults averaging deeper in color especially the wing edgings.

6. Adult Nuptial Plumage acquired by wear, as in the young bird.

Female.—The sexes are practically indistinguishable in all plumages, and the moults are the same.

Parus bicolor Linn. Tufted Titmouse

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, brownish mouse gray. Wings and tail slightly darker, obscurely edged with olive-gray, greenish tinged on the secondaries and tertiaries, brownish on the coverts. Below, dull grayish white, faintly tinged with pinkish buff, deepest on the flanks. Forehead merely dusky and crest insignificant. Bill and feet dusky pinkish buff becoming black when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, late in August, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage, but dull cinereous gray above, deepest on the crown, and grayer below, the sides and flanks deep russet or Mars-brown. The lores and postocular region decidedly white, with black forehead and a distinct crest.

4. First Nuptial Plumage acquired by wear which shows chiefly in the fading of the flanks.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult, in the South in August. Practically indistinguishable from first winter dress, the wing edgings perhaps richer and darker on an average.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in the young bird.

Female.—The plumages and moults correspond, the sexes usually indistinguishable, although the female will average browner and the frontal black patch brownish and duller.

Parus atricapillus Linn. CHICKADEE

1. NATAL DOWN. Pale mouse-gray.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Above, mouse-gray; the pileum, chin and throat dull black. Wings and tail dull slate-gray edged with dull or ashy white, the primary coverts with olive-gray. Below (except chin and throat), dull white, washed on the sides and crissum with pale pinkish buff; lores, suborbital region, auriculars and sides of neck pure white. Bill and feet pinkish buff, the bill becoming slate-black, the feet grayish clove-brown.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning after the middle of July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage except that the flanks and crissum are strongly washed with pale pinkish wood-brown, which also tinges the back, and the posterior black, throat feathers are more veiled with white edgings. The pileum is of a deeper black which extends further on the hind neck.

4. FIRST NUPTIAL PLUMAGE acquired by wear, through which the brownish wash fades to pinkish buff, like the juvenal dress, as early as March, and by June is nearly all lost. The wing edgings are considerably diminished by abrasion. The plumage above is grayer.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult in July and August. Practically indistinguishable from first winter dress, possibly grayer.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male, females practically indistinguishable, but averaging a little browner black on the cap and the wash on the sides paler in all plumages.

I have examined large series of this species taken every month in the year.

Parus carolinensis Aud. CAROLINA CHICKADEE

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complele postnatal moult.

Very similar to same stage of *P. atricapillus* but with olive-gray, narrower, inconspicuous edgings on the secondaries. Above, mouse-gray, the pileum black. Wings and tail dull black, the edgings olive-gray. Below, the chin and throat dull black, the breast and abdomen dingy white, a wash of pale pinkish buff on the sides and crissum. Lores, suborbital and auricular region and sides of neck pure white. Bill and feet dusky pinkish buff becoming slaty.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, in the South apparently in July, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming indistinguishable.

Much like the previous plumage, but the flanks and crissum with a darker wash, and the gray of the back, pinkish-tinged. The posterior feathers of the black area of the throat are somewhat veiled with white edgings. The pileum is blacker.

4. FIRST NUPTIAL PLUMAGE acquired by wear through which much of the pinkish wash on the sides and crissum is lost and the plumage above becomes grayer.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult. Practically indistinguishable from the first winter dress.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in the young bird.

Female.—The sexes are practically alike, the females often browner and the black cap duller; the moults correspond.

Parus hudsonicus Forst. Hudsonian Chickadee

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, brownish mouse-gray, the pileum pinkish drab-gray. Wings and tail dull slate-gray whitish edged, the coverts edged with pale wood-brown. Below, including suborbital region and auriculars dingy white and washed on the sides and crissum with pale cinnamon, the chin and throat dull black. Bill and feet dusky pinkish buff, becoming slate-black.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning early in August in eastern Canada, which involves the body plumage and wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable.

Similar to previous plumage, the pileum darker and the back browner, contrasting but slightly with the cap; the flanks, sides and crissum rich Mars-brown; the black on the throat deeper and the white of the sides of the head and lower parts clearer.

4. First Nuptial Plumage acquired by wear, the flanks, sides and crissum becoming cinnamon through fading, the back grayer and the cap paler. The plumage becomes ragged by the end of the breeding season, due no doubt to the species living among spruces and suffering by abrasion from the harsh foliage.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August. Practically indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are alike and the moults correspond.

SYLVIIDÆ

The Kinglets have an annual moult, the young males of both species assuming the colored crown patches at the postjuvenal moult. *Polioptila cœrulea* has a semi annual moult.

Regulus satrapa Licht. Golden-crowned Kinglet

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, olive-brown, greenish tinged on the back and mottled with dusky edgings, the pileum, auriculars and lores dull black or clove-brown ; grayish superciliary stripe interrupted by black extending upward from the lores ; suborbital stripe dull white. Wings and tail deep olive-brown, most of the coverts, tertiaries, secondaries and rectrices edged with bright olive-green, the greater coverts tipped with buffy white, the tertiaries with pale olive-gray ; the secondaries are crossed by a dusky bar on their proximal third and are basally white, yellow tinged. Below dull grayish white, a few dusky edgings, and tinged faintly with pale buff on the throat, sides and crissum. Bill and feet dusky pinkish buff, dusky later.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning in eastern Canada early in August, which involves the body plumage, the lesser wing coverts chiefly and not the rest of the wings nor the tail, young and old becoming practically indistinguishable. The young bird acquires the orange crown.

Similar to the previous plumage. Above, olive-green, olive-gray on the nape and sides of neck. The crown with a broad median stripe of cadmium orange bordered by lateral streaks of lemon-yellow and these by black. The orbital ring is blacker and the superciliary line whiter, less interrupted by black, broader behind the eye and the white extending across the forehead. Below, browner, largely olive-buff or gray.

4. First Nuptial Plumage acquired by wear not marked till late in the breeding season. The orange crown feathers are very resistant to wear and always look fresh.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Practically indistinguishable from first winter.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the pileum usually has less black than that of the male and is sometimes wholly olive-gray including lores and auriculars. The first winter plumage lacks the orange crown stripe, its place being taken by pale lemon-yellow, and the orange of the male is never assumed in any plumage.

Regulus calendula (Linn.). Ruby-crowned Kinglet

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including wings and tail, clove-brown, the crown and back with faint dusky mottling. Wing edgings olive-green, those of the tertiaries grayer. Below, dull buffy white, browner on the abdomen and crissum. Bill and feet dusky pinkish buff, nearly black later.

Similar to *R. satrapa* but darker, the crown uniform with the back and no superciliary line.

3. First Winter Plumage acquired by a partial postjuvenal moult, in the far North, which involves the body plumage, and the wing coverts, but not the rest of the wings nor the tail, young and old becoming practically indistinguishable. The "ruby" crown is assumed by the young bird.

Above, including sides of head and neck, grayish olive-green brightest on the rump and edgings of the wings and tail, the coverts and tertiaries tipped with white or buff. Median stripe on crown and occiput scarlet vermilion or orange. Below, olive-buff, browner on the sides. A conspicuous orbital ring white, interrupted with dull black above and below.

4. First Nuptial Plumage acquired by wear, the back becoming grayer and the tertiary edgings mostly lost. A few new feathers often appear in the spring indicating a tendency toward a prenuptial moult.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Practically indistinguishable from first winter dress.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male. Females are somewhat browner in autumn and lack in all plumages the red crown spot of the male.

Polioptila cærulea (Linn.). Blue-gray Gnatcatcher

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, drab or smoke-gray. Wings clove-brown the tertiaries broadly white edged. Tail black, the two outer rectrices chiefly white, the third with terminal white spot. Below, grayish white, faintly buff on abdomen. Lores and orbital ring grayish white. Bill and feet pinkish buff, becoming black later.

3. FIRST WINTER PLUMAGE acquired by a partial postjuvenal moult, beginning in Louisiana the middle of July, which involves the body plumage and wing coverts but not the rest of the wings nor the tail.

Similar to previous plumage but dull bluish plumbeous gray above with a brownish wash on the back, and pearl-gray below, whiter on abdomen and crissum.

4. FIRST NUPTIAL PLUMAGE acquired by a partial prenuptial moult, in February, which involves chiefly the anterior parts of the head, chin and throat. The black frontal band and supraloral lines are acquired, the crown becoming bluer and the chin and throat deeper gray. Young and old become indistinguishable.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult. Differs from first winter in having the black frontal band and supraloral lines; the blue and gray tints are also richer.

6. ADULT NUPTIAL PLUMAGE acquired apparently by a partial prenuptial moult as in the young bird.

Female.—In juvenal and first winter plumages indistinguishable from the male. With less blue and without black frontal band in all subsequent plumages.

TURDIDÆ

The uniform rule is an annual moult for all the species of this family with the postjuvenal moult incomplete. The Thrushes are peculiar, especially females, in frequently failing to renew the spotted wing coverts at the postjuvenal moult, so that old and young may usually be told apart by this character during the succeeding twelve-month. The natal down remains attached for a longer period than in most other species of Passerine birds.

Turdus mustelinus Gmel. Wood Thrush

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, deep raw umber-brown, paler on the crown and nape, the rump olive, spotted on crown and nape with tawny olive, tips of the wing coverts and a few linear streaks on the back also tawny olive. Wings and tail tawny olive-brown, the wing coverts with slightly paler edgings. Below, pure white, tinged with buff on the jugulum and sides, heavily spotted on the throat and breast and less obviously on the sides with large rounded black spots. Auriculars dusky, lores ashy, orbital ring white and prominent. Bill and feet pale pinkish buff becoming slightly darker with age.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the end of July, which involves the body plumage, the lesser coverts, usually a part of the other coverts, but not the rest of the wings nor the tail. Young and old often become indistinguishable.

Similar to previous plumage but without streaks on the back and whiter below with larger spots. Above, russet, brightest on the crown, olive tinged on the rump. Below, white, heavily spotted with black, a wash of pale buff on the throat. Orbital ring white and conspicuous.

4. First Nuptial Plumage acquired by wear, the buff wash being mostly lost and the spots becoming rather duller. There is no obvious fading, above.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July and August. Practically indistinguishable from first winter dress, averaging a little darker and the wing edgings uniform with the wings without terminal edgings or spots.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes and moults are alike.

Turdus fuscescens Steph. Wilson's Thrush

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, deep raw umber-brown with dusky edgings and large guttate spots of tawny olive. Wings and tail tawny olive brown the greater coverts and tertiaries edged with tawny olive and darker tipped. Below, white, strongly tinged on jugulum, less strongly on the chin, breast, sides and crissum with tawny olive, heavily spotted or barred on the jugulum, faintly on the breast and anterior parts and sides of the abdomen with clove-brown, the feathers also barred with a subterminal tawny band. Submalar stripes dusky. Bill and feet pinkish buff, remaining pale when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of July, which involves the body plumage, and lesser coverts but not the rest of the wings nor the tail.

Similar to the previous plumage but without the spotting above and the barred effect below. Above, uniform deep russet or pale mummy-brown. Below, white, olive-gray on the sides and flanks, and strongly tinged on the throat, neck and jugulum with pale ochraceous buff ending abruptly on the breast, and sparsely spotted on the jugulum and sides of the throat with pale sepia deltoid spots, a few still fainter on the breast. Lores grayish white with dusky edgings; orbital ring similar and not conspicuous.

Young birds may usually be distinguished from adults by the terminal buff spots of the retained juvenal wing coverts.

4. First Nuptial Plumage acquired by wear, the buff below and the spots fading a little, and the russet above becoming grayer.

5. Adult Winter Plumage acquired by a complete postnuptial moult in July. Young heretofore distinguishable by juvenal plumage, wing edgings and tippings become indistinguishable from adults, which lack them. Adults are of a deeper less yellowish brown above.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes and moults are alike.

Turdus aliciæ Baird. Gray-cheeked Thrush

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, greenish olive-brown, wings and tail darker, the pileum, back, wing coverts (except primary and greater) and rump with buffy white linear shaft streaks. Below, white, very faintly tinged with pale buff on the breast and sides, the breast and throat spotted with black tending to barring on forepart of abdomen and flanks. Sides of head pale buff, black spotted; submalar streaks black; distinct orbital ring rich buff. Bill and feet clay-color in dried skin, the upper mandible sepia. This dress is grayer and with less buff than the corresponding plumage of *T. u. swainsonii.*

Description from an Alaskan bird.

3. FIRST WINTER PLUMAGE acquired apparently by a partial postjuvenal moult, in August in the far North, which involves the body plumage and lesser wing coverts, but not the rest of the wings nor the tail.

Above, similar to corresponding plumage of *T. u. swainsonii*, the olive-brown usually darker with less yellowish tinge, especially on the head. Below, with no buff except a faint wash on the jugulum; the sides of the head and breast are therefore much grayer and the orbital ring distinctly white. The buffy edgings or terminal spots of the retained juvenal wing coverts are usually distinctive of the first winter dress.

4. FIRST NUPTIAL PLUMAGE acquired by wear, birds becoming very slightly grayer above.

5. ADULT WINTER PLUMAGE acquired by a complete postnuptial moult. Usually the edgings of the wing coverts are uniform in color with the wings and the upper parts will average darker than in first winter dress. Young and old now become indistinguishable.

6. ADULT NUPTIAL PLUMAGE acquired by wear as in the young bird. Distinguishable in many cases from first nuptial by lacking the buffy wing edgings or spots which however may be less obvious at this stage on account of wear.

Female.—The sexes and moults are alike.

Turdus aliciæ bicknelli (Ridgw.). BICKNELL'S THRUSH.

The moults and plumages correspond to those of *T. aliciæ.* A buffiness, which is lacking in *T. aliciæ*, characterizes all plumages but plumage differences are extremely small at every stage.

Turdus ustulatus swainsonii (Cab.). OLIVE-BACKED THRUSH

1. NATAL DOWN. No specimen seen.

2. JUVENAL PLUMAGE acquired by a complete postnatal moult.

Very similar to *T. aliciæ* but browner above and with more buff below and about the head, the linear spots deeper buff. Above, olive-brown, wings and tail darker, the feathers of the pileum, back, lesser, median and sometimes part of greater coverts and the rump with linear shaft streaks or terminal spots of buff. Below, strongly washed with buff on throat, breast and sides, and heavily spotted with black on the breast and sides of throat, the fore parts and sides of whiter abdomen indistinctly barred. Sides of head buff, spotted with black ; orbital ring distinct, pale ochraceous buff; submalar stripes black. Bill and feet dark pinkish buff remaining pale when older.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning the middle of August, which involves the body plumage, the lesser coverts and not the rest of the wings nor the tail.

Similar to previous plumage but unstreaked above and less spotted below. Above, uniform yellowish olive-brown ; below, together with the superciliary stripe and distinct orbital ring, rich ochraceous buff, becoming abruptly white on the breast, abdomen and crissum, the sides washed with pale olive-gray, and chains of deltoid clove-brown spots on the throat and breast, paler on the fore part of the abdomen. Spotted wing coverts remaining of the juvenal dress are characteristic, except in precocious individuals. The tail uniform in color with the back easily distinguishes this species from *T. a. pallasii*, and the more spotted breast and striking orbital ring distinguish it from *T. fuscescens.*

4. First Nuptial Plumage acquired by wear through which much of the buff tint is lost, and the upper parts become grayer. There is very little actual abrasion evident until late in the breeding season.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning the middle of August or not before the first of September. Differs in most cases from first winter dress in lacking the retained tell-tale wing coverts of the juvenal plumage and the upper parts will average deeper in color. The wings and tail will average darker and the coverts are without terminal buff spots. Young and old become indistinguishable.

6. Adult Nuptial Plumage acquired by wear as in the young bird, from which in most cases the lack of retained wing coverts distinguishes adults.

Female.—The sexes and moults are alike.

Turdus aonalaschkæ pallasii (Cab.). Hermit Thrush

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, including sides of head, sepia or olive-brown, the rump russet, and everywhere spotted with large buffy white guttate spots bordered with black. The wings rather darker, the coverts and tertiaries with small terminal buffy spots. Tail burnt umber-brown. Below, white faintly tinged with buff, spotted with deep black, on sides of neck, across the breast and on the flanks and crissum, the throat and breast, the fore part of the abdomen and flanks faintly barred. Bill and feet dull pinkish buff remaining pale when older. Compared with corresponding plumage of *T. u. swainsonii*, the brown above is deeper with larger, paler spots, while below there is much less buff tint and the spots are blacker. The reddish tail is, of course, distinctive.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in August, which involves the body plumage, most of the lesser and median coverts, but not the rest of the wings nor the tail.

Similar to previous plumage but without spotting above and the black spots below fewer. Above, including sides of head olive tinged mummy-brown, burnt-umber on rump and upper tail coverts. Below, white, tinged faintly with buff on throat and breast, with olive-gray on the sides and spotted heavily on the throat and faintly on the breast with large deltoid black spots. Lores and submalar lines black; orbital ring pale buff. The buff spotted coverts retained distinguish young from adults.

Above, most resembles *T. fuscescens*, the tail however ruddier; also resembles *T. u. swainsonii*, but browner above, the throat spots larger and the tail distinctive.

4. First Nuptial Plumage acquired by wear, the upper surface becoming rather grayer and the buff below mostly lost.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August and September. Averages darker and lacks the tell-tale coverts and tertiaries of the first winter dress. Young and old become indistinguishable.

6. Adult Nuptial Plumage acquired by wear as in the young bird, from which it is usually distinguishable by the wing coverts.

Female.—The sexes and moults are alike.

Merula migratoria (Linn.). American Robin

1. Natal Down. Mouse-gray.

2. Juvenal Plumage acquired by a complete postnatal moult.

Pileum clove-brown with faint whitish shaft streaks; back, lesser and median wing coverts mouse-gray, each feather with elliptical shaft streaks of pale wood-brown, edged with dull black; rump paler with dusky barring. Wings and tail (except as described) clove brown with whitish edgings, the two outer pairs of rectrices terminally blotched with dull white, the others sometimes tipped. Below, tawny ochraceous, lighter or darker according to individual, sometimes ochraceous rufous, the chin, mid-abdomen and crissum white, the sides of the chin streaked, the throat, breast and abdomen heavily spotted with black, becoming edging or barring posteriorly; under tail coverts white, basally dusky. Auriculars and lores black, obscure superciliary line ochraceous buff, orbital ring paler. Bill and feet dull pinkish buff, becoming dusky.

3. First Winter Plumage acquired by a partial postjuvenal moult, beginning late in August and extending through September and part of October, which involves the body plumage, wing coverts and tertiaries, but not the rest of the wings nor the tail.

Similar to previous plumage, but without spots above and below. Above, including wing coverts, pale grayish olive-brown, veiling dull black on the pileum; the throat, abdomen and sides tawny or pale ochraceous rufous, much veiled by broad white edgings, grayish on the throat; the chin and fore-throat white, streaked with dull black, malar stripe and forehead tinged with ochraceous; lores and auriculars dull black; superciliary line and orbital ring white. Posterior abdomen, crissum and tibiæ white, the tail coverts slaty basally. Wing coverts grayish olive-brown, brownish edged and palest terminally.

4. First Nuptial Plumage acquired by wear through which much of the white edging below is lost so that birds become redder, without veiling, the concealed black of the pileum is brought out and the streaking on the chin becomes clear black and white.

5. Adult Winter Plumage acquired by a complete postnuptial moult in August and September. Usually distinguishable from first winter dress by being grayer above, the head blacker and less veiled; below the ochraceous rufous is richer, less veiled and even invading the chin the streaks of which are broader; the lores and auriculars are blacker than in the young bird and the spots tipping the lateral rectrices are whiter and larger.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The sexes are usually indistinguishable in most plumages although the female is duller in first winter and first nuptial plumages, the black about the head brownish, the wings and tail browner with less distinct tail blotches.

Hesperocichla naevia (Gmel.). Varied Thrush

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, olive-brown, plumbeous on rump; very faint whitish shaft-streaks. Wings and tail clove-brown with ochraceous bands edging the quills and tipping the coverts. Below, ochraceous buff, whiter on abdomen, a pectoral band and edgings of throat and breast, olive-brown. Supra-auricular line buff.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage and wing coverts but not the rest of the wings nor the tail, young and old becoming practically indistinguishable. It is worthy of notice that this is another species which shows parti-colored feathers at the junction of two areas of different colors.

Similar to previous plumage, but deeper tints. Above, deep plumbeous gray with brownish edgings, darker on the pileum, the wing coverts broadly tipped with deep orange buff, forming two wing bands. Below rich orange buff, the abdomen and crissum chiefly white mixed with buff and olive-gray, the sides with olive-gray edgings. A black pectoral band, somewhat veiled with gray, orange tinged.

4. First Nuptial Plumage acquired by wear, which produces slight effects birds becoming grayer above.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Scarcely differs from first winter dress, the colors deeper and the pectoral band broader and blacker.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male. Indistinguishable in juvenal dress, however, especially wings and tail. In first winter plumage duller and browner, the faint pectoral band mouse-gray and the crissum grayer.

Saxicola œnanthe (Linn.). Wheatear

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, mouse-gray, browner on the back and white on the rump, the feathers with dusky terminal edgings and with central whitish spots. Wings dull black, lesser coverts like the back, other coverts, secondaries and tertiaries with cinnamon edgings, paler at the tips of the primaries. Tail basally white, terminally dull black, tipped with pale cinnamon. Below, dull white, the feathers of the chin, throat and breast with dusky terminal edgings. Bill and feet brownish black in dried specimens.

3. First Winter Plumage acquired by a partial postjuvenal moult which involves the body plumage, but not the wings nor the tail.

General color cinnamon, paler on chin, superciliary stripes, and under tail coverts. Lores obscurely black.

4. First Nuptial Plumage acquired by a partial prenuptial moult which involves the body plumage, but not the wings nor the tail.

Smoke-gray above, with white upper tail coverts and superciliary stripe and a black transocular line. Below, white, tinged, chiefly on throat, with pale cinnamon.

The worn wings and tail with remains of the brown edgings of the juvenal plumage distinguish young from old birds.

5. Adult Winter Plumage acquired by a complete postnuptial moult. Similar to first winter dress, but the edgings not so brown and the wings, primary coverts especially, and tail, blacker. A specimen from Roumania (Am. Mus. Nat. Hist., No. 54069, ♂, July 5) is passing by moult from the gray nuptial to the brown winter dress, four of the proximal primaries and a part of the body plumage already renewed at this early date.

6. Adult Nuptial Plumage acquired by a partial prenuptial moult which involves only the body plumage, as in the young bird. The blacker less worn wings and tails without signs of buffy edgings, whiter forehead and clearer white of lower parts less washed with cinnamon, all help to distinguish old birds from young ones.

Female.—The moults and plumages correspond to those of the male, the plumages duller, and the prenuptial moult often limited in extent. The transocular line is obscure in first winter dress, and dull black in subsequent plumages.

Sialia sialis (Linn.). Bluebird

1. Natal Down. No specimen seen.

2. Juvenal Plumage acquired by a complete postnatal moult.

Above, slaty mouse-gray, the back lesser, median and a few inner greater coverts with white guttate spots bordered with sepia, the crown and rump much grayer and unspotted but sometimes with obscure dusky transverse barring. Wings and tail dull azure-blue, the shafts and tips of remiges and rectrices dusky with faint whitish edgings; tertiaries and greater coverts edged with pale chestnut. Below, dull white, mottled on throat, breast and sides with sepia, the feathers centrally white bordered by the sepia and a rusty suffusion. Auriculars dusky mouse-gray mixed with white; lores grayish; conspicuous orbital ring pure white. Bill and feet dusky pinkish buff becoming deep sepia. First primary and outer pair of rectrices without the white edging of the female.

3. First Winter Plumage acquired by a partial postjuvenal moult, in August and September, which involves the body plumage, wing coverts, tertiaries and tail, but not the rest of the remiges.

Unlike the previous plumage and wholly blue and chestnut. Above, including sides of head, orbital ring and wing coverts, deep azure or purplish cobalt-blue, often campanula-blue on the crown, veiled everywhere with pâle chestnut edgings, the tertiaries and wing coverts faintly whitish edged. Below, pale chestnut, white on abdomen and crissum, the anterior part and sides of the chin dull white mixed with a little blue. Tail brighter blue than in juvenal plumage, the rectrices without dusky tips or whitish edgings.

4. First Nuptial Plumage acquired by wear, through which the edgings of the back are lost and the color becomes an ultramarine or azure blue depending somewhat upon the angle at which the light strikes the plumage. The chestnut below fades.

5. Adult Winter Plumage acquired by a complete postnuptial moult beginning about the middle of August. Practically indistinguishale from first winter dress, the colors usually somewhat richer and the chin bluer.

6. Adult Nuptial Plumage acquired by wear as in the young bird.

Female.—The plumages and moults correspond to those of the male. In juvenal plumage the female is similar to the male, but the outer primary and outer rectrix have white outer webs, the blue is everywhere very much duller, and replaced with brown on the tertiaries and wing coverts, the edgings duller and the quills with duskier tips. In first winter plumage the blue is obscure and confined to the wings, tail and rump, the back is dull grayish chestnut, grayer on the crown. The sides of head are gray and white mixed, the orbital ring white. Below, the throat, breast and sides are reddish cinnamon, tingeing also the grayish white chin; abdomen and crissum dull white. The first nuptial plumage is acquired by wear and usually shows a little more blue as the edgings are lost. The adult winter plumage is practically indistinguishable from the first winter but a little bluer above and ruddier below and the adult nuptial is the same, modified by wear.

Postscript.—Although my paper was read on March 13, 1899, and placed in the editor's hands on July 11, 1899, owing to unforseen delays, no proof reached me until nearly a year later, on June 1, 1900. However, thanks to the courtesy of the editor, I have had opportunity to revise the whole paper up to this date, and a portion of it to a still later date, so that it has lost nothing by the long delay in publication, and now constitutes a complete study of the moults and plumages of the Passerine birds of the State of New York.

New York City, Oct. 8, 1900.

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PLATE I.

PLATE I

Dwight—Plumage and Moult

Photograph showing the natural size, pattern and wear of the principal feathers of *Dolichonyx oryzivorus*, a Passerine bird. They are all from males and some of the buff winter feathers have printed so much darker than they actually are that they, unfortunately, appear to be black.

Figs. 1–6.	Throat,	September 2d (J. D. Jr., No. 5125).
7.	Middle rectrix,	" " " "
8.	Secondary,	" " " "
9.	Tertiary,	" " " "
10.	Primary,	" " " "
11.	Dorsal feathers,	" " " "
12.	Scapulary,	" " " "
13.	Greater covert,	" " " "
14.	Median covert,	" " " "
15–16.	Lesser coverts,	" " " "
17.	Crown,	" " " "
18.	Forehead,	" " " "
19–20.	Side,	" " " "
21.	Flank,	" " " "
22.	Breast,	" " " "

23. New black breast feather, March 1st (Amer. Mus. Nat. Hist., No. 32873).
24. Worn black breast feather, May 17th (J. D., Jr., No. 2164).
25. Much worn black breast feather, July 2d (J. D., Jr., No. 1227).
26. New buff abdominal feather, Sept. 2d (J. D., Jr., No. 5125).
27. Worn buff abdominal feather, March 1st (Amer. Mus. Nat. Hist., No. 32873).
28. Partly worn black abdominal feather, May 17th (J. D., Jr., No. 2164).
29. Much worn black abdominal feather, July 2d (J. D., Jr., No. 1227).

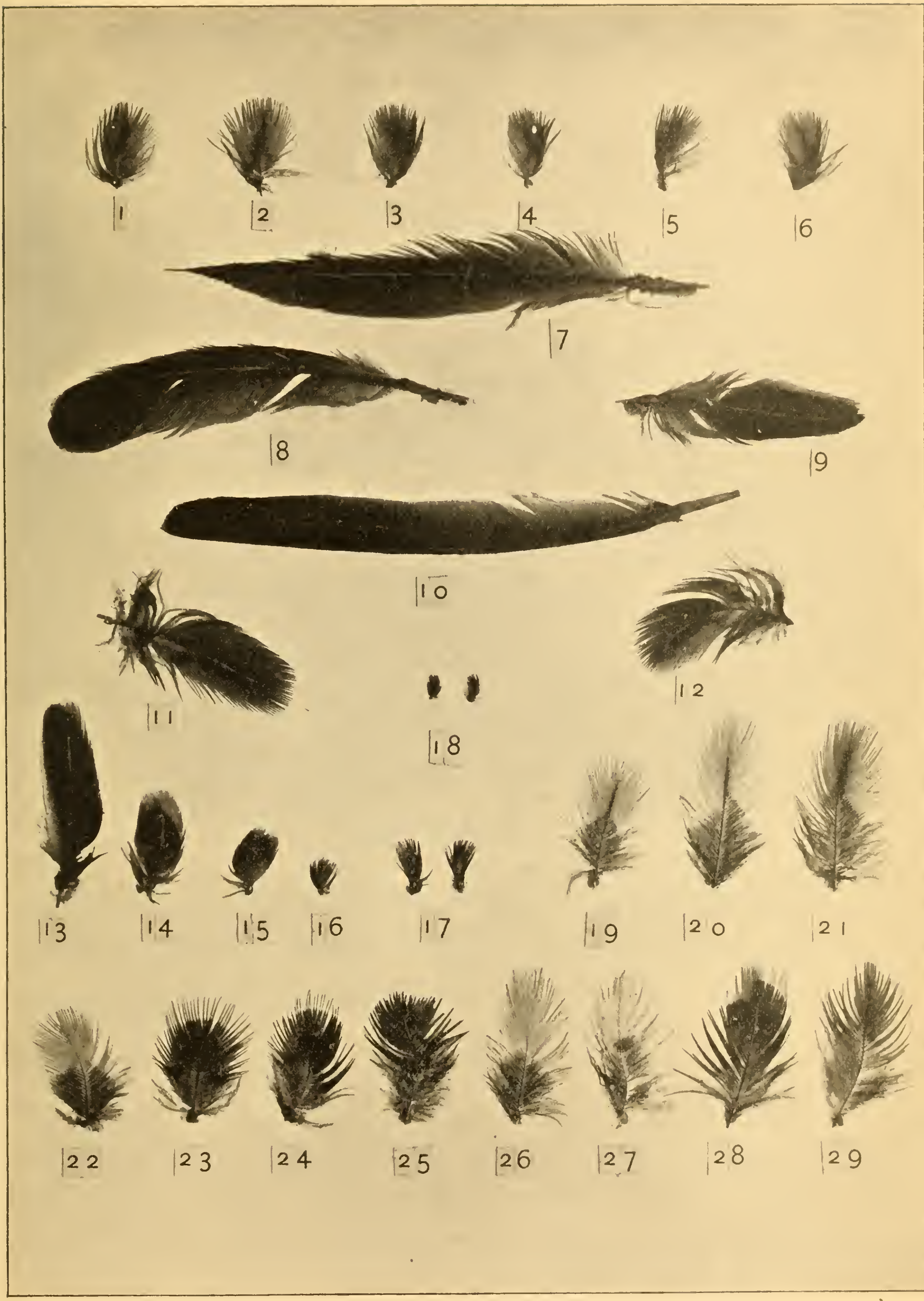
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PLATE II.

PLATE II

Dwight—Plumage and Moult

Photograph of feathers, natural size, from birds of various species illustrating some seasonal effects of moult and wear. The numbers are those of male specimens in my collection.

Fig. 1. *Ammoaramus savannarum passerinus.* Juvenal Plumage tertiary, Sept. 16th (No. 68).

2. *Ammodramus savannarum passerinus.* First Winter Plumage tertiary, Sept. 17th (No. 3468).

3. *Ammodramus savannarum passerinus.* First Nuptial Plumage tertiary, June 19th (No. 2904).

4. *Spinus tristis.* First Winter Plumage tertiary, Jan. 13th (No. 6356).

5. *Spinus tristis.* First Nuptial Plumage tertiary, Aug. 26th (No. 387).

6. *Tachycineta bicolor.* Adult Winter Plumage tertiary, Aug. 24th (No. 6075).

7. *Tachycincta bicolor.* Adult Nuptial Plumage tertiary, May 12th (No. 749).

8. *Icterus galbula.* Juvenal Plumage tertiary, July 28th (No. 536).

9. *Icterus galbula.* First Nuptial Plumage tertiary, May 15th (No. 627).

10. *Icterus galbula.* Adult Nuptial Plumage tertiary, May 17th (No. 2163).

11. *Icterus galbula.* First Nuptial Plumage, tip of rectrix, May 15th (No. 627).

12. *Icterus galbula.* Adult Nuptial Plumage, tip of rectrix, May 17th (No. 2163).

13. *Sturnella magna.* First Winter Plumage, breast feather, Oct. 2d (No. 5146).

14. *Sturnella magna.* First Nuptial Plumage, breast feather, July 16th (No. 3389).

15. *Sturnella magna.* Juvenal Plumage tertiary, July 7th (No. 1237).

16. *Sturnella magna.* First Winter Plumage tertiary, Oct. 2d (No. 5146).

17. *Sturnella magna.* First Nuptial Plumage tertiary, July 16th (No. 3389).

18. *Tyrannus tyrannus.* Juvenal Plumage, tips of first and second primaries, Aug. 30th (No. 6098).

19. *Tyrannus tyrannus.* First Nuptial Plumage, tips of first and second primaries, April 7th (No. 6458).

20. *Chelidon erythrogastra.* Juvenal Plumage, lateral rectrix, Aug. 6th (No. 1991).

21. *Chelidon erythrogastra.* First Nuptial Plumage, lateral rectrix, May 22d (No. 2185).


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PLATE III.

PLATE III

Dwight—Plumage and Moult

Photograph showing location of the Pterylæ or Feather Tracts of a Passerine bird. Natal Down or neossoptiles may be seen at the tips of the juvenal feathers which are just breaking from their follicles. The specimen a young Robin (*Merula migratoria*), five days out of the egg, is photographed life size.

Fig. 1. Superior Aspect of the Feather Tracts.

1. Alar or Wing Tract.
2. Humeral or Shoulder Tract.
3. Capital or Head Tract.
4. Dorsal or Spinal Tract.
6. Lumbar or Thigh Tract.
7. Crural or Leg Tract.
8. Caudal or Tail Tract.

Fig. 2. Inferior Aspect of the Feather Tracts.

1. Alar Tract.
3. Capital Tract (lateral view.)
5. Ventral or Inferior Tract (dividing into two lateral bands).
7. Crural Tract.

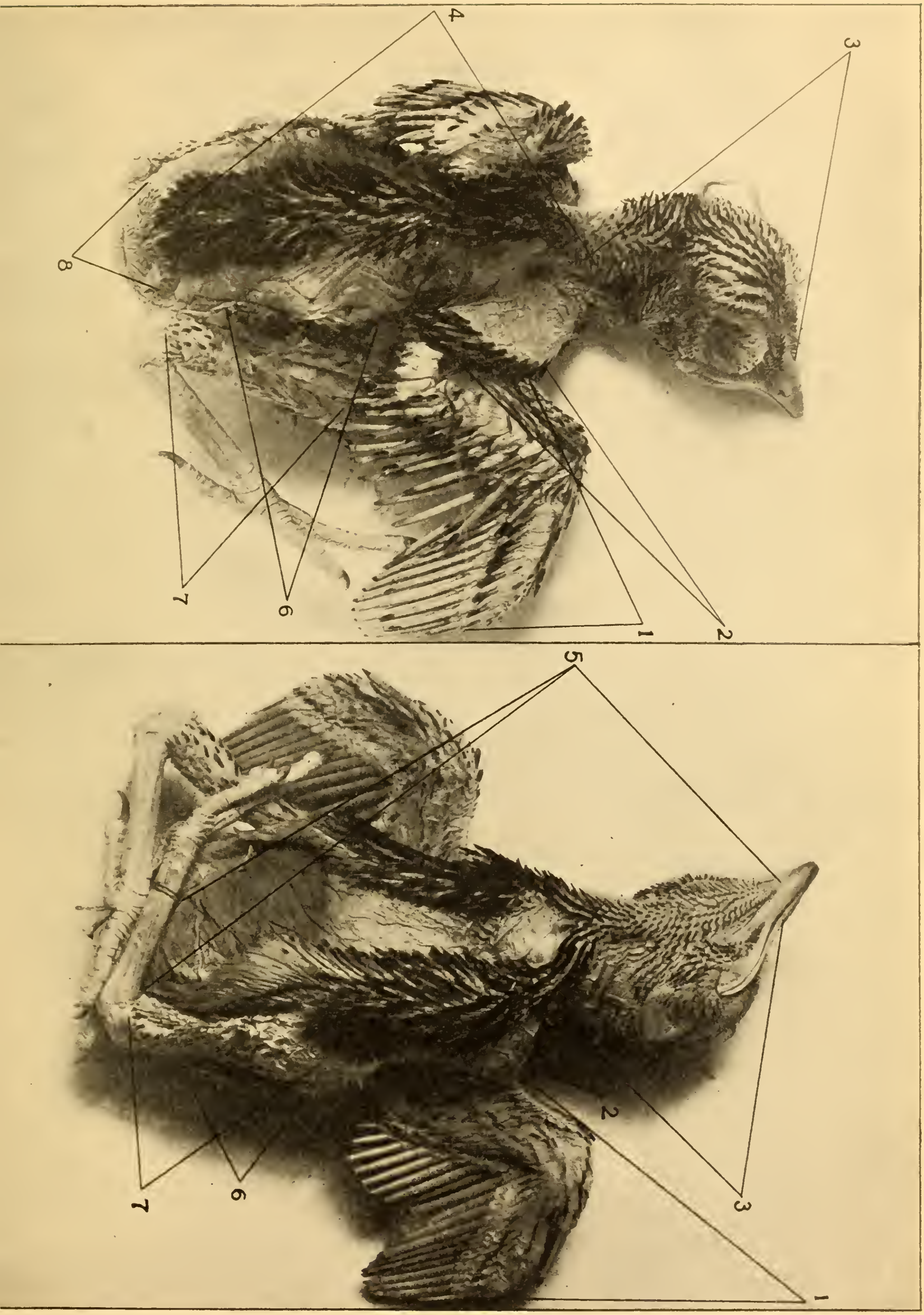
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PLATE IV.

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PLATE IV

DWIGHT—PLUMAGE AND MOULT

Carpodacus purpureus.—Photomicrographs illustrating some of the plumages. (Enlargement about 20 diameters.)

Fig. 1. Juvenal Plumage, crown feather, showing loose structure. (J. Dwight, Jr., No. 1288, July 23d.)

Fig. 2. First Winter Plumage, crown feather, nearly new. (J. Dwight, Jr., No. 5223, Oct. 17th.)

Fig. 3. First Nuptial Plumage, crown feather which is identical with a first winter feather plus wear, no moult intervening. (J. Dwight, Jr., No. 260, April 23d.)

PLATE V.

PLATE V

Dwight—Plumage and Moult

Photomicrographs illustrating Natal Down adhering to tips of Juvenal Plumage feathers.

Fig. 1. *Dolichonyx oryzivorus*, crown feather bearing Natal Down. Specimen in the collection of J. Dwight, Jr., No. 1943, July 28th. (Enlargement about 5 diameters.)

Fig. 2. *Cistothorus palustris*, crown feather bearing Natal Down. Specimen in the collection of J. Dwight Jr., No. 4214, Aug. 20th. (Enlargement about 15 diameters.)

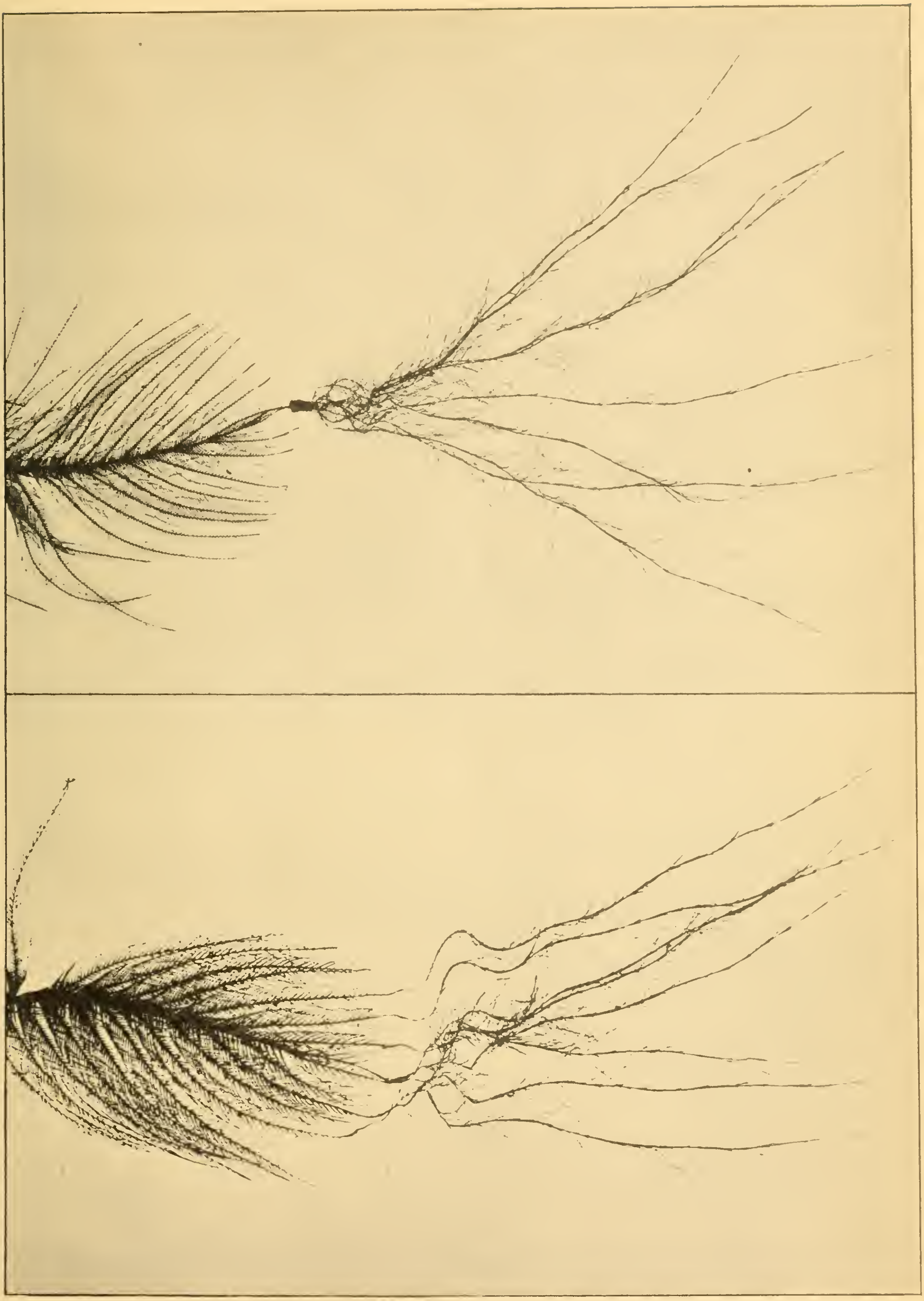


PLATE VI.

PLATE VI

Dwight—Plumage and Moult

Passerina cyanea.—Photomicrographs illustrating some of the plumages. (Enlargement about 20 diameters.)

Fig. 1. First Winter Plumage, brown throat feather, newly grown. (J. Dwight, Jr., No. 2451, Sept. 23d.)

Fig. 2. First Winter Plumage, gray throat feather, worn. (U. S. Nat. Mus., No. 107845, March 11th.) This figure does not do the actual feather justice.

Fig. 3. First Nuptial Plumage, blue throat feather, new. It was still clasped by its sheath, and was growing beside the gray feather shown as Fig. 2.

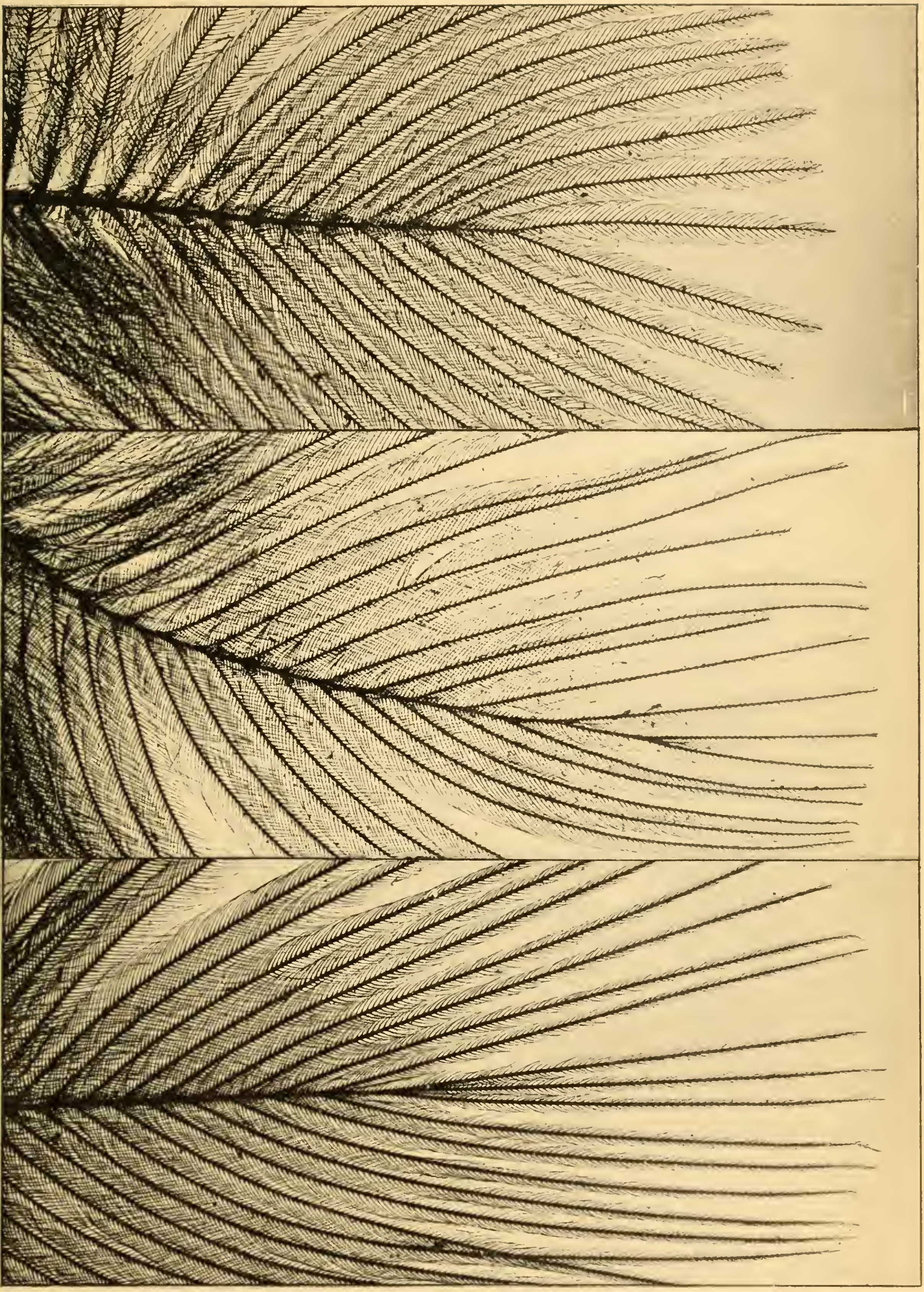


PLATE VII.

PLATE VII

Dwight—Plumage and Moult

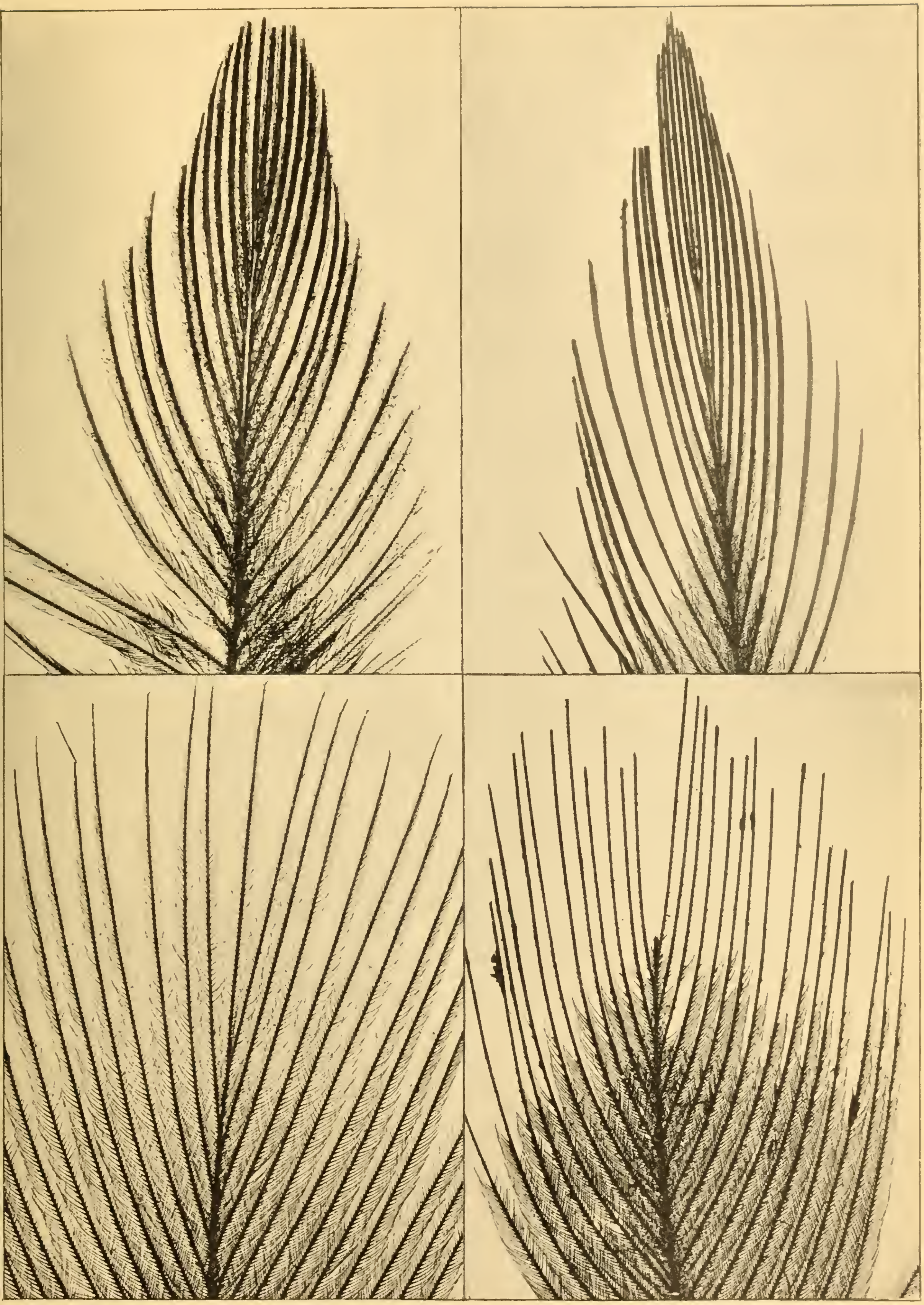
Photomicrographs illustrating the apparent brightening of color in certain feathers. See explanation on pages 80, 173–175. (Enlargement about 15 diameters.)

Fig. 1. *Carpodacus purpureus.* Adult Winter Plumage, crown feather slightly worn. (Collection of J. Dwight, Jr., No. 894, Oct. 29th.)

Fig. 2. *Carpodacus purpureus.* Adult Nuptial Plumage, crown feather, equivalent to Fig. 1 plus wear and consequent loss of barbules. (J. Dwight, Jr., No. 3616, July 7th.)

Fig. 3. *Loxia curvirostra minor.* Adult Winter Plumage, newly grown breast feather (the sheath was adherent). (J. Dwight, Jr., No. 1529, Oct. 16th.)

Fig. 4. *Loxia curvirostra minor.* First Nuptial Plumage, worn breast feather. It was situated beside the one just shown (Fig. 3), which it closely resembled when first developed, a year previously.



[Annals N. Y. Acad. Sci., Vol. XIII, No. 3, pp. 361-380, Jan. 12, 1901.]

THE SECTION AT SCHOHARIE, N. Y.

John J. Stevenson

(Read October 16, 1899)

CONTENTS

INTRODUCTION

The Schoharie River rises on the easterly side of the Catskill mountains, flows westwardly across the rugged area, then turns northwardly and finally enters the Mohawk river near Amsterdam, about one hundred miles from its source. It cuts the Helderberg escarpment at little more than a mile below the village of Schoharie in the county of the same name.

The Helderbergs are practically the northwestern border of the mountainous synclinal area known as the Catskills, the southeasterly border being the Shawangunk mountains. The section shown in the wall, as seen for many miles along the Delaware and Hudson railway, extends from the Hudson to the Hamilton, while the Chemung is reached at from one to four miles from the escarpment's edge. The succession is shown in such detail at many places that this Helderberg scarp from near

Albany to Sharon Springs has always been a favorite ground for students. Prof. James Hall made his first journey along its face in 1832 and three generations of Gebhards have followed him as industrious collectors along the Schoharie and its tributaries. Recent studies have been made by Prof. C. S. Prosser and Mr. N. H. Darton, which have gone far toward removing uncertainty respecting the relations of some of the beds.

Schoharie Valley is a broad indentation of the Helderbergs extending without material contraction for about five miles above Schoharie village. At that distance, however, the Marcellus has passed under the stream, and the hard beds of the Hamilton form the walls of the valley. The writer's study was confined to the immediate vicinity of Schoharie village, where, on both sides of the valley, the section extends from the Hudson to the Corniferous, while the Hamilton can be reached at barely a mile away. The object of the study was to compare the section below the Corniferous with that in south-central Pennsylvania. Many details were obtained during the examination, which are given here for the use of collectors who may visit the locality.

THE HUDSON, MEDINA AND CLINTON

The **Hudson** is represented indifferently at Schoharie, the exposures on the west side near the bridge and near the edge of the escarpment as well as the outcroppings along the east side of the valley north from the village being insignificant. But the beds are better shown along the Delaware and Hudson railway from Central Bridge to Esperance in this county where they are grayish to drab shales and sandstones, making up the low rounded hills northwestward from the escarpment. The thickness is very great, for, according to Mr. Darton, a boring near Altamont showed it 3,480 feet.

The Medina is unrepresented, and the Oneida, so massive in the Shawangunk, is wanting. The Hudson is succeeded by a shale, which is well shown on the west side of the river at a little way above the bridge, but very imperfectly on the valley road and on the point of West mountain. This, regarded as the equivalent of the Clinton, is somewhat variable in color, weathers dirty white and contains much nodular pyrite accompanied by barite. The same characteristics appear at Howe's cave, five miles west from Schoharie. The pyrite was mined near Schoharie thirty years ago, but the venture proved unprofitable. The exposures at Schoharie are incomplete but the thickness cannot exceed thirty feet.

There is here a very striking contrast with the section of southern Pennsylvania and of other localities farther southward.

The Hudson shales, in Evitts mountain, Bedford county, Penn., mostly yellow in color, contain some sandstones near the top, where the color changes and physically there is a gradual passage to the lower or red Medina. *Rafinesquina alternata*, *Plectambonites sericea*, *Rhynchotrema capax* and *Leiopteria radiata* pass upward into the red Medina. The conditions in southwestern Virginia are the same. On the northern side of Big Walker mountain in Bland county, near Sharon Springs, as well as in Lyons gap through the same mountain in Smyth county and Hayter's gap through Clinch mountain in Russell county, exposures are especially good, as they show a fossiliferous bed at about one hundred feet below the white Medina, in which *Rhynchotrema capax*, *Actinopteria emacerata*, *Leiopteria radiata*, a *Modiolopsis* a large linguloid form and fragments of *Orthoceras* occur abundantly. The Oneida seems to disappear in south-central Pennsylvania and thence southward the passage from Ordovician to Silurian is gradual at most of the exposures.

THE NIAGARA

The **Niagara** limestone is represented by the Coralline limestone of the older reports, which, at the complete exposure on Schoharie river above the bridge, is a massive rock in three layers, averaging in all six feet. The upper portion is very dark on fresh surface, the lower portion less so, but both weather light gray. This limestone is well exposed along the west side of the river for an eighth of a mile above the bridge and at several points below the bridge; it can be followed easily to Howe's cave, where it underlies the "Cement rock" of the Waterlime. The only exposure on the east side is that near the African church, but the rock is present along this hill northward and in the Fox-kill valley eastward, as the stone fences hold fragments of it in abundance. Some portions are crowded with *Favosites niagarensis* and *Stromatopora concentrica* but other forms are rare. Occasionally one finds a nest of *Rhynchonella lamellosa* with *Atrypa reticularis* and *Pterinea securiformis*, all well preserved. Besides these are some univalves and cephalopods but for the most part they are indefinite and in some cases even the genus cannot be determined satisfactorily.

THE ONONDAGA

The **Onondaga**, of Dana, is represented only by the **Waterlime**. The Salina shales, so thick in western New York and persistent in southward even to the Baltimore and Ohio railroad[1] in Maryland, have no representative here. The physical change from Coralline (Niagara) to Waterlime is sufficiently sharp in that the color changes abruptly from very dark brown (the "blackrock" of the Cement quarries) to dark gray or dull brown while the fracture becomes more earthy and ragged, though the weathered surface of the two rocks is very similar.

The **Waterlime** is not well exposed at any point near Schoharie. The space between the Coralline and the Tentaculite on the east side is apparently not more than 15 feet, but it is certainly greater on the west side of the river upon the Gebhard farm, where there is a good exposure for more than six feet above the Coralline. The succession is fairly well shown at the Howe's cave cement tunnel, where, in descending from the Tentaculite limestone, one finds

1.	Flaggy and shaly limestone	31′
2.	"Blue rock"	2′ 6″
3.	"Cement rock"	6′
	In all	39′ 6″

[1] As ascertained by I. C. White.

The upper portion of No. 1 is shown at the entrance to Howe's cave, and at the grinding mill as well as in an excavation near by once occupied by a kiln. The middle portion for about 6′ is concealed, while the lower portion is exposed at the tunnel. The flaggy layers are from 6″ to 1′ thick and hard, yielding a good building stone, which was used in the older part of the Cave hotel. The greater part of the mass, however, is made up of layers from one to two inches thick, separated by laminæ of shale. The rock weathers light gray with trace of blue, but is brownish gray on the fresh surface. The "blue rock" is evidently a hydraulic limestone, light blue in color, with irregular fracture and too calcareous for cement. The "cement rock," which forms the base of the mass, varies little from 6′ and is in three layers. It is darker than the last, more ragged in fracture and is the cement rock of the works in Ulster and Schoharie counties.

At Howe's cave, calcite occurs in little patches between the "Blue" and "Cement," sometimes in sufficient quantity to be annoying. Near Schoharie, it has been obtained at Clarke's cave as well as near the Table rock, both on the west side of the river. Near the latter locality, strontianite is associated with the calcite. Several tons of the former mineral were shipped, but the deposit did not prove to be of economic importance as the streaks are too variable. No attempt has been made at Schoharie to utilize the rock in the manufacture of cement, though the character is apparently the same as at Howe's cave, where preparations are making for an output of 2,000 barrels per diem.

While the color and composition of the rock prove a decided change in physical conditions from those prevailing during the Niagara, still that change must have been comparatively unimportant, since it did not suffice to cause local destruction of the fauna. At Howe's cave, *Favosites niagarensis* passes upward from the Coralline and persists in the lower three feet of the "cement," being so abundant in some of the headings as to unfit the rock for use. According to Professor Hall, *Halysites catenularia* passes from Niagara to Waterlime in Herkimer county. At Schoharie, Mr. W. D. Gebhard has obtained some of his best

"Coralline" forms from the lower layers of the Waterlime; and certainly some specimens in the New York University museum, collected many years ago by John Gebhard, Jr., are in rock showing the color and fracture not of Coralline but of Waterlime. It is sufficiently evident that, while the great mass of Salina shale was in process of deposit in central New York and in much of the Appalachian region, the conditions within this portion of New York changed so gradually as to bring about only a slow disappearance of the fauna. There is a steady increase of calcareous matter from the bottom to the top of the Waterlime. No fossils were found in the lower portions of No. 1, but, above the middle, *Spirifer vanuxemi* and *Leperditia alta* were obtained from the thicker layers, showing that the passage to Helderberg was quite as gradual as that from Niagara.

The Waterlime is the cave rock of this region.

THE HELDERBERG

The Helderberg (**Lower Helderberg**) was divided by the older geologists into

1. **Tentaculite Limestone.**
2. **Lower Pentamerus Limestone.**
3. **Catskill or Delthyris Shaly Limestone.**
4. **Scutella Limestone.**
5. **Upper Pentamerus Limestone.**

The succession being in ascending order.

This succession is distinct in southern Pennsylvania and even in southwest Virginia, though in the latter area the upper beds are quite silicious. The formation is termed the Lewistown limestone in the Pennsylvania reports.

1. The Tentaculite Limestone

The passage from **Waterlime to Tentaculite** is marked in the Schoharie region by an abrupt change in color, the latter being the "Blue limestone," with blue so deep in the lower layers as to appear almost black. The succession in descending order is

Tentaculite limestone.

1. Limestone, bluish, irregularly bedded, layers 2″ to 4″ thick	2′ 6″
2. Limestone, bluish, irregularly bedded, often sub-concretionary, the layers separated by very thin shales	13′ 6″
3. Limestone, deep blue, in two layers, 2′ 3″ and 2′ 6″, separated by 2″ of clay, massive, brittle, conchoidal fracture, fetid odor	4′ 11″
4. Limestone, thin layers with laminæ of shale	5′
5. Limestone, blue to bluish-black, massive	2′ 5″
6. Limestone, bluish, irregular, sub-concretionary structure	2′
7. Limestone, thin bedded, with laminæ of shale	5′ 8″
8. Limestone, in layers about 1″ thick	1′
9. Limestone, bluish-black, ragged fracture, massive, in three layers	8′ 5″

in all 45′ 5″ thick.

This section is seen in an almost continuous exposure on the east side, where quarries have been worked for a quarter of a mile below Schoharie village, and there are many partial exposures within half a mile above the village. The only complete exposure on the west side is along the road ascending West Mountain. Occasional outcrops were seen on Foxkill and Cobleskill east and west from the Schoharie and the great quarries at Howe's cave exhibit the same order. At one time, the massive beds were quarried either for building or for ornamental stone, but they are used no longer, as planes of bedding developed on exposure and caused unsightly seams. The weathered surfaces in the quarries show that the massive beds are laminated though the surface of fresh fracture shows no trace of such structure.

The lowest bed was quarried most extensively as it yields blocks of large size. The rock is brittle, rings when struck but has a very ragged fracture. Fossils are comparatively rare, only *Spirifer vanuxemi* and *Leperditia alta* having been seen. But the half-burned rock is clearly a mass of fossils, mostly of the forms mentioned with some *Tentaculites*. No. 8 varies little in thickness and not at all in character. The upper surfaces of the layers are crowded with *Tentaculites gyracanthus*, which at many localities are in perfect condition. No. 7 is more irregular in its bedding. Thin laminæ of limestones in the shales separating the thicker layers are crowded with fossils, seldom in good condition. The predominating forms are *Zaphrentis*, *Stromatopora*, *Spirifer vanuxemi*, *Leiopteria aviculoidea*, *Tentaculites gyracanthus*, *Leperditia alta*, *Beyrichia* and minute univalves. The delicate crinoid, *Homocrinus scoparius*, is said by W. D. Gebhard to belong in the upper portion of this division, but no fragments of it were found. No. 6 contains many *Stromatopora*, some of which are large, one colony having been seen which weighed more than 75 pounds. No. 4 resembles No. 7 and contains the same fossils in the same condition. No. 3 resembles Nos. 5 and 9. It yields the *Spirifer* and *Leiopteria* well preserved but *Tentaculites* is rare. No. 2 is very fossiliferous, and the specimens obtained from the harder parts are very good; *Stropheodonta varistriata* occurs abundantly and a fine pygidium of *Dalmanites micrurus* was found near the top. No. 1 contains few fossils aside from fragments of crinoidal stems, which are shown on the weathered surface. Besides the forms mentioned, some of the massive beds contain *Orthoceras*; no specimens were found in place but several were obtained from the waste piles. Irregular markings occur on the surfaces of the higher beds which may be looked upon as mats of fucoids, shrinkage cracks or trails; all appear to be chafed or water-worn as though the rock had been at the water's edge.

There is no transition from the **Tentaculite** to the **Lower Pentamerus.** The former is blue, brittle, laminated or thin-bedded; the latter is bluish gray, massive, extremely tough and refractory. The best blocks of Tentaculite bear little strain; some, 15 inches thick, in the Schoharie cemetery have broken on irregular foundations under the weight of comparatively small monuments, but the Lower Pentamerus is reported to bear a pressure of 19,000 to 26,000 pounds to the square inch.

2. Lower Pentamerus Limestone

The **Lower Pentamerus** consists of 33 feet of hard, massive limestone below and 32 feet[1] of alternating hard and somewhat softer limestones above. The lower portion forms a bold cliff, which is distinct on both sides of the Schoharie valley to two miles above the village, where it passes under the river at less than half a mile below Davis's dam. It is equally distinct westwardly to Howe's cave and eastwardly along the face of the Helderberg for many miles. The rock is excessively hard, or better, tough, very difficult to break with the hammer. The bedding is evident, but there is a subordinate structure, so that the rock seems to be made up of irregular lenses separated by coatings of clay. This structure is very apparent on the weathered surface, and is recognizable without difficulty in the unweathered rock. The weathered surface is very irregular and suggests a loose structure, but in Mix & O'Reilly's quarry at Schoharie, building-stone of the best quality has been obtained at five feet back from the face. The rock has been exposed to attack from both sides in that quarry, for the joint planes have been converted into open fissures, whose sides are weathered as thoroughly as is the exposed cliff. The clay film may be a cementing material for the lenses. The color is dull grayish on the cliff face, which is often coated with drip lime, but internally the color has more of blue, though wholly different from the blue of the Tentaculite. The full thickness of this portion is not shown on the east side, but is exposed on the west side of the valley, along the road ascending West mountain. The character of this portion is the same as at Howe's cave, where, however, no use is made of the rock except in preparation of road metal.

The upper portion of the **Lower Pentamerus** is not exposed in satisfactory detail near Schoharie. An imperfect exposure was found in a dry waterway in the park back of Schoharie village on the east side, and another in a similar waterway on the west side, about 200 yards south from the schoolhouse.

[1] These measurements are by barometer.

The succession at both places is that of thin limestones varying in hardness but with very little trace of shale. No exposures were seen in open fields on the east side, but the harder beds are shown on the schoolhouse hill south from the waterway just mentioned, where the decayed outcrop gives opportunity to see the fossils.

The toughness of the lower portion is such that fossils can be obtained in very few places; even where decay has gone on for a long period, the result is little more than mere separation of the lenses, leaving the limestone itself as refractory as before. A few layers, however, are more readily treated and yield numerous strophomenoid forms, one of them being evidently the *Stropheodonta* of the Tentaculite. *Sieberella galeata* is found abundantly with the valves separate. *Uncinulus mutabilis*, *Atrypa reticularis* are common; rude fragments of *Orthoceras* and pygidia of *Dalmanites* occur, and fragments of crinoidal stems are not rare. In the upper division the same forms are present, but the *Sieberella* is less common. A layer within two or three feet from the top is characterized by the *Lepadocrinus gebhardi*. A continuous outcrop of more than 200 feet in the field south from the schoolhouse shows the stems in great abundance, but complete specimens are very rare, barely a dozen examples having been obtained during almost seventy years of collecting by three generations of Gebhards. This horizon is exposed in the park near Schoharie village. One of the higher layers contains great numbers of *Mariacrinus* stems, some of which are more than a foot long.

3. The Delthyris or Catskill Shaly Limestone

The immediate contact between the Lower Pentamerus and the Delthyris was not seen, there being a concealed interval of from two to five feet between characteristic beds. The thickness of the Delthyris by barometer is from 85 to 95 feet. The mass is a succession of limestone beds, one to three feet thick separated by beds of calcareous shale varying in like manner. The limestones are bluish to dark gray, some of them very light gray. Many of them are somewhat argillaceous and most of them weather light gray. The shales are hard but weather readily. As a whole the rocks wear away easily so that the place of the Delthyris is marked by a slope between cliffs made by the Lower and the Upper Pentamerus. This slope on the east side of the valley is long and gentle so as to be cultivated and there are few satisfactory exposures; but the slope is comparatively steep on the west side and an almost continuous exposure is found on the schoolhouse hill in a little waterway. Imperfect exposures only were found on West mountain near Murphy's, though there one finds the best exhibition of the uppermost beds. The most extensive exposure is on the west side of Schoharie river below Davis's dam, where one sees all the beds, except the topmost, as they descend to the river; when the water is low, a horizontal space of 25 to 100 feet is bare.

The lower portion for about fifteen feet is silicious and contains much chert. It is shown on the schoolhouse hill where it can be followed for a long distance; but a proper understanding of the structure of this portion can be gained only at the Davis dam locality, where the broad surface shows the interlacing of the cherty masses. The fossils in this part are numerous and beautifully preserved; they are all silicified but cannot be removed except by weathering. The rock is refractory and is apt to break at the wrong place for the collector. The highest beds are soft calcareous shales best shown on West mountain at the Murphy place, where for a hundred feet or more they have rotted away leaving a recess under the Scutella-Pentamerus cliff.

The **Delthyris** is fossiliferous throughout and in many of the beds perfect specimens are the ordinary condition. Owing to the readiness with which the softer beds weather, specimens are set free in great number. Some forms are present throughout. At Davis' dam *Spirifer macropleura* makes its appearance in the cherty beds and persists to the top of the series. It was not found in the highest shales at the Murphy locality. *Atrypina imbricata* and *Coelospira concava* are rare in the upper shales though abundant in the beds below. The most characteristic forms occurring throughout the Delthyris are *Zaph-*

rentis helderbergiæ, *Leptæna rhomboidalis*, *Stropheodonta beckii*, *Orthothetes woolworthana*, *Rhipidomella oblata*, *Dalmanella subcarinata*, *Spirifer macropleura*, *S. cyclopterus*, *S. perlamellosus*, *Meristella arcuata*, *Eatonia medialis*, *Stenochisma formosa*, *Uncinulus nucleolatus*, *Platyceras elongatum*, *Phacops logani*, *Dalmanites* and *Lichas* in fragments. *Orthoceras* fragments are many but obscure.

4. The Scutella Limestone

Resting upon the shales closing the Delthyris is a limestone, eight feet thick, light blue, slightly granular and containing vast numbers of crinoidal stems, whose white color contrasts markedly with the blue of the rock. For two feet at the bottom this **Scutella limestone** is in layers one to two inches thick, but, above, it becomes more nearly massive. It forms the lower part of the upper limestone cliff, which stands out on both sides of the valley to a short distance above Davis' dam, about two miles and a half above Schoharie village. This cliff is less conspicuous than that below, as the rock is less resistant, but its place is distinct. The most notable fossils are the shield-like bodies of *Aspidocrinus scutelliformis*, which in some cases are almost three inches in diameter. The stems accompanying them are from one-fifth to one-third of an inch in diameter, but they can hardly belong to *Scutella*, as in that form the pit for attachment is very small. Other fossils are abundant, most of them forms which are found in the Delthyris. The brachiopods, except *Atrypa reticulatus*, usually have the valves separated.

5. The Upper Pentamerus Limestone

This has been united by Professor Hall with the Scutella under the name of Becraft limestone, as the two limestones appear to be hardly distinct enough in some other localities to deserve separate names. In the Schoharie area, however, they are easily distinguished by the color of the fresh surface, although the weathered surface shows no difference. The Upper Pentamerus forms the upper portion of the second cliff on both sides of the valley and can be reached at many places up to its disappearance above Davis' dam. The color is bluish gray, much darker than that of the Scutella but much lighter than that of the Lower Pentamerus. Like the latter, it is somewhat irregular and roughly lenticular in structure, but less so. The upper layers are easily broken and resemble the Scutella in color as well as in general appearance. They are crinoidal and carry *Zaphrentis* almost to the top, where they seem to contain little more silica than the lower beds. These upper layers include some thin shaly beds, thus differing from the lower portion, which at most localities is rather massive. The thickness as measured on the schoolhouse hill is approximately 22 feet. Exposures on the east side of the valley are not complete, only the lower portion being shown at most localities. Erosion on that side both before and during the glacial period was much more extensive than on the west side. Good measurements can be obtained on the Schoolhouse hill and on West mountain, both on the west side.

The **Upper Pentamerus** is richly fossiliferous ; in some layers only separated valves even of Atrypa and Rhynchonelloid forms can be obtained, but in others the specimens are well preserved and abundant. Some forms are present throughout ; *Leptæna rhomboidalis*, *Schizophoria multistriata*, *Spirifer concinnus*, *Meristella princeps*, *Atrypa reticularis*, *Wilsonia ventricosa*, *Stenochisma formosa*, *Uncinulus nobilis*, *Sieberella pseudogaleata ;* but beside these are many forms, the writer having obtained *Rensselæria*, 2 sp. ; *Rhynchonelloid* forms, 4 ; *Meristella*, 3 sp.; *Spirifer*, with *Orthis*, *Leptæna*, *Stropheodonta*, *Platyceras*, *Orthoceras*, *Trochoceras*, *Favosites*, *Chætetes*, *Stromatopora* and *Lichenalia*. The *Favosites helderbergiæ* is most abundant about midway and is often associated with chert. Where the rock is in proper condition, as at the Brown farm northeast from Schoharie and above Davis's dam, the Upper Pentamerus affords a series of fossils as interesting and as well preserved as those of the Delthyris. Specimens rarely weather free in good condition as they are not silicified, but the limestone is much more tractable than the Delthyris and specimens can be broken from the rock, almost as good as those of the Delthyris.

THE ORISKANY SANDSTONE

The **Oriskany** is thin at Schoharie, not more than ten feet. The contact with Upper Pentamerus was not seen but on the schoolhouse hill and on West mountain the concealed space is not more than 18 inches. The rock is rarely found in place as it decays readily and the crop becomes covered. One exposure on the schoolhouse hill shows 7 feet. On West mountain the interval from the highest observed layer of the Pentamerus to the top of the Oriskany is barely 12 feet. The rock is bluish gray, slightly calcareous sandstone with much ferruginous matter as cementing material. Unweathered, it is very hard, but weathered it is rusty yellow and very tender.

The change from Helderberg to Oriskany is abrupt at Schoharie and according to Mr. Darton's observations it seems to be equally so throughout the region. Professor Hall once stated in conversation that the break at this horizon is one of the best defined in the State of New York. But the case is different farther south in the Appalachian region. The transition is very gradual in southern Pennsylvania, there being as the transition bed a silicious limestone, 20 feet thick, very cherty, whose whitened fragments occur abundantly on every **Oriskany** ridge in Bedford county. This bed contains the Helderberg *Favosites* along with such typical Oriskany forms as *Spirifer arenosus* and *Plagiostoma ventricosum*. The section is almost complete at Hyndman, where the quarries are extensive. This transition bed is persistent southward, being present as the attenuated representative of the Oriskany and Helderberg at several localities in the Valley of Virginia, where those formations thinned out against the old shore-line. The intimate relation between these formations seen in southern Pennsylvania is equally clear in southwestern Virginia, where, however, the Helderberg becomes silicious in the upper portion and the Oriskany contains so many Helderberg forms that the writer during his first examination of the region thought it the Helderberg. In New York the Oriskany does not contain crinoids, but such forms are by no means rare in Maryland and southward.

Fossils abound in some layers of the **Oriskany**. They are not obtained readily from unweathered rock and the weathered rock affords usually only casts, which, however, show the interior structure with extreme accuracy. Sometimes where the decay has not caused complete removal of calcareous matter, exquisite specimens are found, showing shell structure and internal appendages of brachiopods. The forms are not numerous at Schoharie, but many of them are such as to be attractive museum specimens. Those commonly obtained are *Spirifer arenosus*, *S. arrectus*, *Metaplasia pyxidata*, *Meristella lata*, *Rensselæria ovoides*, *Megalanteris ovalis*, *Rhipidomella musculosa*, *Eatonia singularis*, *Stropheodonta magnifica*, *Hipparionyx proximus*, *Anoplotheca flabellites*, *Platyostoma ventricosum*.

Lamellibranchs are not rare, but they are seldom obtained in good condition. The only forms passing up from the Helderberg are the *Eatonia* and *Leptæna rhomboidalis*, the latter very rare.

THE CORNIFEROUS

Everywhere throughout this region there rests upon the Oriskany a mass of shale, grayish, from 95 to 105 feet thick (by barometer). This is the **Cauda Galli grit**, the **Esopus shales** of Darton, and forms the slope above the Upper Pentamerus cliff on both sides of the Schoharie valley. Its bottom layer, 3 to 5 inches, is hard and forms the floor of the bench, protecting the softer Oriskany, whose wasting has formed a subordinate slope Much of the shale is fissile, this being shown on West mountain where the slope is abrupt; the upper portion is rather harder and is jointed so as to come out in blocks, 3 or 4 feet by about 2 feet and 8 to 12 inches thick. The *Spirophyton* is most abundant in the upper part. The exposures near Schoharie are all imperfect, the best being on West mountain: there are very few on the east side where the pre-glacial erosion was very extensive.

The **Schoharie Grit**, between the Cauda-Galli and the Corniferous limestone, is rarely more than 6 feet thick and is exposed at very few localities. It is an excessively hard silicious limestone, containing much ferruginous matter and dark brown on the fresh surface. Weathered, it resembles the Oriskany, but is darker. It is so hard as to suggest that silica is the cementing material. But the iron leads to disintegration and the rock wastes away, so that its outcrop is concealed by heavy blocks of Corniferous, between which debris has accumulated. The only outcrop discovered is on the northwest face of West mountain, but the presence of the rock is shown on both sides of the valley by the fragments strewn about the fields. The unweathered rock is so hard as to yield nothing to the collector, but several layers are extraordinarily rich in individuals of a few types, which can be procured easily from weathered fragments. The ordinary forms belong to *Stropheodonta*, *Pentamerella*, *Atrypa*, *Orthoceras*, *Cyrtoceras*, *Trochoceras* and *Gomphoceras*. Cephalopods are the prevalent forms. *Atrypa reticularis* is the most common of the brachiopods and its casts as well as those of *Stropheodonta* are in admirable condition for study.

The **Corniferous** limestone caps West mountain and the schoolhouse hill on the west side of the valley and is easily followed to where it passes under the river near Borst's dam, about four miles above Schoharie. It is quarried extensively at the lime-kilns below the dam. It is imperfectly shown on the east side at several places within two miles and a half above Schoharie village, but, above that, the valley is eroded in Cauda-Galli and the bluff is covered with debris from the Hamilton. The Corniferous is known as the "Top gray limestone." It is gray, brittle and contains much chert in lenses and irregular layers. The older geologists divided it into Onondaga and Corniferous, but chert appears to be characteristic of both divisions and the older name should be applied to the whole. The thickness in schoolhouse hill is not far from 30 feet but it is greater at the limekilns where the whole is shown. Fossils are abundant but only a few forms are likely to be obtained by the collector. Cyathophylloid corals, *Favosites* and *Syringopora* are the characteristic types; *Gyroceras trivolvis* is obtained occasionally at the limekilns; *Atrypa reticularis* attains large size as it does also in the same limestone further west in this State. Some of the layers contain many trilobites.

THE HAMILTON

The Hamilton is reached on the west side at little more than a mile above Schoharie, while on the east side it caps the hill at about the same distance east from Schoharie. The Marcellus with its Goniatite limestone comes down to the river at Middleburg, five miles above Schoharie, where the Hamilton sandstones form a bold cliff. The shales contain *Liorhynchus limitaris* in profusion while the limestone is rich in *Goniatites*, *Orthoceras* and *Nautilus*. The Hamilton sandstones have yielded many species of lamellibranchs. No measurements of these beds were made.

LOCALITIES FOR COLLECTORS

The impression prevails that as the Schoharie region has been a collecting ground for three-fourths of a century, it must be practically exhausted ; but this is wholly erroneous. It is quite true that weathered specimens free from the rock are no longer to be had plentifully but the writer discovered that the old localities repay careful work as well as they did thirty years ago, when he first collected there.

The **Coralline** limestone is well shown near the African church in Schoharie and fragments of the rock in excellent condition are plentiful in stone fences along the lower road leading northward from the village.

The **Tentaculite** is fully exposed in the long line of old quarries from the cemetery northward, in all of which the waste piles are very large. The *Tentaculites* are in best condition in an old quarry at the south end of the village.

The **Lower Pentamerus** cliff is broken at several places between the cemetery and the point where it crosses the Middleburg road, less than a mile south from Schoharie, and it is quarried extensively just north from the village. The upper layers are shown on the west side in a field barely one-fourth of a mile south from the schoolhouse.

The **Delthyris** gives good returns on the road leading to Mr. Brown's house, northeast from the village ; in a watercourse near the schoolhouse on the west side, and especially in the long exposure on the west side of the river below Davis's dam; the topmost shaly beds are best reached under the Upper Pentamerus cliff on the Murphy farm, West mountain.

The **Scutella** is available on the Brown property, at the upper side of the "Gallows field" and on Stony run, all on the east side; at Murphy's and the schoolhouse hill on the west side.

The **Upper Pentamerus** is well shown and easily worked on the Brown property, and especially at the "Rocks" above Davis's dam, on the east side; while the exposure on the schoolhouse hill on the west side is especially good, as the individual layers are exposed over a broad space.

The **Oriskany** is best on the schoolhouse hill where large weathered fragments occur along a line of more than a quarter of a mile. But one needs heavy tools here, as the smaller fragments have been utilized.

The **Schoharie** grit can be found on the northwest side of West mountain and in the fences on the east side along Stony brook. The best localities for **Corniferous** are on West mountain, schoolhouse hill and the limekilns.

As a locality for study of simple stratigraphy, preliminary to the study of more complicated structure such as that of Kingston and Rondout, the Schoharie valley is unexcelled, and it is to be commended to the attention of instructors in field geology.

APPENDIX

Glacial Action in Schoharie Valley

Archibald E. Stevenson

The hills on each side of Schoharie valley rise about 500 feet above the river. The slopes on the western side are very steep, even those of the Delthyris and Caudi Galli being climbed with some difficulty; but the slopes on the eastern side, with the exception of the Pentamerus cliffs, are so gentle that they are cultivated.

Above Schoharie the contrast is not so strong, for there cultivated benches are seen also on the west side. For the most part, the river runs near the foot of the western hills. The valley contracts at five miles above Schoharie, where it is enclosed in the harder rocks of the Devonian.

Messrs. Mix and O'Reilly recently opened a quarry at a little north from Schoharie, where the stripping exposed a glaciated surface of the Lower Pentamerus, and showed well the character of the till.

The striæ are shallow, some as slight as though they had been made with a pin. The strongest scratches are not more than 1/20 of an inch deep, and 1/10 of an inch wide. The general surface is highly polished. The striæ appear to be in two systems, the stronger of which varies from N. 55° E. to N. 73° E., the most marked running N. 66° E. The other is not so strong, its striæ varying three or four degrees north or south of east.

An interesting feature of the surface in this quarry is the occurrence of two abrupt steps, one about 2½ feet high, running N. 45° E., and the other, not so high, N. 66° E. These must have existed before the ice invasion, as the former is but slightly rounded at the upper edge, while the face is unpolished, whereas the face of the latter is highly polished.

The extreme thickness of till shown is ten feet; the bowlders are large in the lower part, often two feet in diameter, but decrease in size toward the top, where they are mere pebbles of two or three inches. They are of foreign material, the large ones being gneiss, while very many of the smaller ones are apparently from the Hudson shales, which are exposed within a mile or so northward; all are more or less water-worn.

The clay is slightly calcareous, and small stalactitic deposits are frequently found in its cavities. This till was followed up the valley to the old cemetery quarry, where it rests upon the Tentaculite limestone, which, also, is covered with striæ.

The Upper Pentamerus, on this side, at more than 100 feet further up the hill, shows also a glaciated surface on the Brown property with striæ following the same general directions as those on the Lower Pentamerus.

On the west side of the valley, a striated surface of Lower Pentamerus, corresponding to that on the east side, is reached at less than half a mile north from the bridge; while the till is shown at about the same distance south, on the Middleburgh road, where it makes a very cold soil. On this side an angular bowlder of much sheared gneiss, measuring 4 by 6 by 5 feet, was seen, at 370 feet (by barometer) above the river, on the Caudi Galli slope and near it another of gneiss, about half as large. Water-worn fragments of gneiss are scattered over the surface everywhere from the river to the hill tops, while angular fragments of transported rocks seem to be rare.

The distribution of the till and the direction of the striæ seem to show that the valley, as it now appears, has practically the same shape as before the ice invasion. The several benches of harder rock must have existed in the earlier time as now on the east side, where they are separated by the long gentle slopes of softer rocks; for, far back from the river, the Upper Pentamerus bench is scratched, while lower down and nearly one third of a mile nearer the river we have the Lower Pentamerus beautifully striated, while lower yet we have the benches of Tentaculite and Coralline well polished and covered with till. The cutting done by the ice must have been comparatively small; bowlders of Pentamerus and Tentaculite were not seen up the valley above the horizons of those rocks. This weakness in cutting is shown also by the peculiar form of the benches in Mix and O'Reilly's quarry.

NOTE.—Since this paper was read, Messrs. Clarke and Schuchert have published their scheme of the New York Series, in which are revived some of the older names, for which certain terms used in this paper will become synonyms. "Hudson" is synonymous with "Lorraine"; "Waterlime" is the "Rondout Waterlime" of Clarke and Schuchert; "Tentaculite" is synonymous with "Manlius" Vanuxem; "Lower Pentamerus" and "Delthyris" will be replaced by the newer terms "Coeymans" and "New Scotland" of Clarke and Schuchert.
November 22, 1900. J. J. S.

NEW YORK UNIVERSITY, NEW YORK CITY, October, 1899.

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NOTES ON PASSAMAQUODDY LITERATURE

J. DYNELEY PRINCE

(Read February 24, 1899)

CONTENTS

SOURCE OF INFORMATION HEREIN PUBLISHED

Like the material previously published by the writer, pertaining to the wampum records (PRINCE, '8) and to the *Wabanaki* history (PRINCE '8), the following notes were gathered at Bar Harbor, Maine, from the Passamaquoddy Indians who spend the summer there. They have been arranged chiefly from papers prepared for me in Indian and English by Louis Mitchell, former member of the Maine Legislature for the Passamaquoddy tribe.

RECREATIONS OF THE PASSAMAQUODDY AND PENOBSCOT INDIANS

STORY-TELLING. Recreation was never allowed among the Passamaquoddies and Penobscots except during the winter months when the deep snows made sport and war impossible. Perhaps the favorite amusement of the younger people was story-telling (*hookautin*), at which many of the old men and women were adepts. A group of young indians would often gather in a wigwam and listen with eager interest for hours to the protracted tales of some professional narrator (*notathooket*). A great number of these stories of love, war, and witchcraft still exist in the memories of older indians, and, as the tribe diminishes year by year, are bound to perish unless collected by those who feel an interest in the history of the aborigines of America.

Example of Narrative. The following narration of constancy in a *Wabanaki* girl, which is, of course, much abridged from the original, is a fair specimen of their style.

Long ago in the village of Lusigantook,[1] there lived a beautiful maiden whose heart many a young man had tried in vain to win. Finally, however, she succumbed to the charms of a brave and successful young hunter, who had long been in love with her, and, in spite of the ill luck of his fellows, ventured to send to her the *nojiquetsettasit* or "old woman who carried proposals of marriage." Greatly to his delight, he received a favorable reply, and he accordingly determined, indian fashion, to win even greater fame as a hunter. He, therefore, told her that he would not marry her until he had gone on a hunt which should last two years. The girl agreed to his proposal and promised to remain true to him at all hazards, adding that even if he never returned she would stay single all her days, a vow which the young man echoed with equal fervor. Not long after his departure, the village of Lusigantook was attacked and destroyed by Mohawks[2] who carried away all the young girls as prisoners and among them the hunter's promised bride. When the victors reached their own territory, they tried in vain to persuade our heroine to marry one of their braves, even threatening to burn her alive when she obstinately persisted in her refusal. Many of her tribeswomen had yielded to the inevitable and married Mohawk warriors, but she preferred the stake to breaking

[1] *Lusigantook* is the Passamaquoddy form of the *Abenaki Alsigôntegw*, the name of the St. Francis River in the P. Que., Canada, where the *Abenakis*, akin to the Penobscots, now reside (see Prince, '98). The name probably means "river where no habitations are." The indians of St. Francis call themselves *Alsigôntegwiak*.

[2] Canadian Iroquois, see Prince '98, p. 376, note 5.

her vow. The Mohawk chief, however, would not listen to the cruel counsel[1] of his men and gave the girl a longer time in which to make up her mind, intending, as she was of so brave a nature, to marry her to one of his best warriors, in order that their children might become a race of heroes. When the wandering lover returned and found his home in ashes and his bride carried away, after singing his vengeance song,[2] he gathered together a mighty host of *Wabanaki* and started northward to the Mohawk country, bent on avenging his tribe's defeat and his own loss. After successfully surprising the chief Mohawk village and slaughtering many of the offending tribe, he found and rescued his loved one, who showed her gentle nature by interceding for the Mohawk prisoners whom her lover wished to burn and torture.

Barter by Clowns (*nolmihigon*) Games. On long winter evenings when the Passamaquoddies wished to pass away the time, they frequently used to amuse themselves by engaging in a game of barter which was carried on by clowns in the following manner: Two parties assembled in separate wigwams where each dressed one of their number in an absurd manner as a *nolmihigon* or clown. This person, carrying some article of more or less value, such as a pair of snow-shoes, a garment, etc., proceeded with the entire company to the wigwam where the second party was waiting, and with many absurd gestures and contortions, offered to exchange the article in question for something else, inviting bids like a modern auctioneer. The point of the joke lay in the witty songs sung by the *nolmihigon* in praise of his wares which nearly always induced the listening company in the second wigwam to pay for the article offered with another of much greater value. Thus, a canoe was not uncommonly exchanged for a wooden spoon! As soon as one exchange had been effected, the first *nolmihigon* and party retired to the original wigwam, where they received a similar visit from the second company. This simple amusement was often kept up far into the night, the wittier *nolmihigon* and his company, of course, coming out winners at the end of the game.

[1] For the character of the Iroquois' see Prince '98, p. 377, note 10.

[2] *Gewajintowagon.*

Ball (*Twiss*). The *Wabanaki* were also very fond of games of ball, one of which called *twiss* was played a great deal by women. They made a large ball of finely picked hemlock twigs which were bound together in the shape of a cocoanut. To this they fastened a light deer-thong some six feet in length, at the end of which was tied a short sharp-pointed stick. The object of the game was to swing the ball or *twiss* and strike it on the rebound with the stick.

Lacrosse (*elni-epesskeuhdin*). A much more active game was that called *elni-epesskeuhdin* which greatly resembled the present lacrosse in principle, practically the only difference being that the Passamaquoddy game could be played by any number of people, so long as both sides had the same number of players. The game was begun by two men standing face to face and endeavoring to drive the ball in opposite directions by means of bats. As soon as the first cast was made, the game became general and each party tried to drive the ball to a goal which their opponents defended. The number of goals necessary to make a game was optional. When the ball-game was over the losing party always had a chance to recover their prestige by choosing one of their number to engage in a foot or canoe-race with a member of the winning side. This form of sport was the inter-tribal game generally played among the *Wabanaki* when one tribe visited another.

Pull-hair ball (*Toohon*). Another very popular ball-game was *toohon* or pull-hair ball, which the Passamaquoddies enjoyed perhaps more than any other sport. Two sides were formed, equal in number, as in *elni-epesskeuhdin*. The ball was then thrown in the air, amid cries of "*toohe! toohe! toohe!*" The man who caught it endeavored to run with it to his side's goal, but unless he was very agile, was pursued by his opponents who tried to pull his long hair in order to make him drop the ball. The players of his own side, of course, defended him as much as possible. When the ball fell, it was immediately caught up again and the sport was resumed.

WITCHCRAFT

The Passamaquoddies, like all North American Indians, are firm believers in witchcraft. A class of wizards and witches (*medolin*)[1] existed among them who were thought to have acquired miraculous powers by means of a special ascetic training. MITCHELL relates in his manuscript Passamaquoddy papers in apparently perfectly good faith that it was no uncommon feat for *medolin* to sink up to their knees in hard ground in the presence of a number of people. He states that the magician always took seven long steps, at each of which he sank up to his knees in the hardest earth. This feat, called *quetkeosag*, is mentioned by Leland in his "Algonquin Legends" (LELAND, p. 341). MITCHELL states also that the *medolin* had the power to change themselves into any sort of animal, adding "This is no superstition, but is a fact witnessed by many members of the tribe." The following witch-song in six sense-stanzas is an illustration of their belief in the power of magic over nature.

Passamaquoddy Witch Song, "The Song of the Drum"

Nil nolbin naga n' tetlitemen pekholagon. Nitutle-wiquotahan weyisesek . . . pehutenek naga ona pechioo wuchowsenel w' chiksitmagon n' pekholagon.	I sit down and beat the drum,[2] and, by the sound of the drum, I call the animals from the mountains. Even the great storms hearken to the sound of my drum.
Nolbin naga n' tetlitemen pekholagon. Pechioo mechkiskak petagik n' tasitemagok pekhola(gon) naga na k' chi applassemwesitt chenisoo w' chiksitmun n' pekholagon.	I sit down and beat the drum, and the storm and thunder answer the sound of my drum. The great whirlwind ceases its raging to listen to the sound of my drum.
Nolbin naga n' begholin. Nitte Chebelaque w' pechiyan naga w' chiksitmagon n' pekholagon. Eltaguak pechite k' chi Wuchowsen	I sit down and beat the drum, and the spirit-of-the-night-air[3] comes and listens to the sound of my drum. Even the great

[1] Cf. Ojibwe *mĕdēwin* "witchcraft."

[2] Magical drums were generally inscribed with mysterious figures and pictures.

[3] The *Chebelaque* was conceived of as a supernatural monster consisting solely of head and legs, without a body. It was always seen sitting in the crotch of a tree.

w' chenekla oneskee naga w' chicksitmun eltaguak n' pekholagon.	*Wuchowsin*[1] will cease moving his wings to hearken to the sound of my drum.
Nolbin naga n' tegtemen n' pekholagon. Pechioo te Lumpeguinwok moskapaswok naga w' chiksitmunia n' pekholagon naga na Atwuskniges chenaque tehiye naga w' chiksitmun n' pekholagon.	I sit down and beat the drum, and the spirit-under-the-water[2] comes to the surface and listens to the sound of my drum, and the wood-spirit[3] will cease chopping and hearken to the sound of my drum.
Nolbin naga n' tegtemen n' pekholagon naga k' chi Appodumken o' moskatintena negem w' chiksitmun n' pekholagon.	I sit down and beat the drum, and the great *Appodumken*[4] will come out of the deep and hearken to the sound of my drum.
Pesaquetwok, petagiyik, wuchowsenel, machkiskakil, Atwussknigess, applassemwesitt, Lumpeguinwok, Chebelaque; mesioo mame petaposwok nachichiksitmunia eltaguak n' pekholagon.	The lightning, thunder, storms, gales, forest-spirit, whirlwind, water-spirit and spirit-of-the-night-air are gathered together and are listening to the sound of my drum.

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[1] *Wuchowsin* was the storm-bird which sits in the north and makes the gales by the movement of its wings.

[2] *Lŭmpeguin* was the ordinary water-spirit.

[3] *Atwuskniges* was an invisible being who roams the forest armed with a stone hatchet with which he occasionally fells trees with a single blow. The Indians accounted in this way for the sudden fall of an apparently strong tree.

[4] The *Appodumken*, like the *Lŭmpeguin*, dwelt under the water. He had long red hair and was the favorite bugaboo used by Indian mothers to frighten the children away from the water.

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A RECONNOISSANCE OF THE ELIZABETH ISLANDS

ARTHUR HOLLICK

(Read May 15, 1899)

[Plates VIII–XV]

CONTENTS

INTRODUCTION

Location and Names

The Elizabeth Islands, as understood by that name at the present day, comprise the group which extends in a southwesterly direction, for a distance of about sixteen miles, from Wood's Hole, Mass., forming the barrier between Buzzard's Bay on the north and Vineyard Sound on the south; although formerly Martha's Vineyard and its adjoining islands of Chappaquidick and No-Man's Land, seem to have been included under the same name. The principal islands of the group are five in number, besides which there are numerous smaller islands, some of them but little more than isolated heaps of bowlders. Beginning at the eastern end the five are known, in sequence, as Naushon, including Nonamessett, Uncatina, Pine Island, Buck Island

and the Weepeckets ; Pasque ; Nashaweena ; Penikese, including Gull Island ; and Cuttyhunk. Together they constitute the Town of Gosnold and are included with Martha's Vineyard in the County of Dukes, State of Massachusetts.

The names by which the islands are known are of indian origin, but nearly all have undergone more or less change or modification since the time of the aboriginal designations. In an old history of the region[1] may be found the following information relating to them :

Modern Names	Indian Names
Elizabeth Islands.	Nashanow Islands.
Naushon, Naushuan.	Katomuck.
Nonamessett, Monomessett.	Nanomeesett.
Uncatina, Onkatonka.	Uncatincett.
Pasque, Pesque.	Peshchameesett, Pesquineese.
Nashaweena.	
Penikese, Peniquese.	
Cuttyhunk.	Poocutohunkunnoh.

The latter also appears to have been known as the original Elizabeth Island, before the name was made to include the entire group.

It may perhaps also be of interest to note that the name Buzzard's Bay is said to have been derived from "Buzzardet" or little buzzard, the name under which the fish hawk was formerly known and which were very abundant there.

The name Weepecket is supposed to be a corruption of "Wabacuck," the Indian name for the bald eagle.

General Information

The islands had attracted my attention and had aroused my curiosity and interest for some time, partly because little or nothing had been written in regard to them[2] and partly for the

[1] The History of New Bedford, Bristol County, Massachusetts, etc. Daniel Ricketson. New Bedford, 1858.

[2] The earliest reference which I have been able to discover is entitled "Notices on the Geology of Martha's Vineyard and the Elizabeth Islands," by EDWARD HITCHCOCK, in *Am. Journ. Sci.*, vii. (1824), 240–248, but the geological features were merely noted by him in passing by the islands and they are exceedingly brief and superficial.

reason that definite information in relation to them was necessary as a logical sequence to my previous investigations in the vicinity, on Long Island, Block Island, Martha's Vineyard and Nantucket. This entire region was recognized as having been involved in one series of cause and effect, especially during the Quaternary and modern periods, so that any new facts in regard to any portion of the region would be of importance in arriving at final conclusions in regard to the whole.

When I came to look into the matter, however, I found that the proposed trip was not without certain difficulties. Each island is owned by some one individual, family or corporation, with the exception of Cuttyhunk, upon which there are a number of separate holdings, hence there is no line of public travel to or through the group, no public conveyances and no houses of public entertainment, except in connection with Cuttyhunk, and consequently any stranger desiring to explore the group must be dependent upon the good will and courtesy of the owners for both transportation and subsistence.

As soon as my object became known, however, every possible facility was placed at my disposal, and in this connection I wish to acknowledge my indebtedness to Mr. J. Malcolm Forbes; to Mr. J. Crosby Brown and other members of the Pasque Island Club; to Mr. Edward B. Merrill; to Mr. Geo. S. Homer; and to Mr. Wm. A. Woodhull and other members of the Cuttyhunk Club, for facilities and courtesies extended to me respectively on Naushon, Pasque, Nashaweena, Penikese and Cuttyhunk, without which facilities and courtesies the trip as finally accomplished would have been impossible.

Itinerary of the Trip

The trip occupied exactly a week, from August 10, 1898, to August 16th, inclusive. It was begun at the eastern end, at Wood's Hole, from whence the Forbes' steam launch was the means of transportation from the mainland to Naushon, where accommodation was provided for me at the farm house.

August 11th was spent on foot, exploring Nonamessett and Uncatina.

August 12th a horse and wagon was placed at my disposal, by which means I was enabled to drive through Naushon, from end to end, under the guidance of Mr. Frederick H. Lambert, the overseer, and to reach Pasque by rowboat on the same day, where the Pasque Island Club extended its privileges to me.

August 13th was devoted to an exploration of Pasque on foot, after which a sailboat was provided on which I was transported to Nashaweena, where I was received as the guest of Captain John E. Johnson, the representative of the owner.

August 14th was spent on horseback, under the guidance of Captain Johnson, traversing the shore line of Nashawena, with occasional diversions inland.

August 15th was occupied in sailing to Penikese, where about three hours were given to an examination of the island on foot, and thence, again by sailboat, to Cuttyhunk, where I was the guest of the Cuttyhunk Club.

The remainder of the 15th and part of the 16th of August were utilized in field work on Cuttyhunk, after which the regular steamboat was taken to New Bedford.

DESCRIPTION OF THE ISLANDS

[Map, Plate XV.]

Naushon

This island, owned by the Forbes family, is the largest of the group, having a length of about eight miles and averaging about one and one-half mile in width. Uncatina and Nonamessett are joined with it by means of causeways. It is the only one from which the trees have not been removed, and, fortunately, those who have been in possession since the early days—the Winthrops, Swaynes, Bowdoins and Forbes—have keenly appreciated the beauty of natural surroundings and in consequence the larger part of the island is yet covered by a forest growth of primeval wildness, which is jealously preserved from either the destructive attacks of the utilitarian or the conventionalizing of the landscape architect. Even the few roads, which of necessity have been laid out, are to a great extent but little more than well-cleared wagon tracks, which follow the natural winding contours of the surface, or occasionally curve or twist in an unexpected manner, in order to avoid the destruction of, or to bring into view, some striking feature, such as a large tree or bowlder.

The forest growth was a revelation, as most of it had all the appearance of never having been disturbed by civilization. The trees are in every stage of growth, from seedlings and small saplings to those which are in their prime or past it, while lying on the ground, where they have fallen naturally, are the decaying trunks of former generations.

Taken as a whole the arborescent flora is similar to that of the mainland adjacent, and there is as much difference between it and that of Martha's Vineyard, only about four miles distant, as there is between the flora of the New Jersey highlands and that of the pine barrens. There are a few scattered individuals of *Pinus rigida* Mill., and *P. sylvestris* L. has been introduced and planted to a considerable extent, but aside from these two species the trees are almost wholly deciduous, consisting largely of *Fagus Americana* Sweet., *Quercus alba* L., *Q. rubra* L., *Q. velutina* Lam., and a plentiful sprinkling of *Ostrya Virginiana* (Mill.) Willd. There are a few good sized individuals of *Ilex opaca* Ait., widely separated, and *Cytissus scoparius* (L.) Link. has been planted over quite extensive areas, formerly denuded, in order to secure a quick growth of vegetation. This did not appear to be in a very thriving condition however, and in places large patches had apparently died out completely. The arborescent feature, however, which is sure to attract immediate attention is the great abundance of beeches. In certain sections there are acres of the forest where this tree monopolizes fully nine-tenths of the growth, and a complete tree census of the island would undoubtedly show it to be in a considerable majority.

On the outskirts of the forest, or where isolated individuals or clumps of trees occur, a remarkable effect of the winds may be seen. The branches on the side exposed to the unbroken winds are short and stunted, while to the leeward they are elongated and stretch out often to extraordinary lengths. The trees present the appearance of having been artifically trimmed on the windward side so that only half the tree remains. This feature is particularly conspicuous on windward slopes, where the long leeward branches of large trees often extend out and droop until they rest upon or nearly touch the ground thirty or forty feet distant from the trunk, while where the trees grow in hollows or depressions the force of the winds checks the upward growth as soon as it reaches the level of the surrounding hills, leaving a remarkably uniform surface over the entire mass of the tree tops.

Another peculiar effect is also produced by these conditions in the relative heights of trees. The trunks of those which grow in the bottom of any depression are tall, while those on the sides are successively shorter and shorter, according as their location approaches the summit, although the diameters of the trunks may vary but little. Many individuals may thus be singled out in which the lateral extent of the branches is out of all proportion to the height or diameter of the trunk, giving a most weird and peculiar appearance to the tree. These phenomena due to wind action are particularly conspicuous on the south side of the island, which is exposed to the full force of the ocean storms. [**Plate VIII.**]

The denuded areas present but few botanical features which differ from those of similar morainal areas on the adjoining mainland. They are wind-swept and almost destitute of any conspicuous vegetation except for patches of *Myrica cerifera* L., and stunted growths of *Vaccinium* and *Gaylussacia*. *Euthamia Caroliniana* (L.) Greene seemed to be about the most abundant or conspicuous herbaceous plant in such situations, at the time of my visit.

A species perhaps wortny of special mention is a form of *Plantago major* L., found on Uncatina. It was in considerable abundance, although apparently restricted in its habitat to a zone located just above high-water mark. My attention was at once attracted to it by reason of its lanceolate 3-nerved leaves and the fact that the entire plant was more or less covered by a short hoary pubescence. More extended examination may prove it to be worthy of varietal rank.

The island is composed of a series of rounded morainal hills, with a maximum elevation of 160 feet. Many of the depressions are amphitheater-like in form, in some of which there are swamps or ponds, often without visible outlets. One of these is occupied by West End Lake, a body of clear fresh water, some 45 acres in area, the surface of which is usually about 5 feet above tide level, while the bottom is said to be about 75 feet below. At the time of my visit a considerable stream was flowing from it, although this was stated to be not always the case and due to the unusually wet season and recent heavy rains. In its general features it is strikingly like Lake Ronkonkoma on Long Island and is evidently caused by similar morainal conditions. Its limited drainage area would, alone, be insufficient to account for the almost uniform level maintained by the water, but the depth of the basin, and its nearness to tide water at once suggests that seepage may account for it, augmented at time of rains by surface drainage, when it overflows. If the depth quoted is correct, the bottom is lower than that of any portion of Buzzard's Bay adjacent.

In several localities, notably in the vicinity of Tarpaulin Cove, the accumulation of bowlders is especially conspicuous, both for numbers and size, and they may be seen to advantage either where they are completely exposed on the shore [**Plate IX**] or partially so in the adjacent hills, interspersed with patches of stunted *Myrica cerifera* L. [**Plates X, XI**]. "Fern Rock" is an immense bowlder, partly fractured and covered by a luxuriant growth of *Polypodium vulgare* L., situated in a dense wood not far from West End Lake.

The general topography of the island is characteristically morainal and the larger part of the bowlders are granitic. Around the more sheltered north shore and in the coves and inlets, away from violent wave action, the beach shingle largely retains its original angular character as glacial drift material and there is but little observable difference between it and material freshly washed out from the adjoining sloping banks, from the base of which there is a uniform grade to the water's edge. On the exposed southern shore however the shingle is rounded and water-worn and in places is thrown up into extensive ridges, beyond ordinary high-water mark, by wave action during storms, often masking the base of the adjacent bluffs and causing an abrupt line of demarkation between the irregularly wave-tumbled, rounded beach shingle, and the steep face of the eroded moraine, with its angular ice-transported fragments. It is along this shore that erosion is proceeding most extensively, as may be readily seen in the steep escarpments of the bluffs which face it, and also in the rapid descent to deep water, as evidenced by the location of the submarine contours.

Inasmuch as these islands, considered as a whole, seemed to bear every indication of being simply a partly submerged and gradually disintegrating ridge in the morainal region south of the New England shore line, it was recognized that theoretically they ought to have the same general structure as the similar but larger ridge to the south, represented by Long Island, Block Island, Martha's Vineyard and Nantucket. In other words that the superficial morainal material ought to be found resting upon a superstructure of Cretaceous strata. A careful search was therefore made for plastic clays and also for the ferruginous clay concretions and hardened fragments, which are invariably found under similar conditions in the islands mentioned. Such concretions were finally found on Nonamessett, and by tracing them up a bed of plastic clay, some of it highly lignitic, other portions brightly colored in reds and yellows, was found at the base of a bluff on the south shore, near the eastern end. No organic remains, other than the lignite were found, but the lithologic identity of the concretions and plastic clays with those of Gay Head, Block Island and Glen Cove was unmistakable. At no other locality was any indication of either the clays or the concretions discovered, although this is hardly to be wondered at considering the limited time given to the exploration.[1]

[1] The only reference which I have seen in regard to the occurrence of Cretaceous clays in the Elizabeth Islands is in a paper on "Glacial Brick Clays of Rhode Island and Southeastern Massachusetts," by N. S. Shaler, J. B. Woodworth and C. F.

Considered from the social standpoint the island constitutes a magnificent domain, easy of access and yet unspoiled by the destructive elements of civilization. It is a place in which deer and other wild creatures roam and breed freely amid natural surroundings and the general impression is that of a home of modern luxury and culture located in a wilderness, such as one would never expect to find in this part of the United States.[1]

Pasque

This island, owned by the Pasque Island Club, an organization devoted to striped bass fishing, has an area of about 1½ square miles and is entirely treeless, except for a small clump of *Pinus sylvestris* L., which was planted near the club house, at the eastern end. It is a dome-shaped portion of the moraine, somewhat elongated in an east and west direction, with a maximum elevation of about 120 feet through the central axis and sloping irregularly in all directions to the shore line. In consequence there are no very high bluffs anywhere exposed and no sections of any extent are available for study.

Swamps occupy many of the depressions, in which *Clethra alnifolia* L. and *Decodon verticillatus* (L.) Ell. are conspicuous and *Oxycoccus macrocarpus* (Ait.) Pers. is plentiful. The hills are bare and wind-swept, resulting in a sort of turf composed of stunted herbaceous plants of several species, as well as grass, of which *Solidago nemoralis* Ait. and *Aster ericoides* L. are the most prominent constituents. *Chrysopsis falcata* (Pursh) Ell., *Sericocarpus linifolius* (L.) B. S. P., *Hieracium Canadense* Michx., *H. Gronovii* L. and *Gyrostachys gracilis* (Bigel) Kuntze, were also in sufficient abundance to be specially noticed.

The general superficial geological conditions are identical with

Marbut, in the 17th Annual Report of the United States Geological Survey, Part I., pp. 951–1004, where they are incidentally mentioned on pp. 962 and 983, without, however, giving any exact locality. On the latter page is also figured a theoretical section through Buzzards' Bay, Naushon, Vineyard Sound and Martha's Vineyard.

[1] Those who are interested in this phase of the subject may find a reference to the social life of the island in Oliver Wendell Holmes' "Autocrat of the Breakfast Table," Chapter II., and an illustrated popular account by Gustav Kobbé in the *Century Magazine*, LVI (Sept., 1898), 753–759.

those of Naushon, but the entire absence of arborescent vegetation has caused the effects of rain and wind erosion to be more pronounced. Wherever the turf is destroyed erosion is rapid and depressions are soon formed by the removal of the finer material, leaving the bowlders prominently exposed.

Around the shores the effects of wave and wind action are very pronounced. In places where depressions have been reached by tide water, in the gradual recession of the shore line, these are often dammed by an accumulation of wave-thrown shingle and the result is the formation of a swamp or pond. [**Plate XII.**] The dam is constantly pushing further and further inland and every stage in the evolution and final obliteration of such a swamp or pond may be seen. Often the old swamp deposit, with the water seeping through, may be found exposed on the slope of the beach at low tide—the sole reminder of these former conditions. Occasionally dune sand accumulates on the dams and vegetation obtains a foothold, in which case a compact barrier beach results.

Bolted firmly to the bowlders on the shore and in the adjacent water, and extending out for a considerable distance, are the fishing stands, each one provided with a seat, on which the fisherman may sit, and any description of the island would be incomplete without at least a brief reference to this feature. [**Plate XIII.**]

Nashaweena

This island, owned by Mr. Edward B. Merrill, is next in size to Naushon, having a length from east to west of about three miles and an average width of about one mile. The greatest elevations are about 125 feet, in a series of scattered hilltops, located towards the southwestern part of the island. Good sections of about 60 or 70 feet are exposed in the bluffs on the south shore near the west end, which show stratified, grayish, sandy clays, similar to those which are prominent in Mohegan Bluffs on Block Island and at Montauk Point on Long Island, and on which the superficial bowlder till rests—the entire series representing the varying conditions which obtained during the Quaternary period. The probable age and conditions of deposition of these strata are well discussed in the report on "Glacial Brick Clays, etc.," previously quoted.

Although there is constant general erosion and recession of the coast line on all sides, there are places where land has evidently been making in recent times. This is noticeably the case at the east end of this island, where the former shore may be traced around the borders of the low swamp land in that vicinity, by means of the old beach shingle, now almost entirely hidden by extensive dune deposits. This was apparently a cove or embayment, before Quick's Hole had been broken through, and doubtless the formation of that channel so altered the previous conditions that new tidal currents were established and deposition began in places where erosion had previously prevailed. Quick's Hole, as well as each of the other channels between the islands, apparently began as coves on opposite sides of the land, the shore lines of which gradually progressed inward, by reason of subsidence and erosion, until they finally met, when, a break once made, tidal scouring soon caused the formation of a channel. The relative locations of and conditions in connection with Tarpaulin and Kettle Coves, on Naushon, indicate such a series of present and future effects.

Nashaweena supports some quite extensive clumps of stunted trees, which are mostly massed in the depressions and on the sheltered slopes of the northeastern portion. The sheltered areas are more numerous and larger than on Pasque and vegetation in general is more abundant. It does not differ materially from that of Naushon, except for the greater relative abundance of oaks as compared with beeches. One or two holly trees were noticed, but I was unable to ascertain whether or not they were native. Probably the most conspicuous botanical feature was the masses of *Clethra* in the swamps. Water lilies were very abundant in the shallow ponds and mushrooms were to be found in nearly all the pastures. The only plant collected, however, to which particular attention need be called, was a single specimen of *Centaurea arenaria* Bieb., an introduced species, which I believe has not heretofore been reported from the United States.

Except for one farm house there is no human habitation on the island, which is a complete wilderness, utilized only as a sheep range, but serving occasionally as a refuge for some of the deer from Naushon, which at times swim over from there.

Penikese

This little island, now owned by Mr. Geo. S. Homer, is about ¼ square mile in area, and is probably most widely known as having been, during one period of its history, the home of Agassiz's school. It rises from the shore line on all sides to a height of some 85 feet near the center, and is about as barren and unattractive a pile of gravel and bowlders as can well be imagined. The only plant sufficiently conspicuous to attract my attention, was *Solanum rostratum* Dunal, which was growing in abundance around the ruins of the old school.

Certain species of terns breed there in immense numbers, and while wandering over the nesting grounds I saw perhaps a score or more of this season's young ones hopping and fluttering over the grass and stones, evidently unable to fly. Several were picked up in order to examine them, and in each instance it was found that one or both wings were aborted. The number of these cripples was evidently considerable, as I saw the dead bodies of many others. All, of course, must have died of starvation as soon as they were finally deserted by the old ones. At the time of my visit the entire colony was yet there and the frightened cries of the cripples at once attracted all the birds in the vicinity, who formed a vast whirling cloud, hovering close overhead, individuals from the mass every now and then making closer downward swoops and all joining in making a deafening noise. It was a sight alone worth a journey to the island to see.

Cuttyhunk

This island is the only one of the group which is divided amongst a number of owners. It has an area of about 1½ square miles and a maximum elevation, near the center of the eastern end, of about 150 feet. This elevation forms a bold headland, which slopes abruptly to the adjacent shores, while at its western end it merges into the central ridge which gradually becomes lower and lower until it reaches tide level. As these hills are absolutely destitute of trees, the sky line from almost any direction is peculiarly sharp and conspicuous. [**Plate XIV, Fig. I.**]

A sand spit of recent deposition is a prominent feature at the eastern end, which extends almost to Nashaweena, from which it is separated by Canapitsett Gut. As in the case of the similar deposit mentioned at the eastern end of Nashaweena, it is probably due to the eddies and currents which were established subsequent to the formation of the passage between the islands. Facing the southern and western shores there are precipitous bluffs, in which good sections are exposed. The material is entirely of glacial origin, but bowlders are fewer than on the islands to the eastward. The finer deposits are of grayish sandy clay, for the most part distinctly stratified.

Except for the few trees planted in the vicinity of the little settlement at the eastern end, the island is absolutely treeless, although there is abundant evidence that at one time it was well wooded. Near the western end, on the south shore, is a depression once occupied by a swamp, one edge of which is exposed by the breaking away of the bluff. In the bottom of this depression may be seen numerous large stumps and logs, buried in a peat-like mass of fine vegetable debris, and subsequent microscopic examination of specimens collected showed these to be oak and beech.

In the "History of New Bedford, etc.," previously mentioned, there are numerous references to Bartholomew Gosnold's account of the island, which he called "Elizabeth Island." In Gabriel Archer's journal of Gosnold's voyage he says: "On the north side, near adjoining unto the island of Elizabeth, is an islet in compass half a mile, full of cedars, by me called Hill's Hap." [Penikese.] He also notes that Elizabeth Island [Cuttyhunk] was covered with trees—"oaks, ashes, beeches, walnut, witch-hazel, sassafras, and cedars, with divers other unknown names."

In the account of the voyage written by John Brereton he also describes Cuttyhunk as thickly wooded, principally with beech and cedar. They also found, he says: "red and white strawberries, as sweet and much bigger than ours in England," also raspberries, gooseberries and whortleberries. He next mentions the "great store of deer and other beasts, as appeared from their tracks" and finally states that they all grew fat on the young sea fowl which they found in nests upon the banks and in low trees.

CONCLUSIONS

If the superficial facts, as previously outlined, be considered in connection with the adjacent submarine contours,[1] it may be readily seen that a comparatively slight elevation would completely drain the channels which now separate the islands from each other and from the mainland and would convert the entire series into a long peninsula, consisting of a range of morainal hills extending in a southwestern direction from Wood's Hole.

In order to emphasize this point I have prepared the accompanying map [**Plate XV**] of the islands, showing the location of the 8-fathom contour,[2] together with the few other soundings of greater depth in Buzzard's Bay and Vineyard Sound. From this it may be seen that if the 8-fathom contour be considered as the shore line of a previous period in the history of the region, not only would the islands form a continuous ridge of land, but this ridge would be considerably extended both in length and width and Buzzard's Bay would be almost obliterated.

If the windings of the contour be followed around it is evident that the indication of the first break which was made through the ridge is at Quick's Hole and that the area which includes Nashaweena, Cuttyhunk and Penikese formed one island before Pasque and Naushon had been separated from each other or from the mainland. Penikese was apparently the next to be isolated, then Cuttyhunk and Nashaweena, then Pasque and finally Naushon.

[1] See Coast Survey Chart No. 112. Vineyard Sound and Buzzard's Bay.

[2] NOTE.—My reason for taking the 8-fathom contour was because a contour of any greater depth would almost entirely eliminate Buzzard's Bay as a former feature of the region.

From the location of the islands and the general character and arrangement of the material of which they are composed, it is evident that they represent a partially submerged morainal ridge, probably a portion of the later, northern branch of the terminal moraine, represented by Orient Point on Long Island, Plum Island, Gull Islands and Fisher's Island. That these represent a more recent stage of glacial action than Montauk Point, Block Island and Martha's Vineyard is also strongly indicated by the almost total absence of Cretaceous material, which is so characteristic of the earlier or southern branch of the moraine. Nearly all of this material, on account of its incoherent character, would almost inevitably have been eroded on the first advance of the ice sheet over the Buzzard's Bay and Vineyard Sound area, and subsequently incorporated in the first moraine, as we find to be the case on Martha's Vineyard. A precisely similar case is also presented by the eastern end of Long Island, where the older branch of the moraine, represented by Montauk Point, contains practically all of the eroded cretaceous material, while the more recent branch, represented by Orient Point, contains almost none.[1]

Under the circumstances we may consider it as peculiarly fortuitous that the limited exposure of plastic clay on Nonamessett has been preserved, while the close proximity of this to the mainland indicates that there may yet remain some isolated patches which have resisted or escaped erosion, farther up the old estuaries, where theoretically the formation once extended.

Whether the ridge represented by the Elizabeth Islands was caused by an inequality in the crystalline rocks beneath we are hardly in a position to say, but reasoning from analogy the probabilities are against this idea and the inferential relations between these rocks, the Cretaceous clays and the Drift deposits, according to the facts now in our possession, I have endeavored to indicate in the accompanying section from New Bedford to Martha's Vineyard. [**Plate XIV, Fig. 2.**]

[1] For more extended discussion of this phase of the subject see : *Trans. N. Y. Acad. Sci.*, XII (1893), 189–202 ; 222–237 ; XIII (1893), 8–22 ; (1894), 122–132 ; XV (1895), 3–10 ; XVI (1896), 9–18 and *Ann. N. Y. Acad. Sci.*, XI (1898), 55–88.

PLATE VIII.

PLATE VIII.

Sketch, showing bowlders and wind-contorted trees, south side of Naushon. Page 392.

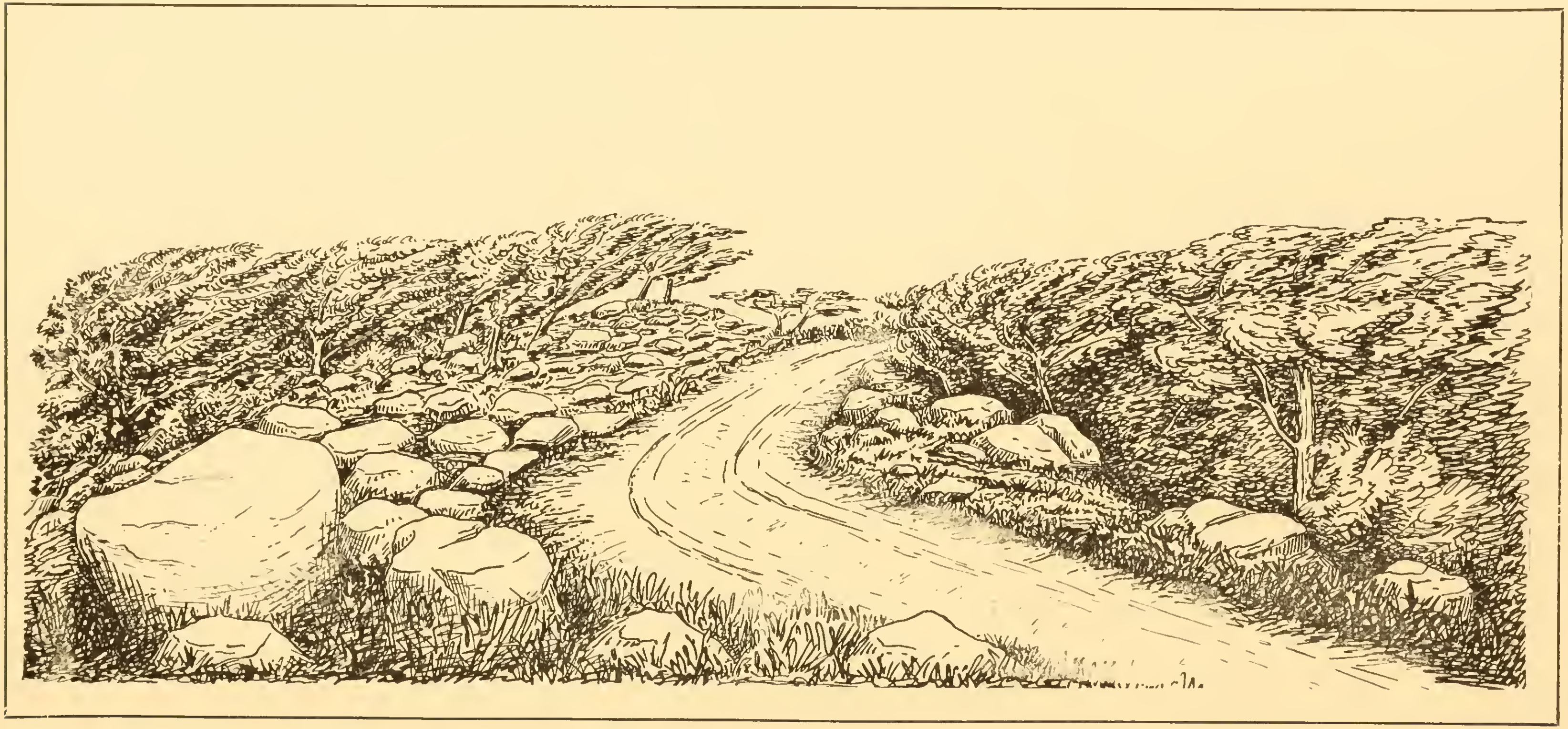


PLATE IX.

PLATE IX.

View of the shore at Tarpaulin Cove, south side of Naushon, showing bowlders. Page 393.

PLATE X.

PLATE X.

View of a portion of the morainal hills, near Tarpaulin Cove, showing bowlders. Page 393.

PLATE XI.

(409)

PLATE XI.

View of a portion of the morainal hills, near Tarpaulin Cove, showing bowlders and patches of stunted *Myrica cerifera* L. Page 393.

PLATE XII.

PLATE XII.

View of a portion of a depression, occupied by a swamp and dammed by a barrier beach. South shore of Pasque. Page 396.

PLATE XIII.

PLATE XIII.

Sketch, showing bowlders and stands for striped bass fishing, south shore of Pasque. Nashaweena in the distance. Page 396.

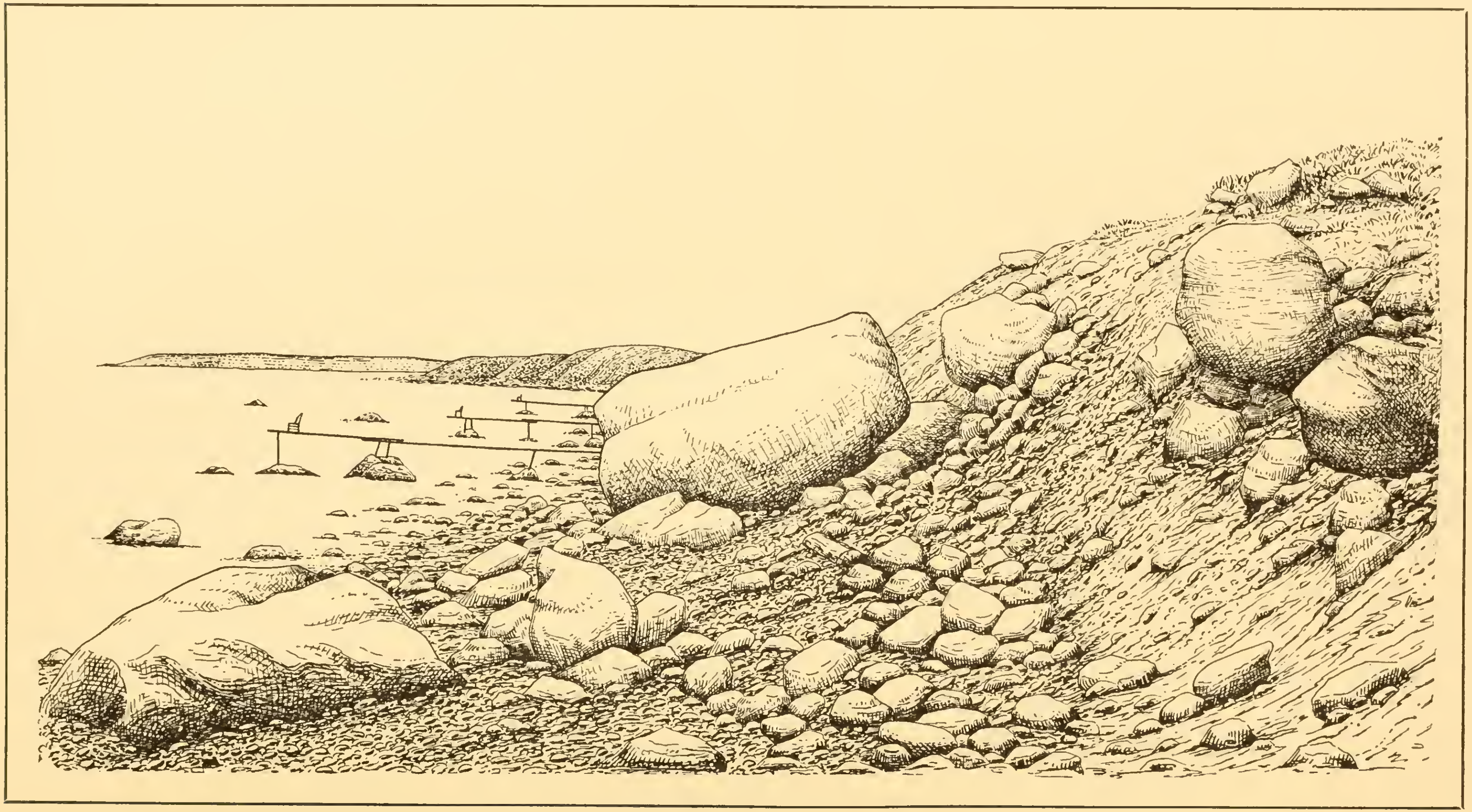


PLATE XIV.

PLATE XIV.

FIG. 1. Sketch, showing the sky line of the central morainal ridge of Cuttyhunk, from northeast to southwest. Page 399.

FIG. 2. Geological section, from New Bedford to Martha's Vineyard, showing the theoretical relations between the Cretaceous clays, the crystalline rocks below and the Quaternary deposits above. Page 401.

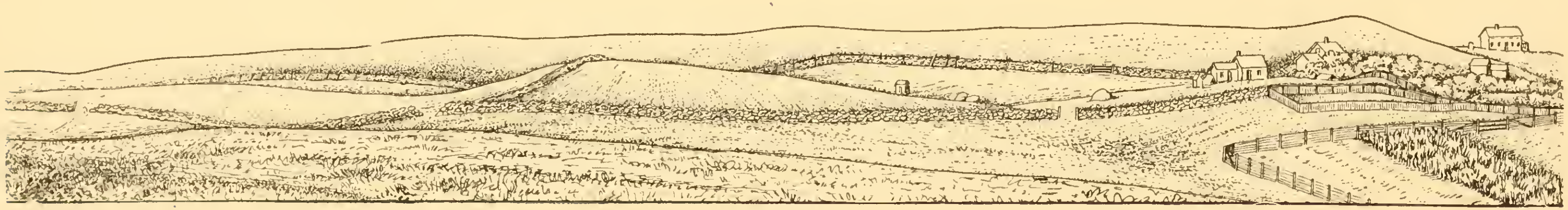


FIG I.

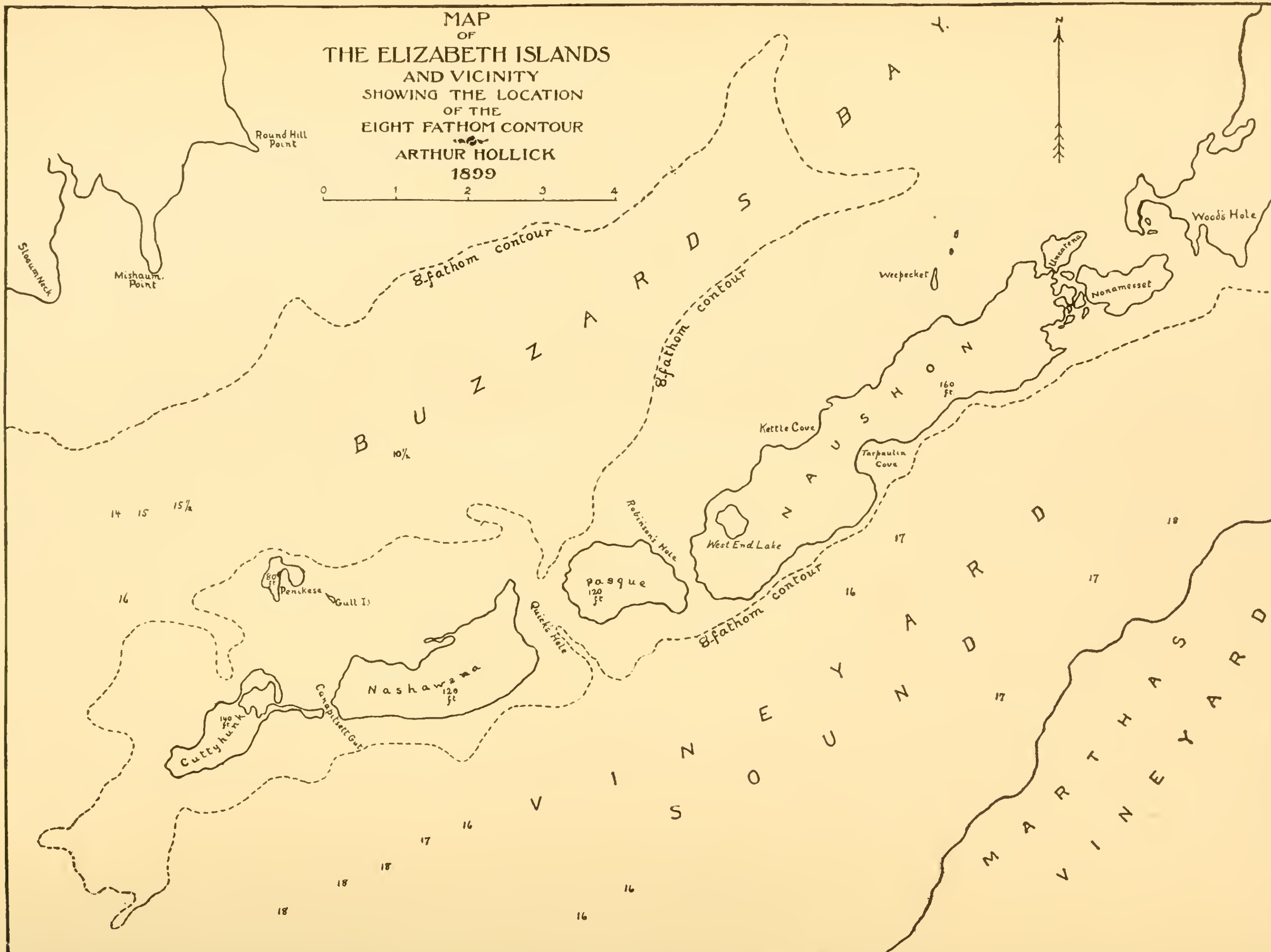

New Bedford
Buzzards Bay
Naushon
Vineyard Sound
Marthas Vineyard

FIG. 2.

PLATE XV.

PLATE XV.

Outline map of the Elizabeth Islands and vicinity, showing the location of the 8-fathom contour. Pages 390 and 400.


MAP
OF
THE ELIZABETH ISLANDS
AND VICINITY
SHOWING THE LOCATION
OF THE
EIGHT FATHOM CONTOUR
ARTHUR HOLLICK
1899
0 1 2 3 4
N
Round Hill Point
Mishaum Point
Slocum Neck
BUZZARDS BAY
8 fathom contour
8 fathom contour
8 fathom contour
Woods Hole
Uncatena
Nonamesset
Weepecket
NAUSHON
160 ft
Kettle Cove
Tarpaulin Cove
West End Lake
Robinsons Hole
Pasque
120 ft
Quicks Hole
Nashawena
120 ft
Canapitsett Gut
Cuttyhunk
140 ft
80 ft
Penikese
Gull Is
VINEYARD SOUND
MARTHAS VINEYARD
10½
14 15 15½
16
16
17
18
18
18
16
16
16
17
17
17
18

[ANNALS N. Y. ACAD. SCI., VOL. XIII, No. 6, pp. 419–430, Jan. 14, 1901.]

PRELIMINARY NOTES ON THE OCCURRENCE OF SERPENTINE AND TALC AT EASTON, PENNA.

F. B. PECK

[Plate XVI ; text figures 4, 5]

(Read January 30, 1900)

The band of pre-Cambrian rocks which extends across the northern part of New Jersey in a southwesterly direction, crosses the eastern border of the State of Pennsylvania between Easton on the north and Kintnersville on the south. The band is here broken into a series of parallel ridges consisting chiefly of hornblende gneiss with intervening valleys of dolomites of post-Algonkian age.

The northernmost of these ridges is the southwestern extension of Scott's Mountain in New Jersey and crosses the Delaware river just north of Easton. On the Pennsylvania side of the river it is known as Chestnut Hill. Just across the river on the New Jersey side it is known as Marble Mountain.

Chestnut Hill is a rather sharp, even-crested ridge, having a maximum altitude of 700 feet above tide, and having a general trend of S. 60° W. It diminishes in altitude toward the southwest, and at a distance of four and one-half miles from the Delaware river disappears under the post-Algonkin dolomites. This, with two other similar ridges north and west of Bethlehem, twelve miles distant, constitutes the only recurrence of pre-Cambrian rocks in Pennsylvania north of the Lehigh River. A description of it as regards composition and structure will constitute the substance of this paper.

Chestnut Hill is composed of a dense hornblende gneiss with distinct bedding planes which dip at an angle of from 40° to 60° to the southeast. Interstratified in the gneisses are beds of carbonates of varying thickness (5 feet to 30 feet) consisting usually of a mixture of pink calcite and gray dolomite but occasionally consisting wholly of either the one or the other.

Hornblende (usually tremolite), phlogopite, and occasionally

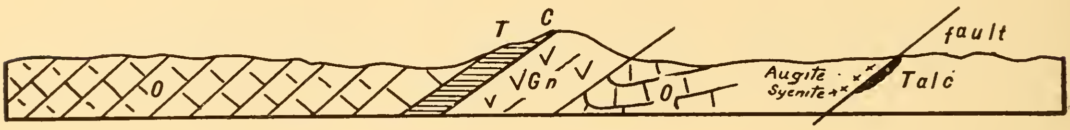


FIG. 4. Section No. I, taken along Bushkill Creek. O = Post-Algonkian dolomites; T = Tremolite beds presumably altered form of C which = calcite-dolomite beds ; Gn = pre-Cambrian gneiss.

pyroxene occur so abundantly in these beds as locally to replace all or nearly all the carbonates, so that locally they become altered to a nearly pure tremolite rock with streaks or patches of phlogopite or pyroxene or containing at time considerable amounts of the original carbonates. These tremolite beds are confined to the southeastern slope of Chestnut Hill, and at the southwestern extremity of the ridge lie for the most part at or near the contact of the post-Algonkian dolomites on the pre-Cambrian gneisses. Here, as can be seen in the cut made by the Bushkill Creek, all three, viz., the dolomites, the tremolite beds and the pre-Cambrian gneisses dip uniformly to the southeast and are apparently conformable. (See **Fig. 4.**)

The explanation of the occurrence here of beds of tremolite would seem to be simple. In the first place the post-Algonkian dolomites are more or less silicious as the following analysis shows :

SiO_2	= 3.52	
Fe and Al	= 2.92	
$CaCO_3$	= 53.40	
$MgCO_3$	= 40.54	100.38

Immediately below them come the beds of carbonates which are usually highly dolomitic and may have contained original silica. Underlying these in turn are the pre-Cambrian gneisses which with their included quartz lenses and granite intrusions could furnish free quartz enough by infiltration to transform the beds of carbonates over into silicates of lime and magnesia, and it is not impossible that the overlying post-Algonkian dolomites may have played some part in the formation of these tremolite beds. This process of transformation was doubtless greatly facilitated by dynamical forces resulting from faulting, as will appear later.

Into these, what we may term altered pre-Cambrian sediments, viz., the gneisses with their interstratified bed of carbonates, have been intruded in this limited area at least two kinds of eruptives.

The first and by far the most abundant is a coarse hornblende granite, which occurs in the form of lenses and bosses, the principal outcrop of which lies on the southeastern slope of Chestnut Hill just across the Delaware River from the southernmost extremity of Marble Mountain. It varies from a very coarse to a fine grained rock and is for the most part highly feldspathic, consisting almost wholly of orthoclase but containing varying amounts of quartz and an occasional blade of dark green hornblende. In the contact zone the hornblende predominates, replacing locally nearly all the quartz and feldspar.

The other eruptive, an augite syenite, occurs in much smaller quantities but presents some points of interest which had best be enumerated here. It appears as a much altered type in the serpentine-tremolite rocks, to be described later, lying in the northern part of the granite area above described. It appears again in the same manner in a series of dykes cutting across the beds of gneiss at the northern end of the Bushkill cut. Its principal occurrence, however, is at a point one-half mile east of Walter's Station on the Bushkill Creek, where some six distinct outcrops appear along an obscure fault (marked M. N.) which has the same trend as the gneiss ridge south of it. It occurs in the post-Algonkian dolomites and may have been intruded in the form of a dyke along which slipping subsequently took place, or it may have been faulted up from below.

Macroscopically the rock consists of an abundance of dark green augite with very little feldspar which gives the rock a very basic appearance. It is for the most part fine grained but is occasionally quite coarsely granular, almost granitoid in texture and shows about equal amounts of feldspar and augite with a sprinkling of biotite scales.

In microscopic thin section the rock is seen to have as its most prominent constituent hypidiomorphic augite, having the peculiar green tinge of the soda bearing variety. On separation with Toulet's solution it gave the following analysis :

$$
\begin{array}{lrr}
SiO_2 & = 50.55 & \\
\left.\begin{array}{l} FeO \\ Fe_2O_3 \end{array}\right\} & = 7.27 & \\
Al_2O_3 & = 8.66 & \\
MgO & = 11.00 & \\
CaO & = 19.70 & \\
Na_2O & = 1.70 & \\
K_2O & = .48 & 99.36
\end{array}
$$

which shows an approach to an ægirine augite.[1]

The allotrimorphic feldspars, as a rule about equal in quantity to the augite, consist usually of microperthitic intergrowths of albite or oligoclase and orthoclase. The feldspars generally show a wavy extinction due to pressure and frequently the confused, patchy intercrystallization seen in many syenites containing nearly equal amounts of both soda and potash. On isolation the feldspars were shown by an alkali determination to contain 8.04% of potash and 4.55% of soda.[2] The last constituent of importance is biotite which in one locality quite replaces the augite and the rock thus becomes essentially a mica syenite. Magnetite occurs in but limited quantities. Long prisms of apatite are quite abundant in places and were as usual among the first crystals to form, being included in both the biotite and augite.

[1] This separation and analysis was made by Mr. Fred H. Moffit, post-graduate student in geology and assistant in chemistry in Lafayette College, Easton, Pa.

[2] This determination was also made by Mr. Fred H. Moffit.

An analysis of the rock as a whole gave the following:

SiO_2	= 53.58	
Al_2O_3	= 13.56	
Fe_2O_3	= 1.48	
FeO	= 4.75	
CaO	= 8.20	
MgO	= 8.93	
K_2O	= 2.37	
Na_2O	= 3.08	
P_2O_5	= .17	
Mn^3O^4	= .92	
H_2O	= 1.33	Sp. gr., 2.89.[1]
	98.37	

On comparing this with analyses of other syenites, it is found to contain about the average amount of SiO_2, to be low in Al_2O_3, but unusually high in magnesia and lime, having of the two together over 17%, while most syenites contain only from 2% to 6%. In this respect it resembles Weed and Pirsson's shonkonite of the Highwood Mountains, Montana. In general, however, it quite closely resembles some of the finer grained augite syenites of Norway, described by Professor Brögger as occurring in connection with the nepheline syenites of the Christiania region, for which reason perhaps it would seem natural to associate it genetically with the well-known nepheline syenite of Beemerville, N. J. A careful search for other occurrences of the rock in the region about has failed to discover it.

The serpentines and talcs of Chestnut Hill are all of them associated with a system of faults which follows the trend of the ridge. Within a distance of two miles north and two miles south of Easton there are four distinct thrust faults, all of them of types described by Mr. Bailey Willis in his "Mechanics of Appalachian Structure" as occurring in "The District of Folding and Faulting of Virginia, Tennessee and Georgia."[2]

[1] This analysis was made by Mr. Richard K. Meade, assistant in chemistry in Lafayette College, Easton, Pa.

[2] Thirteenth Annual Report, Part II, of the Director of the U. S. G. S. for the year '91–'92.

The first of these faults extends along the northwestern side of Marble Mountain and Chestnut Hill and constitutes the boundary line between the pre-cambrian and the post-Algonkian (**Plate XVI. *A-C.***). It is a typical break thrust fault. At *A* there is a branch fault given off which runs along the southeastern slope of Chestnut Hill to a point *B* where it appears to die out. It is along this branch fault *AB* which cuts, as it were, diagonally across the ridge that all the talc and serpentine deposits of the region, with one exception, occur.[1] It partakes here more of the nature of a stretched thrust and all of the rocks involved in the faulting are so sheared, stretched and profoundly altered as often to be recognized with difficulty. The granites, for example, have every particle of their feldspar constituent sheared into a stringy, almost fibrous variety of sericite, not a trace of the original feldspar remaining, while the quartz remains as lenticular or film-like patches but crushed almost to a powder. The hornblende alters for the most part to serpentine, in fact the richly hornblendic granites seem to furnish one source of serpentine. The calcite-dolomite beds shear to a slaty, foliated, talcose mass consisting of a mixture of talc, tremolite, serpentine, with occasional seams of tremolite (?) asbestos, imbedded in a fibrous carbonate of lime (aragonite?), the fibers of both minerals lying parallel to each other and normal to the walls of the seam; or without shearing, become changed to beds of nearly pure white tremolite. The phlogopite which is developed locally in large quantities in connection with these beds, sometimes in huge crystals a foot in diameter but usually in rather finely granular masses, alters quite uniformly to serpentine and constitutes the chief source of that mineral in the Easton quarries. Huge masses of it weighing many tons are removed from time to time, consisting quite wholly of phlogopite mica in different stages of alteration to serpentine. Locally these masses of phlogopite become changed to the very finest variety of "Royal" of "Victoria Serpentine" which occurs here in such abundance as to

[1] The principal occurrences of talc and serpentine are indicated by a widening of the fault lines along which they occur and quarries from which they have been taken are numbered 1–7.

rival the famous Connemara quarries of Ireland and excite the wonder of men of lifelong experience in the quarrying of decorative stones. One variation of this phlogopite serpentine is exciting considerable interest among architects. It consists of numerous rose-colored dolomite crystals scattered in masses of serpentine, which mixture when sawn and polished presents a most exquisitely beautiful combination of colors. This particular variety has been called "Verdolite" (Contraction of Verd-antique and dolomite), by Mr. William B. Read, president of the company now owning the quarries. This company, known as "The Verdolite Company," was formed for the purpose of purchasing and operating the quarries lying in the northern half of the granite area on the southeast slope of Chestnut Hill ridge and designated on the sketch map (**Plate XVI.**) as quarries No. 2, 3 and 4. These are the important quarries of the region. From No. 3 (Richard's quarry so called) is taken the best quality of serpentine. This quarry is directly on the highway and within two miles of the Lehigh Valley R. R. station. Between 3 and 4, a few hundred feet up the hill lie heavy ledges of verdolite and two or three hundred feet farther takes one into quarry No. 4 (known as Williams' quarry). This last named quarry has been excavated in a nearly pure tremolite rock which lies in heavy beds nearly 50 feet thick and dipping south under granite, which constitutes the hanging wall and lying on granite and gneiss to the northward. Evidently this rock has been faltered into its present position by thrusts from the south. The shearing to which it has been subjected has partially altered the tremolite to talc along the shearing planes, which rock has for years been quarried and ground for commercial purposes. Scattered through this finely crystalline, sometimes massive white tremolite rock, are seams and irregular aggregations of what was originally phlogopite or pyroxene, now altered thoroughly to a beautiful apple-green serpentine (Williamsite) which contrasts beautifully with the white tremolite. The relation of the tremolite to the serpentine and verdolite, in fact the relation and occurrence of all of the rocks under discussion, can be seen in Fig. 5 which is constructed along section line II. From fault line *AB* are given

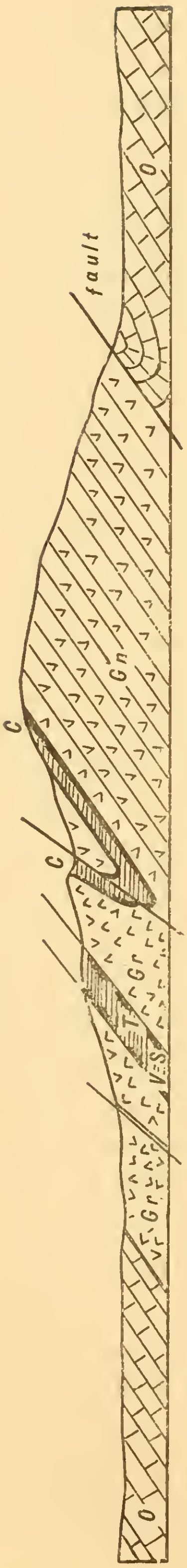


Fig. 5 Section No. 11, taken diagonally across Chestnut Hill at its eastern end. *O* = Post-Algonquin dolomites; *gr* = granite; *T* = tremolite beds with included Verdolite (*V*) and Serpentine (*S*); *gn* = pre-Cambrian gneiss with interstratified calcite-dolomite beds (*C*).

off two well defined and a third more poorly defined branch faults which intersect the granite, along the northernmost of which occur quarries 3 and 4. Here as explained the tremolite (*T*) beds lie dipping to the south between two granite walls. Along both the hanging and the foot wall, in close proximity to the granite, have developed (by infiltration of silica from the granite?) large quantities of phlogopite, under the hanging wall mixed with pink dolomite and constituting verdolite (*V*), on the foot wall altered to royal serpentine (*S*). More or less serpentine is found scattered through the tremolite. The serpentine as usual is not continuous but occurs in irregular masses varying from a few pounds to many tons in weight.

One other occurrence of talc should be mentioned, viz., that at 6, along the northern boundary of the augite syenite. It lies on the fault M. N. and is developed on the contact of the augite syenite on the post-Algonkian dolomite. The best of it constitutes the finest quality to be found in the region. Its origin, as it would seem from the manner of its occurrence, is different from that at the other localities. Here the post-Algonkian dolomites seem to have been the rocks to suffer change, the augite syenite remaining perfectly fresh and unaltered throughout, while the change from talc at the contact outward towards the dolomite is a gradual one. With the exception of a few cubes of iron pyrites, the entire product of the metamorphosis here is talc, there being no serpentine and no tremolite.

One point more should be mentioned regarding the occurrence of the tremolite beds in the Anthony's Nose granite area. After the formation of the fault *AB*, which cut diagonally across the pre-Cambrian ridge, the two dislocated ends, viz., Chestnut Hill on the southwest and Marble Mountain on the northeast seem to have been thrust by each other along the fault plane *AB*, the tremolite beds as well as the Anthony's Nose granite on the southeastern slope of Chestnut Hill being made to override the under thrust end of Marble Mountain in a series of thrust faults by which the tremolite beds became faulted in between granite walls, while the tremendous shearing to which the rocks were subjected brought about the alterations which have been described. That there has been crustal shortening in a direction at right angles to the principal folding is shown by a series of more or less parallel faults running at right angles to the series already described. In the southern limits of the city of Phillipsburg are two thrust faults which hade to the east, and which bring the pre-Cambrian gneisses to the surface in two masses separated by about thirty feet of post-Algonkian dolomite. The Pennsylvania Railroad in traversing this mass has blasted all the way through in the dolomite, being the line of least resistance, and leaving either wall of the cut as gneiss. Two other faults cutting at right angles across the southwestern end of Chestnut Hill can be made out. The force producing this transverse series of faults could be called into requisition in explaining the thrusting by each other of the dislocated ends of the Chestnut Hill ridge and at the same time the curved branching thrusts which intersect the granite.

LAFAYETTE COLLEGE, EASTON, PA., January, 1900.

PLATE XVI.

PLATE XVI

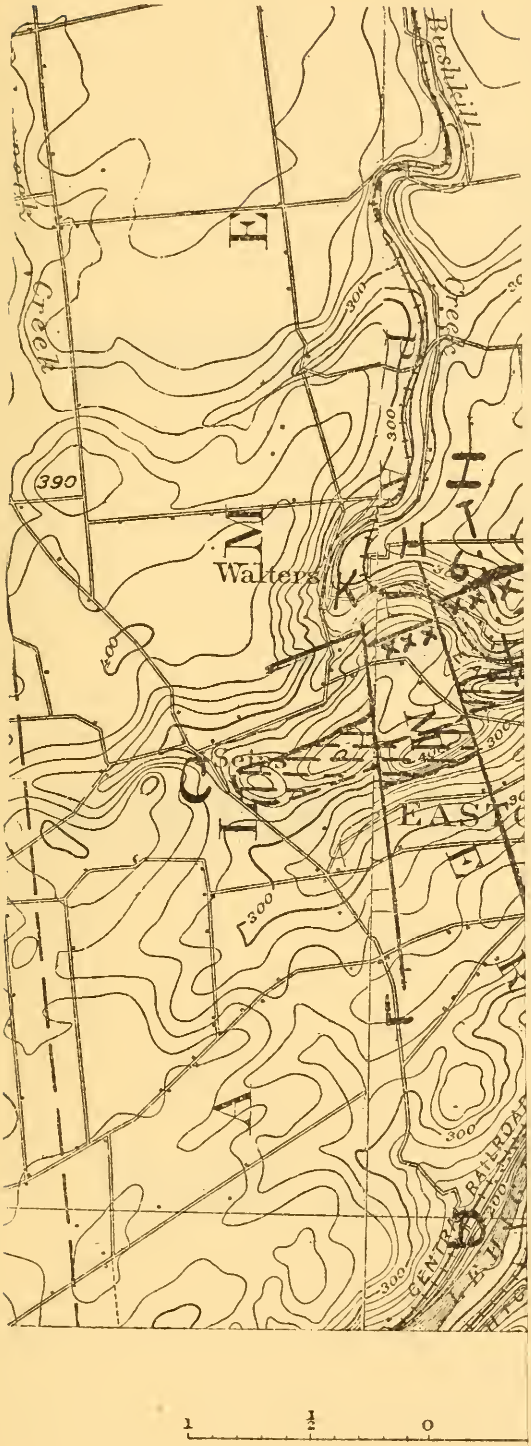
Sketch map of the vicinity of Easton, Penna., showing the occurrence of serpentine and talc and their relations to the main geologic features of the region.

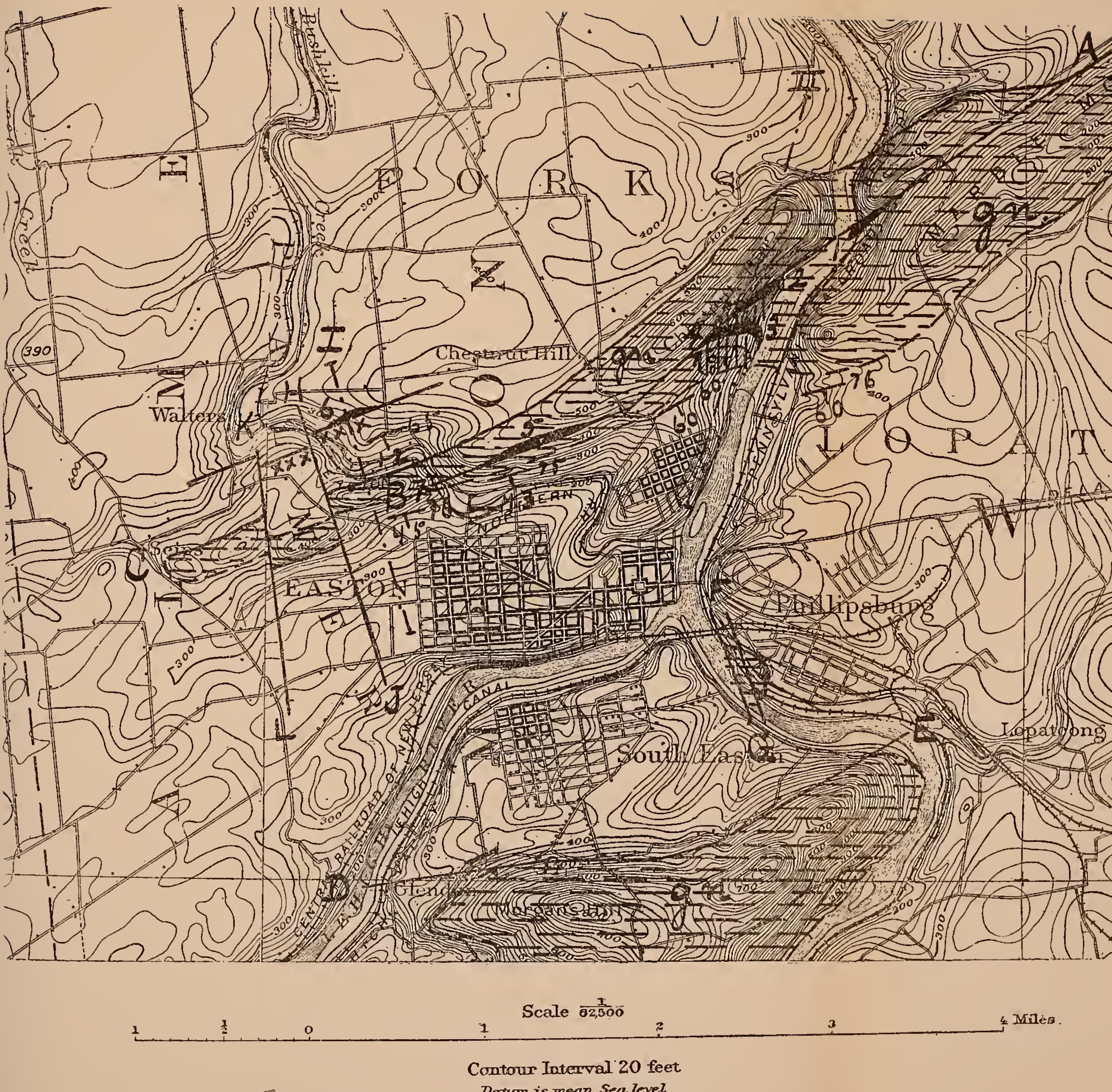
gn = pre-Cambrian gneiss. gr = granite. xxx = augite syenite.

The principal occurrence of talc and serpentine are at points numbered 1 to 7 and are represented by thickenings of the fault lines.

A–B, etc., are fault lines.

I and II are lines along which sections are taken. See figs. 4 and 5 on pages 420 and 426 of text.


Bushkill
Creek
Creek
300
390
400
Walters
EAST
CENTRAL RAILROAD
300
1
½
0


Chestnut Hill
Walters
EASTON
Phillipsburg
South Easton
Lopatcong
Glendon
Morgans Hill
FORKS
LOPATCONG
CANAL
Scale 1/62,500
Miles
Contour Interval 20 feet
Datum is mean Sea level

[ANNALS N. Y. ACAD. SCI., VOL. XIII, No. 7, pp. 431–516, Feb. 12, 1901.]

RECORD OF MEETINGS

OF THE

NEW YORK

ACADEMY OF SCIENCES

JANUARY, 1900, TO DECEMBER, 1900

RICHARD E. DODGE

Recording Secretary

[Annals N. Y. Acad. Sci., XIII, No. 7, pp. 431--516, Feb. 12, 1901.]

RECORDS OF MEETINGS

OF THE

NEW YORK ACADEMY OF SCIENCES.

January, 1900, to December, 1900.

Richard E. Dodge, *Recording Secretary.*

SECTION OF BIOLOGY.

January 8, 1900.

Section met at 8:15 P. M., Professor F. S. Lee presiding. The minutes of the last meeting of Section were read and approved. The following program was then offered :

David Griffiths, Structure and Development of the Sordariaceæ.

F. S. Lee, The Survival of Muscle after Somatic Death.

Wm. J. Gies, The Influence of Protoplasmic Poisons on the Formation of Lymph.

Bashford Dean, On the Egg of the Myxine Glutinosa.

F. B. Sumner (By Title), Kupfer's Vesicle in Relation to Gastrulation and Concrescence.

Summary of Papers.

Mr. **David Griffiths** spoke of the structure of certain species of the Sordariaceæ and briefly reviewed the work which has been done on the group. Certain species were taken as types of the principal genera, and their life history traced ; *Sordaria finicola*, *Podospora coprophila*, *Hypocopra equorum* and *Sporormia intermedia* being spoken of specially. Some time was devoted to a discussion of the much mooted question of fertilization in this and kindred groups. The principal methods of spore distribution were outlined.

Professor **Frederic S. Lee** said that the duration of the life of voluntary muscle in mammals after the death of the individual has not been well known. Under the author's direction, Messrs. Adler and Bulkley have been investigating this in cats and rabbits. In each experiment the animal was killed, a particular muscle was excised and stimulated by electric shocks at five-minute intervals and the resulting contractions were recorded. The muscles used were the *soleus* (deep red) and the *tibialis anticus* (pale). Each survived several hours, the maximum for the red muscle being 14 hours and 37 minutes, and for the pale 12 hours and 20 minutes. It is known that in comparison with white muscle-fibers red fibers contain relatively more sarcoplasm, which is nutritive in function, and relatively less fibrillar substance, which is the contractile part. This may perhaps account for the longer survival of the red muscle. So far no constant difference in duration has been observed between the cat and the rabbit. In both the red and the pale muscle the decrease of irritability was gradual, but occasionally in the *tibialis* there was a sudden fall at the end of about one hour, the irritability then continuing at a low ebb for hours, but with a gradual decline. The sudden fall may have been due to the early death of the white fibers, which, intermingled with red ones, occur in the pale muscle. Besides the theoretic interest, the above results have a practical bearing, since they show that mammalian muscle can readily be used for experimental purposes in the physiological laboratories. This is now being done at Columbia University.

Dr. **William J. Gies** reported upon the changes which may occur in lymph after the administration of protoplasmic poisons. Quinin did not interfere with the usual influence of dextrose, although it did suppress the action of leech extract. The results with dextrose, therefore, indicate that the increase in the quantity of lymph following its injection in large quantity is due mainly to physical factors. In the case of leech extract, on the other hand, there is an interference with the action of the physiological factors that appear to be responsible for the changes usually brought about by this lymphagogue. That the increase in the amount of lymph after large quantities of dextrose have been injected is not due primarily to increased capillary pressure, as is held by Cohnstein and Starling, was shown in one of the experiments in which quinin caused the death of the animal, and yet from which the lymph continued to flow for three hours. After injecting arsenic, which is said very greatly to increase the permeability of the blood vessels, especially those of the portal system, there was little in the flow and character of the lymph resembling the usual effect of lymphagogues. It appears, therefore, that Starling's hypothesis of increased capillary permeability does not fully account for the action of lymphagogues, and that the mechanical theory of lymph formation fails as long as it does not explain the most striking phenomena of the process—those following the injection of Heidenhain's lymphagogues or Asher's 'liver stimulants.' The physiological theories of Heidenhain and Asher would explain them.

Dr. **Bashford Dean** described the condition in seven eggs which he had received from Professor A. E. Verrill. These had been collected in 1880 on the Newfoundland banks in water of 90 and 150 fathoms. The egg membranes were regarded as more specialized than those of Bdellostoma.

FRANCIS E. LLOYD,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

JANUARY 15, 1900.

Section met at 8:15 P. M., Mr. G. F. Kunz presiding. The minutes of the last meeting of Section were read and approved. The following program was then offered :

F. B. Peck, ON SERPENTINES AND TALCS IN VICINITY OF EASTON, PENNSYLVANIA.

J. J. Stevenson, C. E. Bertrand's Theory Respecting the Origin of Certain Coals.

H. Ries, Note on Occurrence of Allanite in the Yosemite Valley.

The following report was presented by Professor **J. J. Stevenson,** in behalf of the Committee appointed November 20, 1899 in reference to the death of Sir J. William Dawson, of Montreal. On motion of Professor D. S. Martin, the report was adopted.

J. William Dawson was born in Pictou, Nova Scotia, October 13, 1820; educated at Pictou College and Edinburgh University. Upon his return to Nova Scotia he was chosen Instructor in Natural History by Dalhousie College, and shortly afterward was appointed Superintendent of Instruction for the Province. When thirty-five years old he became Principal of McGill University, Montreal, then a struggling corporation, with no endowments, few professors, and a wretched equipment. Through his efforts, the struggling college developed into a university with equipment in many respects unsurpassed, with a large corps of professors, an enthusiastic body of students, and a generous endowment.

His contributions to geology are of the first rank. The store of facts accumulated during his term as Superintendent of Instruction was published under the title of Acadian Geology, a volume of about one thousand pages. In later years much of his study was given to palæobotany; we are indebted to him for the discovery of many of the earlier forms of land plants, and for the elucidation of many matters respecting relations of Palæozoic and Mesozoic forms. The phenomena about Montreal led him to investigate Pleistocene problems; his numerous papers upon such questions were summarized in a volume published in 1893.

Sir William's labors were incessant. He published many volumes on topics more or less related to geology; he was active in efforts to foster science, to advance the interests of higher education, and to improve the condition of his fellows. He was a consistent Christian, living his belief, respected and beloved by all who had dealings with him. Honors came to him abundantly; he was President of both the American and the British Association, as well as of the Geological Society of America, and the Royal Society of Canada.

Feeble health came to him in 1892, and soon necessitated the relinquishment of his university duties. Strength never returned to him; but he failed gradually until on November 19, 1899 he passed away, leaving an untarnished name, and a record which is one of the brightest. His memory will be cherished as that of a conscientious man, and an unselfish worker in science.

J. J. STEVENSON,
Chairman.

The Chairman called attention to the coming meeting in Paris this year, of the Eighth Session of the International Geological Congress; described the proposed excursions, and suggested the earnest coöperation of the Section by delegates, contribution of papers, and financial aid. On motion by Professor J. F. Kemp, the matter of representation of the Academy was referred to the Council for action.

SUMMARY OF PAPERS.

In the discussion that followed the paper by Professor **Peck**, Professor **Kemp** stated that in the talc deposits on the west side of the Adirondacks, described by Professor Smyth, the derivation of the talc had been attributed to the magnesian limestone or intrusion of a magnesian silicate rock. Professor Peck replied that he considered the tremolite rock to be due to the alteration of a siliceous dolomite; the talc, possibly to the interchange of silica from the Pre-Cambrian gneisses, and magnesia from the adjacent dolomite limestone. The serpentine and "viridolite" had indeed been subjected to much shearing and fracture, but had been solidly recemented, so that they could be quarried out in large blocks, free from cracks, sometimes of twenty tons weight, in the case of the "viridolite."

In the discussion of Professor **Stevenson's** paper, Professor **F. E. Lloyd** remarked that the cells of algæ, to whose accumulation Bertrand and Renaud mainly attribute the formations of these coals, are exceedingly delicate and often mucilaginous. Those of *sphagnum* are much thicker, solid and woody, and yet a large quantity of this is required to produce much deposit of carbonaceous matter in swamps.

The chairman inquired whether freezing or the introduction of silty waters might cause the precipitation of ulmic acid referred to by these authors. Professor Stevenson stated that ulmic acid so precipitated would tend to carry down suspended matters and to clear the waters.

Dr. **Ries** stated that while in the Yosemite Valley in September, 1899, his attention was attracted by a black, coaly looking mineral in the pegmatite veins on the northwestern side of the valley. On closer inspection the mineral proved to be allanite, and as it has not yet been recorded from this region, it seems of interest to note the fact.

The rocks forming the walls of the Yosemite are a grano-diorite, according to Turner (17th Ann. Rep. U. S. G. S., Pt. I, p. 710). Traversing this in many directions are veins of pegmatite, which are sometimes straight and unbroken, at others curved, branched, or even broken into. These pegmatite veins are very prominent on the face of El Capitan and also in the rock forming Eagle Peak. It was in the talus at the foot of the latter that the allanite was found, and while the mineral was at times abundant in the pegmatite blocks, still none of it was noticed in the grano-diorite. In only one instance was a distinctly bounded individual found, and on this a combination of orthopinacoid and base were recognizable. The other specimens were irregularly bounded grains that varied from a sixteenth to a quarter of an inch in diameter.

In addition to the quartz, muscovite and orthoclase present in the pegmatite, there were a number of radiating masses of epidote, which were evidently of primary origin ; but in two instances the epidote occurred as a coating on hornblende and then seemed to be secondary. None was found in association with the allanite.

In conclusion it may be said that it is interesting to find that allanite is evidently not the rare mineral that it was formerly considered to be, and that a careful watch is beginning to show its presence at many localities in the United States.

Alexis A. Julien,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

January 22, 1900.

Section met at 8:15 P. M., Dr. Franz Boas presiding. The name of one candidate for resident membership was read and referred to the Council according to the by-laws. The following program was then offered:

Clark Wissler, Some Phenomena of Indirect Vision.

J. McK. Cattell, On Relations of Time and Space in Vision.

E. P. Buchner, On Number Forms.

Summary of Papers.

Mr. **Wissler** described experiments that were made by exposing small letters or numerals in the indirect field of vision, while the attention of the observer was fully occupied with objects in the direct field. The subjects were not conscious of seeing the characters presented in the indirect field, indeed, one of the subjects whose results was reported did not know until several tests had been made that the characters were there at all. In spite of this failure to receive conscious expressions from the letters and figures, two subjects were found who could by association and afterwards by memory, give in a large number of cases the correct numeral or letter. These subjects made their associations in the form of visualized images. Many of the errors made were similar to those made in normal vision. Thus, *c* was mistaken for *o*, *35* for *55*, etc. It was held that the experiments suggest a relation between normal phenomena and the abnormal as seen in the hysterical eye, and that they point out a way to a more complicated experimentation in induced automatic movements.

Professor **Cattell's** paper described experiments on the perception of moving surfaces, which show that a time series may be perceived as a spatial continuum, and explained that the same phenomena held in the ordinary vision of daily life. Although the eyes, head and body are in continued movement, and the images on the retina are constantly shifting, the field of vision appears to be distinct and stationary. Thus, if one glances along a row of books, images follow one another on each retinal element in rapid succession, but these successive and rapid changes result in the perception of a space continuum, *all* the objects being distinct and arranged side by side.

Professor **Buchner** described, with the aid of sketches, the fixed visualizations experienced since childhood by a woman 35 years of age. There are three distinct, uncolored, tridimensional forms. The first is half fan-like in shape, lying almost entirely to the left of the mental point of regard, and includes the numbers from 1 to 100. The second includes the names of eight days, from Sunday to Sunday. The third has the names of the twelve months from January to December. The paper pointed out the elements which must appear in any theory of the genesis of the phenomena to which this group belongs.

CHARLES H. JUDD,
Secretary.

PUBLIC LECTURE.

UNDER AUSPICES OF THE SECTION OF BIOLOGY.

JANUARY 29, 1900.

Professor **G. H. Parker,** of Harvard University, delivered a lecture on THE NEURON THEORY IN THE LIGHT OF RECENT DISCOVERIES.

The lecturer gave a summary of the development of our knowledge of the histological structure of the nervous system, and contrasted with the neuron theory as widely understood that of Apathy's which declares the absolute continuity of the nervous system by means of the fibrillæ in the nerve cells and fibers as demonstrated by his method of technique. The lecture was closed by a criticism of Apathy's interpretation of his preparations.

FRANCIS E. LLOYD,
Secretary.

BUSINESS MEETING.

FEBRUARY 2, 1900.

Academy met at 8 P. M., Professor M. I. Pupin presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows:

The following nominations of officers for the ensuing year, drawn up in accordance with the rules:

President, Robert S. Woodward.

First Vice-President, Charles A. Doremus.

Second Vice-President, Franz Boas.

Corresponding Secretary, William Stratford.

Recording Secretary, Richard E. Dodge.

Treasurer, Charles F. Cox.

Librarian, Livingston Farrand.

Councillors: Daniel W. Hering, Harold Jacoby, Frederic S. Lee, M. I. Pupin, Edward L. Thorndike, L. M. Underwood.

Curators: Harrison G. Dyar, Alexis A. Julien, George F. Kunz, Louis H. Laudy, William D. Schoonmaker.

Finance Committee: Henry Dudley, John H. Hinton, Cornelius Van Brunt.

The following nominations for Fellows were made in accordance with the by-laws, which say "candidates may be nominated by the Council, in writing, at a business meeting in January or February, and shall then be balloted for at the subsequent annual meeting":

Dr. W. S. Day,
James Douglas,
Jonathan Dwight, Jr.,
Marshal A. Howe,
Charles H. Judd,
E. G. Love,
Albert W. Trotter,
Henry S. Washington,
Theodore G. White.

The following nominations were made for Honorary and Corresponding Members, in accordance with the by-law that "Honorary and Corresponding Members may be nominated by the Council, in writing, at the business meeting in January or February, and elected at the subsequent Annual Meeting."

HONORARY MEMBERS.

Julius Hann, University of Graz, Austria.
Henry A. Rowland, Johns Hopkins University.
Edward C. Pickering, Harvard University.
H. Poincaré, Sorbonne, Paris.
E. B. Tylor, Oxford, England.

CORRESPONDING MEMBERS.

Professor A. DeLapparent, University of Paris; Paris, France.

Professor W. H. Holmes, National Museum, Washington, D. C.

Professor Kakichi Mitsukuri, Imperial University of Japan, Tokyo.

Professor Geo. H. Parker, Harvard University, Cambridge, Mass.

Professor C. R. Van Hise, University of Wisconsin, Madison, Wis.

Professor Sho Watase, Tokyo (Univ. of Chicago).

The Council has voted to appoint Professor J. J. Stevenson delegate to the International Geological Congress, to be held in Paris in 1900; and Professsor Charles A. Doremus delegate to the International Chemical Congress. The Academy has voted to subscribe to these Congresses.

The Council has voted to change the title of the Section of Astronomy and Physics, so as to read Astronomy, Physics and Chemistry.

The Anthropological Club, which has hitherto coöperated with the Academy in the meetings of the Section of Anthropology and Psychology, has been superseded by the American Ethnological Society, which has been revived. This Society will continue to coöperate with the Academy, as before.

Professor **Kemp**, as Chairman of the Reception Committee, has made the following report to the Council :

The American Museum authorities have kindly agreed to assign us one of the east wing rooms, 60 x 80, for Wednesday and Thursday, April 25th and 26th, at an expense to us for fittings, etc., as last year, not to exceed $200.

The following chairmen of sub-committees have consented to serve :

Anthropology, Franz Boas.
Astronomy, J. K. Rees.
Botany, D. T. MacDougal.
Chemistry, C. E. Pellew.
Electricity, Geo. F. Sever.
Psychology, J. McK. Cattell.
Geology and Geography, Richard E. Dodge.
Metallurgy, H. M. Howe.
Mineralogy, L. McI. Luquer.
Palæontology, Gilbert van Ingen.
Physics and Photography, William Hallock.
Zoology, C. L. Bristol.

The following candidates for resident membership, approved by the Council, were duly elected :

Charles L. DuVivier, 22 Warren Street.
Ludwig Riederer, 145 West 94th Street.
James S. Peabody, Mixed High School.
Francis B. Sumner, College of the City of N. Y.
F. C. Waite, University Heights, N. Y.

RICHARD E. DODGE,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

February, 5, 1900.

Section met at 8:35 P. M., Professor M. I. Pupin presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

J. K. Rees, Report on November Meteors. (Read by Dr. S. A. Mitchell.)

J. K. Rees, The Variation of Latitude and the Constant of the Aberration of Light, as Determined from Six and One-half Years Observations made at the Columbia University Latitude Observatory. (Read by Professor H. Jacoby.)

Geo. N. Bauer, The Parallax of μ Cassiopeiæ and the Positions of 56 Neighboring Stars, as Deduced from the Rutherfurd Photographic Measures.

Summary of Papers.

Professor **Rees,** in the first paper, stated that arrangements were made by the Columbia University Observatory to observe and photograph the meteors during the week of November 12–18, 1899. At West Point Dr. S. A. Mitchell, assisted by Messrs. Bauer and Jenkins, was provided with a Rowland concave grating and two cameras. No photographs however were obtained. At Bayport, L. I., Mr. C. A. Post placed his observatory and his services at the disposal of the Columbia Observatory staff. Six cameras and two telescopes were in use. On one plate in a camera provided with a Goerz lens, a photograph taken on November 15th, between 16 h. 9 m. 30 sec. and 16 h. 40 m. 44 sec. when pointed near Procyon, showed a meteor trail. Dr. Elkins of the Yale Observatory, will measure this plate.

A number of students and others watched for the meteors for the purpose of counting them at West Point, New York and Bayport, with the result as shown in the following table :

Date. 1899.	Time (Standard).	Number of meteors.	Leonids.
	(At West Point.)		
Nov. 12.	13 h. 15 m. to 15 h. 30 m.	5	1
13.	13 h. 10 m. to 14 h. 30 m.	1	0
14	12 h. 0 m. to 17 h. 0 m.	0	0
15.	11 h. 40 m. to 15 h. 30 m.	17	12
16.	13 h. 0 m. to 14 h. 30 m.	5	1
	(At New York City.)		
Nov. 15.	12 h. 55 m. to 18 h. 0 m.	68	68
	(by Misses Harpham, Proctor and Tarbox).		
Nov. 15.	14 h. 15 m. to 16 h. 45 m.	36	
	(by Mr. and Mrs. Woods).		
	(At Bayport).		
Nov. 15.	13 h. 57 m. to 17 h. 35 m.	39	

Professor Rees, observing casually while attending to the photographic apparatus at Bayport, observed a first magnitude Leonid at 15 h. 29 m. on November 15th, between the two lowest stars in the handle of the dipper. At 15 h. 39 m. he observed another first magnitude Leonid under Sirius. At 17 h. 15.5 m. a fine Leonid trail lasting 3 seconds was seen over Procyon. At 17 h. 30 m. a very bright Geminid was seen 20° south of Regulus.

Professor **Rees** stated in his second paper that observations of latitude had been made at the new site of Columbia University from April 24, 1893, to the present, and will be continued until May 1, 1900. The observers were Professors Rees and Jacoby, and Dr. H. S. Davis. A zenith telescope made by Waunscaff, of Berlin, was employed throughout. Its aperture is 80 mm. and its focal length is 1 meter. Four groups of stars were used having mean right ascensions of about 6 h., 14 h., 18 h., and 22 h. respectively. Each group contained 7 stars. Up to the present time, 6516 pairs have been observed on 758 nights. From the observations, a curve was drawn showing the latitude. This was compared with the curve required by Dr. S. C. Chandler's formula (*Ast. Jour.*, No. 446). From 1896 the observed epochs of maxima and minima seem to follow the computed time.

These observations give for the constant of aberration of light, the value

$$20''.464 \pm 0''.006.$$

Mr. **Bauer**, in his paper, stated that the star under consideration has a large proper motion and measurements of its parallax have been made by various methods and observers. The present determination is based on 28 Rutherfurd photographic plates, and the method of position angle was used in measuring them, as Professor Jacoby has already made a reduction using the method of distance. Eleven independent determinations were made, giving a value of

$$0''.238 \pm 0''.014.$$

Professor Jacoby found by the method of distance $0''.275 \pm 0''.024$, these results agree even better than might have been expected. In forming the catalogue of 56 stars about μ Cassiopeiæ, the usual corrections for refraction, precession, nutation, aberration, proper action, etc., were applied. Since the coördinates were measured in distance and position angle, these were then converted into difference of right ascension and declination. After finding the positions for the epoch 1872.0 the precession and secular variation were computed and tabulated.

Wm. S. Day,
Secretary.

SECTION OF BIOLOGY.

February 12, 1900.

Section met at 8 P. M., Dr. Bashford Dean presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

J. H. MacGregor On the Development of the Skull in Ceratodus.

F. B. Sumner, Kupfer's Vesicle in Relation to Gastrulation and Concrescence.

G. S. Huntington, Some Muscle Variations of the Pectoral Girdle.

Summary of Papers.

J. H. MacGregor gave a brief preliminary report on the development of the skull in Ceratodus, the Australian lung-fish. The research is made conjointly with Professor Bashford Dean.

Only the early stages of the chondrocranium have as yet been studied; but it is noteworthy that these early stages show even closer resemblance to the amphibian skull than does the adult. The suspensorium is ante-stylic from the first, and the union of quadrate to cranium by ascending and otic processes is exactly as in urodele amphibia. The hyomandibular appears later than the body of the hyoid arch, and has no connection with the jaw. The trabulæ are widely separated, leaving a large ventral fontanelle, also an amphibian character. The palatopterygoid bar is almost entirely suppressed. The one character which is entirely fish-like is the otic capsule.

Dr. **Sumner's** paper brought out the following points:

I. The generally accepted account of gastrulation in the Teleosts, as proposed first by Götte, was shown to be incomplete, in so far as it failed to give a true account of the hypo-blast.

II. A view of Kupfer's vesicle was maintained, closely similar to that proposed by the great morphologist, after whom this structure has been named.

III. The present author has arrived, on purely morphological grounds, at a view of concrescence identical with that proposed by Kopsch on the basis of the latest experimental work.

Dr. **Huntington's** paper dealt specifically with the retro-clavicular group of supernumerary muscles, for the purpose of determining their mutual relationship and common derivation. The new muscle, here described for the first time, completes a series of retroclavicular aberrant muscles which represent different stages in migration and recession of the typical mammalian-sterno-chondro-scapularis. The members of this group appear, therefore, as myo-typical reversions representing persistent portions of this muscular plane, with secondary skeletal attachments, depending upon the degree of recession.

Francis E. Lloyd,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

February 19, 1900.

Section met at 8:15 P. M., G. F. Kunz presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Henry S. Washington, The Magnet Cove Laccolith, Arkansas.

Summary of Paper.

The structure of the complex is described and, from the evidence of the form of the area, the relations to the surrounding shales, the presence of an overlying zone of metamorphosed rock, the arrangement of, and the serial petrographical and chemical characters of the main rock types, with other minor points, the conclusion is drawn that the igneous complex is probably a laccolith, and certainly a unit; and that the main component abyssal rocks are not due to successive injections, as was suggested by J. F. Williams, but are the result of a differentiation *in situ* of the mass of magma.

The main rock types are described, some new analyses being given, and they are shown to form a regularly graded series of interesting rocks, ranging from basic jacupirangite, through ciotite-ijolite, typical ijolite, shonkinitic syenite and leucite-syenite, to foyaite. This serial, and common genetic character is shown both mineralogically and chemically. It is probable that the dikes of tinguaite and nepheline-porphyry are aschistic, while those of monchiquitic rocks are diaschistic.

The arrangement of the abyssal rocks is shown to differ radically from most other cases of differentiated laccolithic masses and dikes, in that there is progressive increase in acidity toward the periphery. One or two other instances of this are mentioned, the most closely analogous being the laccolith at Umptek in Kola (Finland).

An explanation of this is given, based on a process of fractional crystallization or freezing of the magma, and the idea applied to other cases. It is suggested that the laccoliths and similar magmatic masses, which have been studied, may be referred to three distinct types, the differences between which would be satisfactorily accounted for by the hypothesis.

In the ensuing discussion, Dr. Washington pointed out that the specimens of the rocks, represented by his analyses, had not been selected in a radial line, but in various directions at increasing distances from the central mass of basic constitution.

The following specimens were exhibited by the Chairman:

Corundum from Raglan Township, Ontario, Canada.

Variously colored sapphires from a new locality, Clear Creek, Granite County, Montana.

Corundum from a serpentine dike at a new locality, Corundum Hill, Plumas County, California.

Professor **R. E. Dodge** announced the death of Dr. Hans Bruno Geinitz, on December 30, 1899. The Chairman briefly discussed the character and work of Dr. Geinitz, and, on motion, Professor Stevenson was appointed a committee to prepare a minute on this great loss to the Academy and to science.

Alexis A. Julien,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

February 23, 1900.

Section met at 8:15 P. M., Dr. Franz Boas presiding.

The following program was then offered:

Carl Lumholtz, Symbolism of the Huichol Indians.

A. L. Kroeber, Symbolism of the Arapahoe Indians.

F. Boas, The Growth of Children.

Summary of Papers.

Dr. **Lumholtz** stated that the Huichols are a small tribe of about four thousand souls living in the southwestern part of Mexico, on a spur of the Sierra Madre. Their country being difficult of access, they have been left comparatively untouched by civilization, and thus preserved their ancient beliefs and customs intact to the present day. The paraphernalia of the warrior of ancient times, *i. e.*, of the gods of the present race, furnish the principal symbolic objects by which prayers are expressed, and the most important of these articles is the ceremonial arrow left as a sacrificial offering in the temples and considered a carrier of prayers. It is painted and otherwise decorated with symbolic emblems, and attached to it are representations of other paraphernalia of the warrior, as the front shield and the back shield, the latter being also viewed as the mat or bed of the god. Frequently the object of the prayer is incorporated in an attachment to the arrow. The vivid imagination of the people makes them see analogies in the most heterogenous phenomena. They see serpents in the sky, the clouds moving through space, the wind sweeping over the fields, the rain falling down, even in their girdles and ribbons. Certain insects which appear during the wet season are identical with corn, and corn is identical with hikuli, and hikuli with deer. The same tendency to consider heterogeneous objects as identical may be observed in the fact that a great variety of objects are considered as plumes. Clouds, cotton-wool, the white tail of the deer, the deer's antlers, and even the deer itself are plumes, and the serpents are believed to have plumes. Naturally, much ambiguity is found, and there are few symbols that express always the same meaning; nor is an idea always expressed by the same symbol. Although this gives a certain individuality to the symbolic objects, we can always trace the connection between the thought to be expressed, and the symbol expressing it.

In Mr. **Kroeber's** paper it was shown with the aid of lantern slides that the decorative art of the Arapahoe Indians is throughout realistic (*i. e.*, pictorial) or symbolic. Geometric patterns occur, but rarely, and the general character of the art is suggestive rather of pictography. Symbols representing animal life, physical nature and abstract ideas predominate.

Professor **Boas** showed that a series of measurements of children repeated at annual intervals proves that the variations of growth must be interpreted as mainly due to acceleration and retardation of growth, combined with hereditary influences, which determine the amount of annual growth. It has shown that it is possible to determine the essential elements which determine the amount of annual growth by admission of regulated measurements. These result in a determination of (1) the relation between final development and development of any given period; (2) the typical development at a given period; and (3) the variability of the series in regard to period.

Charles H. Judd,
Secretary.

ANNUAL MEETING.

February 26, 1900.

The Academy met for the Annual Meeting at 8:15, President Osborn in the chair, who opened the meeting with the following address:

Members of the New York Academy of Sciences:

You are welcome to the 81st annual meeting of the Academy. We must congratulate ourselves upon our increasing strength which we trust is keeping pace with the rapid development of the City of New York as a scientific centre. This is not an institution for popular scientific education—a duty we may well leave to the Schools, the Universities, the Museums, and the recently established scientific parks. Our main object is the centralization of the best scientific thought of the city. In cordial coöperation with the several other scientific societies, this object should constantly be kept in view. We meet for high thinking and the encouragement of research. The rise of this Academy in the esteem of the people of this city and of similar academies abroad, will depend, not upon our scientific organization, which we now believe to be well nigh perfect, thanks to the careful efforts of the last few years; but upon the scientific discoveries which are stimulated and made known here. We all stand for plain living. The votaries of science do not need an elaborate meeting place ; but there is a certain stimulus in the scientific atmosphere of the historic associations which cluster around this Academy, which we shall lack until we secure a building of our own. We ask the intelligent people of this city, who owe everything they possess to the applications of science, for two large funds. First, an endowment fund for the publication of our researches ; this fund should not be less than $60,000. This, in my judgment, is of more pressing importance than the building.

Secondly, we ask for a building fund for a suitable meeting place, which we propose to share with the other societies of the Scientific Alliance. To this fund one of our Patrons, Mrs. Esther Herrman, has already generously contributed.

Upon the whole the sections of the Academy have gained steadily in strength. We regret that the disbandonment of the Philological section became necessary. At the same time we appreciate the fact that the Anthropologists have recently organized an Ethnological Society, but will continue to hold part of their meetings with us ; this branch of science, stimulated by the expeditions of the American Museum of Natural History, promises to be very strong. We have added Chemistry to the subjects covered by the Astronomical and Physical section.

During the past year I regret to say that some of our most distinguished Honorary Members have passed away. Among these are the veteran chemists, Professor Bunsen, of Heidelberg, and Sir Edward Frankland, Foreign Secretary of the Royal Society of London. We also mourn the loss of Sir William Dawson, the eminent geologist and palæontologist of Canada ; and of Professor Geinitz, who long held a leading position in Germany. I must refer to the death of Sir William Flower, Director of the British Museum of Natural History, as a personal loss, for I had the pleasure of esteeming him among my warm friends. He rendered great services to the study of mammals and to the development of scientific museums.

In retiring from the Presidency, I desire to express my warm appreciation of the honor you have conferred upon me, and I trust you will give equally cordial support to my successor.

The minutes of the last Annual Meeting were then read and approved.

No report of the Corresponding Secretary was given.

The report of the Recording Secretary, which is filed herewith, was then read and approved.

The accompanying report of the Treasurer was read and referred to the Finance Committee.

The accompanying reports of the Librarian and Editor were accepted, and votes of thanks passed for the work of the Librarian and Editor.

The following nominations for Honorary Members were read, as selected by the Council :

Julius Hann, Ph.D. Professor of Meteorology, University of Graz.

Edward Charles Pickering, LL.D. Paine Professor of Practical Astronomy, Harvard University.

Jules-Henri Poincaré, F.R.S. Professor of Mathematical Physics, Faculty of Sciences, Paris.

Henry Augustus Rowland, LL.D. Professor of Physics, Johns Hopkins University.

Edward Burnett Tylor, D.C.L., LL.D., F.R.S. Professor of Anthropology, University of Oxford.

Brief addresses in reference to the candidates were made as follows :

Dr. Hann, Professor Richard E. Dodge.

Professor Pickering, Professor J. K. Rees.

Professor Poincaré, Professor Woodward.

Professor Rowland, Professor Hallock.

Professor Tylor, Dr. Franz Boas.

The Secretary was then empowered to cast one ballot for the list as read.

The following list of corresponding members was nominated by the Council, and the Secretary was instructed to cast one ballot for their election, which was done.

Albert De Lapparent, Professor of Geography, École Libre de Hautes Études, Paris.

William Henry Holmes, Curator, United States National Museum, Washington, D. C.

Kakichi Mitsukuri, Ph.D., Professor of Zoology, Imperial University of Tokyo.

George Howard Parker, Ph.D., Associate Professor of Zoology, Harvard University.

Charles Richard VanHise, Ph.D. Professor of Geology, University of Wisconsin,

Sho Watase, Ph.D., Professor of Histology, Imperial University of Tokyo.

The following list of resident members was nominated as Fellows, by the Council, and the Secretary was instructed to cast one ballot for their election, which was done.

Dr. W. S. Day, Secretary Section of Astronomy, Physics and Chemistry.

James Douglas, Pres. American Institute of Mining Engineers.

Jonathan Dwight, Jr., Ornithologist.

Dr. Marshall A. Howe, Curator of Columbia University Herbarium.

Professor Charles H. Judd, Professor of Psychology, N. Y. University.

Dr. E. G. Love, Entomologist.

Alfred W. Trotter, Civil Engineer and Mining Expert.

Dr. Henry S. Washington, Petrographer.

Dr. Theodore G. White, Palæontologist.

The President then appointed as tellers, Mr. Kunz, Professor Lloyd, and Dr. White, to take charge of the election.

Dr. E. G. Love was nominated as Curator in place of Mr. W. D. Schoonmaker, who was not eligible.

Ballots were distributed, votes received and counted, and the following list of officers elected.

President—Robert S. Woodward.

First Vice-President—Charles A. Doremus.

Second Vice-President—Franz Boas.

Corresponding Secretary—William Stratford.

Recording Secretary—Richard E. Dodge.

Treasurer—Charles F. Cox.

Librarian—Livingston Farrand.

Councillors—Daniel W. Hering, Harold Jacoby, Frederic S. Lee, M. I. Pupin, Edward L. Thorndike, L. M. Underwood.

Curators—Harrison G. Dyar, Alexis A. Julien, George F. Kunz, Louis H. Laudy, E. G. Love.

Finance Committee—Henry Dudley, John H. Hinton, Cornelius Van Brunt.

The President-elect then took the chair, and after a brief address, introduced the retiring president, who gave his presidential address, entitled: THE GEOLOGICAL AND FAUNAL RELATIONS OF EUROPE DURING THE TERTIARY PERIOD, AND THE THEORY OF THE SUCCESSIVE INVASIONS OF THE ETHIOPIAN FAUNA.

The Academy then adjourned.

RICHARD E. DODGE,
Recording Secretary.

REPORT OF THE TREASURER.

February 26, 1900.

RECEIPTS.

Balance on hand, as per last annual Report		$1,489.85
Income, Permanent Fund	$420.14	
" Publication Fund	90.00	
" Audubon Fund	89.86	600.00
Life Membership Fees		200.00
Initiation Fees		80.00
Annual Dues, 1895	10.00	
" 1896	10.00	
" 1897	65.00	
" 1898	150.00	
" 1899	2,340.00	
" 1900	50.00	2,625.00
Total Receipts		$4,994.85

DISBURSEMENTS

Cost of Publications	$1,250.45	
Less received from sales	130.85	
		$1,119.60

Rent of Rooms		440.00	
Expenses of Officers:			
Recording Secretary	$363.09		
Librarian	278.48		
Treasurer	43.81	685.38	
Sectional and General Expenses		28.11	
Cost of Lectures		66.48	
Cost of 6th Annual Reception		366.17	
Preliminary Expenses of 7th Annual Reception		50.00	
			$2,755.74
Balance now on Hand			$2,239.11

DETAILS OF PERMANENT FUND.

Balance, as per last Annual Report	$1,468,68
Life Membership Fees rec. during year	200.00
Initiation Fees, rec. during year	80.00
Balance now on hand, for Investment	$1,748.68

DETAILS OF GENERAL INCOME ACCOUNT.

CREDIT.

Received from Annual Dues	$2,625.00
Income of Permanent Fund	420.14
" Publication Fund	90.00
	$3,135.14

DEBIT.

Deficiency brought over from last year	$281.55	
Net Cost of Publications	1,119.60	
Rent of Rooms	440.00	
Expenses of Officers	685.38	
Sectional and General Expenses	28.11	
Cost of Lectures	66.48	
Cost 6th Annual Reception	366.17	$2,987,29
Balance, surplus		$ 147.85

Summary.

Balance to credit of Permanent Fund...	$1,748.68
" " " " Audubon Fund....	100.00
Total, awaiting investment......	$1,848.68
Accumulated Income of Audubon Fund awaiting appropriation by the Council.	292.58
Balance to credit of General Income a/c available for future expenses........	147.85
	$2,289.11
Less, amount advanced for Preliminary Expenses of 7th Annual Reception.........................	50.00
Balance, cash on hand.........	$2,239.11

It appears from the foregoing figures that the total expenses of the Academy for the year were $429.40 less than its available income, so that a deficiency of $281.55 was wiped out, and a surplus of $147.85 created in General Income Account.

Assets.

Cash in Bank......................		$2,239.11
Investments in Bonds and Mortgages @ 5%:		
a/c Permanent Fund............	$8,402.75	
a/c Publication Fund............	1,800.00	
a/c Audubon Fund.............	1,797.25	12,000.00
Annual Dues in Arrears:		
For 1896.....................	40.00	
" 1897.....................	130.00	
" 1898.....................	200.00	
" 1899.....................	450.00	820.00
Total........................		$15,059.11
Amount last year..................		14,109.85
Gain for year......................		$ 949.26

C. F. Cox,
Treasurer.

REPORT OF THE RECORDING SECRETARY.

February 26, 1900.

The last Academy year has been one of progress, but has not been marked by any striking events that make it noteworthy. The attendance at the meetings has continued pleasing, and in every way the work of the Academy has continued along the lines previously adopted.

During the last year there have been seven meetings of the Council, six Business meetings, thirty Sectional meetings, four Public Lectures, and one Public Reception. At the Sectional meetings and Lectures there have been presented a total of eighty-two papers, which may be classified as follows:

Anthropology 7.	Palæontology 6.
Archæology 3.	Petrography 5.
Astronomy 5.	Philology 4.
Botany 2.	Physics 8.
Electricity 1.	Physiography 1.
Descriptive Geology 5.	Physiology 1.
Economic Geology 3.	Psychology 9.
Mechanics 2.	Unclassified 1.
Mineralogy 3.	Zoology 15.
Ornithology 1.	

There are at present a total of 333 members, and there have been elected during the last year 16, of whom 7 have not yet qualified. There have unfortunately been 13 resignations. It is with regret, also, that the Academy records the death of seven Honorary Members.

There are pending for consideration this evening five nominations for Honorary Members, six for Corresponding Members, and nine for Fellows.

The Annual Reception and Exhibition was held in April, in the American Museum of Natural History, and like its predecessors, was extremely successful. For the first time since the Reception has been held in the American Museum it was possible to have an unoccupied room, whereby there was no confusion between the Academy and Museum exhibits. The same plan will be followed during the coming year. The Academy feels that it owes a great deal to the President and Trustees of the American Museum of Natural History, for their kindness and courtesy in allowing the Annual Reception to be held in the Museum, under such favorable auspices, and at such a moderate expense to the Academy.

A few changes have been made during the last year in the organization and management of the sections. It is with regret that the Academy has seen the Sub-Section of Philology discontinued because of lack of public interest in the meetings. It is with pleasure that the Council has added to the field of operations in the Section of Astronomy and Physics by incorporating therewith work in Chemistry. Mention should also be made of the extremely satisfactory and pleasing work which is being accomplished by the Section of Anthropology and Psychology.

During the last two years the Anthropological Club has been coöperating with the Section of Anthropology and Psychology in their meetings. This Club has lately been superseded by the Ethnological Society, which has been revived. The Ethnological Society will continue to coöperate with the Section of Anthropology and Psychology, and it is hoped that strength may be acquired by both organizations through this mutual assistance.

The Council feels that the success and increased interest evident in the meetings since the removal of the meeting place to this building is a very pleasing feature in the Academy's work. Almost without exception the meetings of the different sections have been individually and as a whole largely increased in attendance during the last year and a half. Many faces that were never seen at the other meeting places are now regularly seen at the sections that most interest them.

The work of the Recording Secretary's office has been systematized, and in many ways improved during the last year, so that the necessary and frequent details are managed more efficiently and with less expenditure of energy and time.

The needs of the Academy remain as a year ago, many. The particular need is for a larger publication fund, which will make it possible for the Academy to publish a number of large and important papers which it is now obliged to refuse, owing to a lack of funds. A publication fund would be one of the best endowments that the Academy could receive.

The other great need of the Academy, as it is the need of all the other scientific societies in the city, is a permanent meeting place, at which the library could be housed, and where members would have freedom at all times. The Academy trusts that the beginning of a fund of this sort, so kindly started last year by Mrs. Herrman, may be increased in the near future.

No changes in the policy or plan of procedure of the Academy are anticipated for the coming year.

Respectfully submitted,

RICHARD E. DODGE,

Recording Secretary.

REPORT OF THE LIBRARIAN.

FEBRUARY 26, 1900.

The Library of the Academy consists in round numbers of 9,000 volumes. The total number seems a small one; but it will be recalled that the value of the Library consists largely in its sets of scientific periodicals. Hardly five per cent. of the volumes are in separate title. On the shelves of the Library are now about 8,500 volumes; the remainder, consisting of Consular, Signal and Patent Offices reports, educational, health, and statistical State publications, have been placed for the present, at least, in storage; they are so disposed, however, that they are accessible on short notice. The following statistics may be added: Bound volumes, Quarto, 505; Octavo, 6,115. Unbound volumes, Quarto, 220; Octavo, 950.

At the beginning of his term of office, the Librarian found the room, 507 Schermerhorn Hall, provided with cases for the reception of the collection. The books, it will be remembered, had up to this time been stored in the basement of Schermerhorn Hall, pending the provision of the class rooms, and furnishings of Columbia University. His first duty, therefore, was to attend to the time-consuming work of unpacking the Library, arranging it on the shelves, revising the catalogue, and adjusting the entire matter of serial publications. The last-named task proved in many ways the most difficult, since owing to the moving of the University, the serial publications had accumulated since 1896 or 1897. Recalling that the Academy has upwards of 800 Societies on its exchange list, it is easily seen that the mass of exchanges was represented by a small mountain of periodicals in all languages, in almost hopeless confusion. The receipt of the exchanges had also to be acknowledged. At the present time the following items are noted as having been accomplished :

The volumes have been arranged on the shelves, the latter have been numbered, and all serial publications—the greatest part of the Library—can be readily found by reference to the shelf numbers now placed in the card catalogue. The card catalogue has been carefully revised, it having been found that the subject and locality titles had been unsatisfactorily arranged. The room of the Library has been suitably lighted. One hundred volumes have been bound and added to the shelves. For the convenient grouping of the incoming periodicals, a large case has been prepared and the present stock of pamphlets (periodicals) has been classified and are in large part placed in order in this case. A geographical arrangement has been found most convenient. Suitable labels will be put in place, different colors representing different countries, so that the visitor can find the recent numbers with the least possible loss of time.

There are many things left undone which I intended to do. I had in mind the publication of a catalogue of the collection, to be sent to the members of the Academy. This I had hoped to bring up to date ; but unexpected difficulties found in the classification of the periodicals have prevented me from carrying out the plan. I was also in hopes of having all separate pamphlets and odd volumes recorded by shelf numbers in the card catalogue. The most that I have succeeded in doing in the last matter is the arrangement of these volumes or pamphlets on definite shelves, according to their subjects, a grouping which will, I think, temporarily, at least, serve a useful purpose. Thus, the visitor who wishes to determine whether a separate book or pamphlet is in the library, say on the subject of Zoology, will be told that if an octavo he will find it in case 27, or if a quarto in case 41, shelves 1 and 2, or 4 and 6. If the book is, as is usually the case, entered in the card catalogue, the visitor will have no difficulty, I think, in thus securing his book with very little loss of time.

Respectfully submitted,

BASHFORD DEAN,
Librarian.

REPORT OF THE EDITOR.

FEBRUARY 26, 1900.

The Editor desires to make the following report for the past Academy year:

Volume XII of the ANNALS, Part I, comprising 3 papers of 89 pages, with 4 figures, has been printed and distributed. Parts II and III of Volume XII will be issued together, making a total of 14 papers and about 600 pages in the complete volume. Of these numbers 4 to 9 have been issued as author's separates.

Six numbers, in all about 250 pages, are already in hand for printing in Volume XIII.

Volume II, Part I of the Memoirs, entitled "The So-Called Devonian Lamprey, *Palæospondylus gunni*, with notes on the systematic arrangement of the fish-like vertebrates," Bashford Dean, 4to, pp. 1–32; pl. I (litho), January 20, 1900, has been distributed; and Volume II, Part II, entitled "The Egg of the Hag-Fish, *Myxine glutinosa*," Bashford Dean (7 typewritten pages and 1 plate), is in press.

The following is the list of papers already issued as separates, soon to appear in the remaining parts of Volume XII. Arthur Hollick—"Some Features of the Drift on Staten Island, N. Y.," pp. 91–102 (July 7, 1899), pl. I (map); Richard Weil—"Development of the *Ossicula Audita* in the Opossum," pp. 103–118; pls. II and III (zinc) (July 7, 1899); Frederick J. H. Merrill—"Origin of the White and Variegated Clays of the North Shore of Long Island," pp. 113-116 (July 8, 1899); Hubert Lyman Clark—"Further Notes on the Echinodermata of Bermuda," pp. 117–138, pl. IV (zinc); R. P. Whitfield—"List of Fossils, Types, and Figured Specimens used in the Palæontological Work of R. P. Whitfield, showing where they are probably to be found at the present time," pp. 139–186 (Nov. 15, 1899); John Duer Irving—"A Contribution to the Geology of the Northern Black Hills," pp. 187–340; pls. V–XVI, text figures 5–20 (Dec. 18, 1899). The following papers also to appear in Volume XII, are still in press; author's separates have not been issued. Walter C. Kretz—"The Positions and Proper Motions of the principal stars in the Cluster of *Coma Berenices*, as deduced from measurements of the Rutherfurd Photographs," about 150 printed pages; W. M. Rankin—"The Crustacea of the Bermuda Islands, with notes on the collections made by the N. Y. University Expedition in 1897 and 1898"; about 40 pages text and plate XVII. Louis H. Gray—"Contributions to Avestan Syntax, The Conditional Sentence"; 30 printed pages. William E. Ritter—"Some Ascidians from Puget Sound"; collections of 1896; 30 pages text and three colored lithographed plates, nos. XVIII–XX. Records, about 40 pages.

The edition of the ANNALS has been increased from 1000 to 1250, and during the year the mailing list has been extensively revised and straightened out. There is necessarily some delay in the issuing of the papers, owing to the necessary slowness in reading the proof of certain articles; some changes to be made in the mode of publication with intent toward insuring regular time of appearance of the parts of the ANNALS is absolutely necessary.

The work of the Editor has on the whole progressed satisfactorily.

Respectfully submitted,
Gilbert van Ingen.
Editor.

BUSINESS MEETING.

March 5, 1900.

Academy met at 8 P. M., President Woodward presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows:

That the delegates to the Scientific Alliance for next year were President Woodward, Mr. Cox and Professor Doremus.

That the Academy had voted to secure, if possible, photographs of the past presidents of the Academy, to be framed and hung in the Library.

That Professor Osborn had been elected a delegate to the International Congress of Geology.

The following candidate for resident membership, approved by the Council, was duly elected:

W. D. Matthew, American Museum of Natural History.

Richard E. Dodge,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

March 5, 1900.

Section met at 8:20 P. M., Professor M. I. Pupin presiding.

The minutes of the last meeting of Section were read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-Laws:

The following program was then offered:

R. S. Woodward, An Account of the Jubilee of Sir George G. Stokes.

A. C. Longden, Resistance of Thin Films Deposited by Kathode Radiation. Selenium Rings.

Summary of Papers.

The Jubilee, described by Professor **Woodward,** was held on the 1st, 2d and 3d of June, 1899, on the fiftieth anniversary of the professorship of Sir George G. Stokes at Cambridge. Stokes' most important scientific work was done between 1842 and 1855. In fluid motion he showed that the conditions under which the equations of motion were integrable, were the conditions that the motion should be irrotational. He made researches concerning the elastic solid theory of light. He made advances in the theory of physical geodesy. He showed that the shape of the earth's surface should determine the law by which gravity varied from place to place. He cleared up a good many obscurities in the work of Fourier in regard to Fourier series.

The Jubilee began with the Rede lecture, delivered by Professor Cornu of the École Polytechnique, on the "Wave Theory of Light," and its influence on modern physics. Beside dinners, garden parties, etc., the most important ceremonies were the presentation of addresses by the delegates representing about seventy institutions, and the conferring of the honorary degree of Doctor of Science upon Messrs. Cornu, Darboux, Michelson, Mittag-Leffler, Quincke and Voigt. At the dinner which ended the celebration, Sir George Stokes made a speech in the course of which he said that he wished he had done more scientific work, but that if he had, he might not have been there to celebrate his jubilee.

Mr. **Longden,** in the second paper of the evening described his method of depositing thin metallic films on glass, and showed some specimens. These films can be used as high resistances instead of the very expensive wire resistances ordinarily used. Films of gold or platinum can be deposited, which have not the lack of durability of alloys. At the same time, unlike the metals in the form of wire, they have very low positive or even negative temperature coefficients. The films are deposited from a kathode of the same material by the discharge of electricity through a vacuum, and can be deposited in any thickness desired, and of any metal, gold and platinum being however the most convenient. The speaker showed a gold film of varying thickness in different parts, the thickest part showing the green color like gold leaf when viewed by transmitted light, and the color varying through blue to violet as the film became thinner.

In the third paper the speaker stated that at the suggestion of Mr. C. C. Trowbridge, he had attempted to deposit a thin conducting film of selenium, but he was unsuccessful as the film deposited was non-conducting. He obtained, however, a film of varying thickness which exhibited the phenomenon of Newton's rings in a beautiful manner.

The section then proceeded to the election of sectional officers. The motion was made and passed to take an "informal" ballot. The informal ballot was taken. For Chairman, Professor Pupin received three votes, and Professor Hallock six votes. For Secretary, Dr. Day received nine votes. The motion was then made and passed that this ballot be regarded as the formal ballot. Professor Hallock was therefore declared elected Chairman and Dr. Day, Secretary.

The section then adjourned.

WM. S. DAY,
Secretary.

SECTION OF BIOLOGY.

MARCH 12, 1900.

Section met at 8:15 P. M., Professor F. S. Lee presiding. The minutes of the last meeting of Section were read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-Laws.

The following program was then offered :

E. L. Thorndike, MENTAL LIFE OF ANIMALS.

D. T. Macdougal, SYMBIOSIS OF ROOTS AND FUNGI.

R. Ellsworth Call, The Newburg Mastodon and Its Associated Fauna.

Summary of Papers.

Dr. **Thorndike** described some of the features of the mental life of the monkeys, contrasting their behavior and abilities with those of other mammals. He presented evidence showing the importance of the use of the fore-limbs, delicate discrimination in vision, and incessant general activity as factors in the mental development of the monkeys. He also reported in detail some observations concerning their formation of various intelligent habits, which hint at a near relationship to the human methods of learning.

Mr. **Macdougal** stated that the roots of an extremely large number of plants form asssociations with fungi in such manner that a felt of hyphæ a millimeter or more in thickness covers the surface, or the fungus may penetrate the tissues and develop coils and clumps of hyphæ in the cortex, from which a number of tubes extend out into the soil.

Roots alone may absorb only minute quantities of the complex products of decomposition of organic matter, but fungi derive almost their entire supply from such sources. The union of the root and fungus result in the latter yielding some of the absorbed humous products to the higher plant. The fungus in turn receives more or less shelter and certain carbohydrates which it uses as food to advantage.

Associations of such symbiotic nature are followed by degenerations of the stele and of the general structure of the root stems, and leaves of the higher plant.

Dr. **Call** referred to the general geological structure of the region about Newburg, which is Hudson River group rock, for country rock, surmounted with a heavy deposit of glacial till. The remains of the mastodon which were under discussion were in the upper portion of the till, partially imbedded in it, and capped with from four to six feet of a black soil rich with vegetable debris. The locality is in a depression of considerable extent, and had, at one time, been a beaver dam, as was indicated by the numerous remains of beaver-gnawed sticks and logs, which were found during the excavations.

Associated with the mastodon bones were a number of species of fresh-water mollusca, among which the following were recognized: *Limnæa stagnalis*, Linn.; *Limnophysa humilis*, Say; *Physa heterostropha*, Say; *Planorbella campanulata*, Say; *Gyraulus parvus*, Say; *Valvata tricarinata*, Say; *Valvata sincera*, Say; *Amnicola limosa*, Say; and *Pisidium æquilaterale*, Prime. All but the species of *Physa* were abundant. The *Limnæa stagnalis* were very large, larger than are now found in recent stations.

The shell-marl was a later deposit than that in which the mastodon remains were found. The place was a peat bog, but never one of great extent nor of great depth.

None of the large leg bones of the mastodon have been found, and the small ones of but a single foot. The animal was not found at the place where it died, but where it had likely floated after partial dismemberment.

At the close of the scientific program, Prof. Patrick Geddes, of the University of Dundee, was invited by the Chairman to present a plan for the formation of an International Association for the Advancement of Science, Arts, and Education, the first assembly of which is to meet at Paris, 1900.

On motion of Professor E. B. Wilson, the thanks of the section were extended to Professor Geddes for his exposition of the plan, with the request that he communicate the matter formally to the Council of the Academy.

The application of Dr. M. A. Howe for the Newberry Fund Grant was read, and referred to a committee consisting of Professor F. E. Lloyd, Professor C. L. Bristol, and Dr. G. N. Calkins.

The election of sectional officers was, on the motion of Dr. G. N. Calkins, postponed one month.

Francis E. Lloyd,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

MARCH 19, 1900.

Section met at 8:15 P. M., Mr. Geo. F. Kunz presiding.

The following program was offered :

Henry B. Kümmel, THE PALISADES. Illustrated by lantern slides.

John C. Smock, ON THE PROTECTION OF THE PALISADES.

SUMMARY OF PAPERS.

A summary was read of the information thus far collected in regard to the Geology of the Palisades of the Hudson River, illustrated by numerous views, many of them taken by Mr. Prince, of Orange, N. J. Most of the details of the paper will be found in the 1897 Report of the State Geologist of New Jersey. Observers are nearly all agreed that the Palisades are an intrusive trap sheet, which has cooled at great depths. The basal contact is observable at 19 localities, in 15 of which the trap is unconformable upon the sandstone and shales beneath, and is penetrated by tongues of the latter, and in three is apparently conformable. The altitude of the lower contact increases from the south to the north, where it reaches 200 feet elevation. The upper contact. is seen in six localities. At three of these, dikes penetrating the overlying shales occur at the contacts ; in two the contact is unconformable, and in one conformable. In every instance the beds superjacent to the trap are metamorphosed. In no locality of the Palisades range proper does the upper contact of the trap show any of the characteristics of surface cooling. Well-borings at Fort Lee penetrate 875 feet of the trap, and the total thickness probably exceeds 950 feet, much erosion having taken place. Subsequent to deposition of the overlying sandstones the area was tilted, and the sandstone wasted away by erosion of many streams, the vacant channels of which are still present. The largest of these stream-gaps was one and a half miles wide, and is just north of the New Jersey State boundary. The cutting of gaps throughout the dissected tilted peneplain which remains was very uniform, and indicates that the former land level was 220 feet lower than the present. If this is the case, we have an instance of rivers beheaded close to their mouths. In addition to the wild beauty of the Palisades escarpment, the timber of this tract is the most luxurious and valuable of the State of New Jersey, although its area is much less than that of the pine groves to the south.

Professor **John C. Smock,** State Geologist of New Jersey, followed with an account of the efforts expended on the protection of the Palisades from devastation by quarrymen. Legislative prohibition of such destruction is retarded by (1) lack of interest in the matter on the part of residents in southern New Jersey ; (2) prospects of the future commercial value of the riparian lands at the base of the cliffs, for purposes of shipping and manufacturing, which the removal of a portion of the cliffs would render available ; (3) the present value to the State of its quarrying interests along the water front ; (4) the income derived from riparian grants of these lands by the State to the quarrymen, which income is devoted to the maintenance of the public schools, the approximate value to the State for this purpose of the lands from Fort Lee to the State border being about one million dollars. This clash between the interests of the schools and the preservation of beautiful scenery is the most serious obstacle with which legislation against defacing the Palisades has to contend.

"In the face of these obstacles it is evident that the wholesale absorption of this territory for a purely sentimental object is impossible. The opposition to such a scheme could only be broken by years of fighting, and in the meantime the destruction of the cliffs and wooded slopes will continue with ever-increasing extent."

As a compromise, Professor Smock suggested that an interstate commission of New Jersey and New York lay out a driveway along the base of the Palisades, quarrying, manufacturing, and shipping interests to be confined to the water-side of the driveway, and the cliff side to be permanently preserved intact after the drive is completed. Edinburgh, Quebec, and Sterling were cited as exhibiting rocky heights whose grandeur was enhanced by the fringe of manufactories at their base, such buildings lending a basis to the eye by which to measure the proportions of the cliffs. Cliff defacement is also in progress upon the New York Palisades, where are the grandest wooded slopes and highest peaks. There is no need of encroachment on the cliffs in either State, for there are many other places where as good road material exists in equally great quantities, and can be mined at practically the same expense.

"Whatever is done should be done at once, or else we shall have lost a great part of the scenery which we wish to preserve, and this must be done without destroying, or coming in contact with the large public and private business interests that are involved."

In discussion Mr. **Kunz** voiced the sentiment that the opposition to legislation arose more with officials at Trenton than with residents of southern New Jersey, and felt that smoke and other nuisances from factory settlements along the cliff would be seriously detrimental. Were a restricted park created, the value of residential property would in a few years benefit the State many times over the value of the riparian grants. Railroad tunnels might be permitted a distance of a few miles apart, with commercial villages at their water front terminals. The stone from such tunnels would defray the cost of quarrying.

Dr. **Levison** suggested that the removal of portions of the talus would increase the apparent height of the cliffs, if blasting of the latter could be prevented. Dr. **Hovey** described the similar trap formations of Connecticut.

The Secretary announced that this section and the Biological section had been requested to nominate candidates before April 20th, for the grant of the Newberry Research Fund, the grant this year being restricted to those working in botany and geology. Authority was granted to the chairman and secretary of the section to make such nominations to the Council.

The Chairman announced the course of lectures on "The

Principles of Geology," to be delivered at Johns Hopkins University in April, under the G. H. Williams Memorial lectureship, by Professor W. C. Brögger, of Christiania; also the receipt of the program of the International Geological Congress, at which the Academy will be represented by Professor J. J. Stevenson.

The chair also announced the death of Dr. Oliver P. Hubbard, one of the earliest members of the Academy.

On motion of Professor R. E. Dodge, a committee of three was appointed to draft resolutions on the death of Dr. Hubbard, and the chair appointed Dr. Julien, Professor Stevenson and Dr. Hovey such committee.

Professor **Stevenson** presented the following minute upon the life of Dr. H. B. Geinitz, whose death was announced at the February meeting:

"Professor Hans Bruno Geinitz, for many years an Honorary Member of this Academy, died January 23, 1900, in the 86th year of his age. His work as a geologist began very early, for in 1837, when only twenty years old, he published a paper on the Muschelkalk. From that time until within a few weeks of his death, brief notices, memoirs and volumes appeared in rapid succession. There seemed to be no limit to his capacity for hard work. He studied the Cretaceous, Triassic and Carboniferous in detail, and his works on the coal fields of Saxony and Germany were marvels, when published, half a century ago. His papers on palæontology—vertebrate and invertebrate—and palæobotany, are numerous and important.

He was put in charge of the Royal Mineralogical Cabinet in 1846, and retained the position until 1898. The collections increased rapidly, so that in 1857, the Royal Cabinet became the Royal Museum, which, in later years, was one of the chief attractions for foreign visitors. In addition to his other labors he was Professor of Mineralogy in the Royal Polytechnic School of Dresden, from 1850 to 1896, serving meanwhile upon numerous government commissions.

Professor Geinitz was a typical student, caring little for things of this world, devoted to geology and his family. He was genial, sincere, a tender father, a generous friend. By his death

German science has lost one of its most conscientious workers, and Saxony one of its most respected citizens."

Dr. Alexis A. Julien and Dr. Theodore G. White were unanimously elected Chairman and Secretary, respectively, of the Section for the ensuing year.

After a vote of thanks to the lecturers of the evening, the meeting adjourned.

THEODORE G. WHITE,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

MARCH 26, 1900.

Section met at 8:15 P. M., Professor Cattell presiding.

The following program was offered:

A. L. Jones, THE SYMBOLIC CHARACTER OF GEOMETRICAL FORMS AS A PRINCIPLE OF EXPLANATION.

R. S. Woodworth, THE FATIGUE OF VOLUNTARY MOVEMENT.

E. L. Thorndike, WEBER'S LAW IN JUDGMENTS OF COMPARISON WITH A MENTAL STANDARD.

SUMMARY OF PAPERS.

Among the attempts to explain formal beauty that of Lipps in his Raumästhetik is the most striking. He maintains that the æsthetical value of beautiful geometrical forms is due to the fact that they symbolize the activity of mechanical forces working themselves out freely; that we sympathize with the forces thus represented and receive pleasure when their action is unhindered; that the forces and laws of their action are not consciously recognized but are merely *felt* or known unconsciously. His explanation involves some questionable metaphysics. The action of mechanical forces is no doubt an important element in many beautiful objects, but it remains to be proved that it is sufficient to explain all formal beauty in objects.

Dr. **Woodworth** stated that the fatigue movement may be studied in reference to the loss in force, in accuracy, or in speed. In each of these respects experiments show that a movement may be continually repeated for hundreds and even thousands of times with only a comparatively slight loss of efficiency. The ergographic curve given by Mosso for force of movement is to be abandoned absolutely as a true picture of the curve of fatigue. This fact has been of late recognized in some able articles by Treves, working in Mosso's own laboratory; but is best brought out by the use of Cattell's spring ergograph. One of the great causes of fatigue in force, and also in speed of movement is the failure of the muscles to relax completely between successive contractions. If care is taken to secure this relaxation, 1,000–1,500 maximal ergographic contractions can be made with a loss of only 10 per cent. of the initial force. From the slowness of fatigue of various modes of voluntary movement, the inference follows that the fatigue o nerve centres is not rapid, as Mosso and Lombard have supposed, but slow in progress. This view is confirmed by tests of prolonged, hard and monotonous work of a mental kind. The quick and overmastering fatigue of common experience is not so much actual inability and loss of function, as it is disinclination, resulting from disagreeable sensations and emotions, and from impulses to change.

The third paper by Dr. **Thorndike** presented the results of some experiments on the accuracy of discriminations of weight, length, and area, by subjects who judged by the aid of mental standards only. Within the limits chosen (40–12 gr., ½–12 ins., 20–60 sq. cm., and 2–12 sq. irs.), the accuracy of discrimination was found to decrease very slowly, very much more slowly than Weber's law or even the law of the combination of errors would allow. The theory proposed to account for this was that our judgments of amount or of difference are of complex origin, and may be made on various grounds. In so far as the ground is an accurate mental standard, the sensations corresponding to large amounts may be associated with the proper judgment nearly or quite as readily as small amounts. In so far as the ground is a combination of feelings or judgment, the inaccuracy of judgment may vary, because of the combination of errors, as the square root of the amount. In so far as the ground is the mere mental shock of difference, the inaccuracy of the judgments may vary in some more direct relation to the amount.

CHARLES H. JUDD,
Secretary.

BUSINESS MEETING.

APRIL 2, 1900.

Academy met at 8:23 P. M., President Woodward presiding.

The minutes of the last business meeting were read and approved.

In the absence of the Secretary of the Academy, the President requested Dr. W. S. Day to act as Secretary pro tem.

The following Candidates for resident membership, approved by the Council, were duly elected :

Charles Bergen Davis, 321 West 124 Street.

Miss Esther Byrnes, 85 Hancock Street, Brooklyn, N. Y.

WM. S. DAY,
Recording Secretary pro tem.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

APRIL 2, 1900.

Section met at 8:25 P. M., Professor W. Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

William Hallock, OVERTONES OF A TUNING FORK.

William Hallock, NOTE ON SPECIFIC GRAVITY WEIGHINGS.

M. I. Pupin, A NEW FARADMETER.

C. E. Furness, CATALOGUE OF STARS WITHIN ONE DEGREE OF THE NORTH POLE AND THE OPTICAL DISTORTION OF THE HELSINGFORS ASTROPHOTOGRAPHIC TELESCOPE.

Summary of Papers.

Professor **Hallock** stated that the first regular overtone of a tuning fork is about two and a half octaves above the fundamental, but Lord Rayleigh pointed out that when the amplitude of the vibration became so great that the restoring force was no longer proportional to the displacement, the octave appeared, as indicated by theory. Lord Rayleigh recognized the presence of the octave with his ear and by the use of a resonator. Professor Hallock obtained direct evidence of this effect by means of a photograph of a manometric flame, the capsule of which was resting against the prong of the fork.

In a paper on "Specific Gravity Weighings," Professor **Hallock** spoke of a number of points in which the ordinary operations could be improved. It is very convenient to use the principle of the Jolly balance in which there is a pan always immersed to hold the body when weighing it in water. The effect of capillarity on the supporting wire which at best lessens the sensibility of the balance, can be avoided by sending a series of little waves across the surface of the water while weighing. To get rid of bubbles in little corners of irregular bodies, these bodies may be held under the tap at the sink and moistened with water before immersion or, still better, they may be moistened with alcohol and then with water before immersion.

Professor **M. I. Pupin** described a new faradmeter, which he had devised, an instrument for measuring the capacity of a condenser. This instrument is essentially a Wheatstone's bridge, using alternating currents, in which one leg of the bridge consists of two resistances in series and the other leg consists of two capacities in series, one of the two being that of a standard condenser, the other being the unknown capacity to be measured. In the bridge connecting the two points, one between the two resistances, the other between the two capacities, is a telephone. If the two separate circuits, each containing one of the two capacities, are arranged so that the capacity reactance is by far the greatest part of the impedance in that circuit, then silence in the telephone will be obtained when the two resistances are to each other inversely as the two corresponding capacities. The apparatus has been employed in the Columbia University laboratory and gave complete satisfaction. It is capable of a tolerably high degree of accuracy, but its principal merit is its convenience.

Professor **J. K. Rees** presented a paper by Miss C. E. Furness on "A Catalogue of Stars Within One Degree of the North Pole and the Optical Distortion of the Helsingfors Astrophotographic Telescope." The paper gave the results of measurements on 65 stars. By using stars near the Pole, the same group of stars can be taken at different angles with reference to the object glass of the telescope. At Helsingfors the Pole is sufficiently far from the horizon to avoid trouble with refraction. From the measurements, the distortion of the Helsingfors lens was found to be not appreciable.

Wm. S. Day,
Secretary.

SECTION OF BIOLOGY.

April 9, 1900.

Section met at 8:15 P. M., Professor F. S. Lee presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

M. A. Bigelow, Embryology of Lepas.

F. E. Lloyd, The Genus Lycopodium in North America.

Summary of Papers.

Mr. **Bigelow's** paper was based upon the results of an investigation recently completed, which was undertaken with the view to applying the cell-lineage method in an accurate study of the cleavage and the formation of the germlayers in *Lepas* and other Cirripedes.

Four species have been studied, but the only complete series of embryonic stages was obtained from *Lepas anatifera.*

The cleavage of *Lepas* is totally unequal and regular. Stages of 2, 4, 8, 16, 32, and 64 cells are normally formed. Cells of a given generation may anticipate their fellows in division, but no second division of such cells takes place before all other cells have completed corresponding cleavages and become of the same generation.

The first cleavage is nearly parallel to the long axis of the ellipsoidal egg. The egg is divided into an anterior ectoblastic cell and a posterior yolk-bearing macromere. The second cleavage is at right angles to the first, both cells dividing, and from the yolk-macromere is cut off a second ectoblastic cell. The third cleavage is essentially perpendicular to the first two, dividing all of the cells, and a third ectoblastic cell is separated from the yolk-macromere, which is now mesentoblastic. Thus by the first, second and third cleavages three cells are separated from the yolk. These three cells contain all the ectoblast, and by repeated division they form the blastoderm. The fourth cleavage separates the mesoblast from the ectoblast, which is now represented by the yolk-macromere.

The 16-cell stage is composed of fourteen ectoblastic cells which largely surround the entoblastic yolk-cell. The single mesoblast cell lies in the blastoderm at the posterior edge of the blastopore, where the entoblastic yolk-cell is still exposed to the exterior. By the fifth cleavage all these cells are divided, the two mesoblastic cells still remaining on the surface. During the sixth cleavage the two mesoblastic cells sink beneath the blastoderm as it closes over the blastopore. At the same time four cells of the blastoderm, lying at the anterior and lateral edges of the blastopore, divide perpendicularly to the surface. Four cells are thus formed, beneath the blastoderm, and they are apparently added to the mesoblast. The entire mesoblast then originates from one cell which is separated from the entoblast in the fourth cleavage 16-cell stage, and from four other cells which are derived from the ectoblast in the sixth cleavage forming the 62-cell stage.

The course of the cleavage as sketched above has been determined to be quite constant. Cells of definite origin in the early cleavage stages, are the ancestors of cells which occupy particular positions in later stages. Following Conklin's terminology ('97) the cleavage may be characterized as "determinate." This conclusion is completely opposed to the results of the earlier investigators of cirripede development.

Gastrulation is of the epibolic type, and is the result of the extension of the ectoblastic blastoderm over the entoblastic yolk-macromere. The blastodern usually closes over the blastopore during the sixth cleavage (62 cells). The blastopore is identified as marking the ventral and posterior of the future embryo.

In the general features of the late development of the embryo the results of this investigation confirm those of some earlier workers.

On account of the discomfort caused by the low temperature of the room the second paper of the evening was omitted by general consent.

On motion of Professor F. E. Lloyd, a committee of one was appointed to communicate with the Recording Secretary in regard to the unsatisfactory heating arrangements, with a request that a complaint be lodged against the culpable parties.

Mr. Lloyd was asked to serve as the committee.

Adjournment followed.

FRANCIS E. LLOYD,
Secretary.

GEOLOGY AND MINERALOGY.

APRIL 16, 1900.

Section met at 8:20 P. M., Dr. A. A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

R. Ellsworth Call, SOME PRELIMINARY NOTES ON CRYSTAL GROWTHS IN MAMMOTH CAVE. (Illustrated by Lantern Slides.)

E. O. Hovey, SCENERY OF THE HARNEY PEAK DISTRICT IN THE BLACK HILLS, S. D. (Illustrated by Lantern Slides.)

E. O. Hovey, Biographical Notice of Professor Oliver P. Hubbard.

Summary of Papers.

Dr. **Call's** mineralogical notes were preceded by a brief resumé of the geology of the vicinity of Mammoth Cave. The strata making the geologic section are nearly horizontal, and all the rocks forming the cavern are of sub-carboniferous age. The region of the cavern is capped with sandstones of the Chester Group, 500 feet thick. Under these are oolitic and other limestones, in which the cavern is excavated to a thickness of over 350 feet. The drainage level of the cavern is determined by the present level of Green River. Five different levels have existed during geologic time. No gypsiferous strata are known in the region. The overlying sandstone is usually quite ferruginous; but no pyrite occurs in either strata. Secondary crystallization has occurred in many of the stalactites, causing them to simulate the fibrous appearance sometimes assumed by aragonite. The stalactites of recent origin almost all have a downward-projecting tree root as their origin of fixation, or are beneath sink-holes. The chief objects of mineralogical interest are the gypsum crystals, which cover the sides and ceilings of certain avenues in the cavern, in the upper of the five levels only, and not in any levels now occupied by streams. These crystals are sometimes curiously and remarkably contorted, and the terminations of the crystal masses are often recurved in a direction contrary to the direction of gravitation. Occasionally the gypsum assumes a botryoidal form, but is commonly found as needles or aggregated in loose masses of fibrous crystals. The gypsum crystals occur only along cracks, and are built up by increase from the base, while the calcium-carbonate stalactites are always built up by additions to their surface or terminations. It is difficult to account for the large amount of sulphur needed by assuming its origin in organic bodies, such as plants and the forests which are of abundant growth in the region, and have been abundant for geological ages. The origin of the carbon dioxide necessary for the great work of solution which has been accomplished is likewise found in the decaying vegetation. The origin of the sulphuric acid required to produce these enormous quantities of gypsum crystals, which have fallen so abundantly as to fill up certain avenues, is still problematic. Only one other mineral is found— flocculent crystals of magnesium sulphate, pendant from the ceiling of two or three small rooms. There are no calcite or quartz crystals.

The paper was illustrated by lantern slides, showing the peculiarities of the stalactite and gypsum formations.

Professor **Kemp** in discussion, suggested that the small percentage of sulphur present in the limestones themselves might, after solution of the latter, aggregate sufficient sulphur to afford gypsum along the crevices. Dr. **Julien** and Professor **Stevenson** each cited cases in the Caribbean and Bermuda Islands where the amount of vegetation now or formerly growing on the surface was insufficient to accomplish the solution required for the great caves which exist in the coral limestones, both of Tertiary and recent growth in the islands.

Dr. **Hovey's** paper was read by Professor Kemp, owing to the former's unavoidable absence. After a brief resumé of the geology of the Black Hills District, a series of views was shown illustrative of the extraordinary erosion forms of the schists and pegmatites of the Harney Peak District. His views also showed the tin mines of the Black Hills, in which spodumene crystals of large size have recently been obtained as a valuable source of Lithium, as a commercial product. One spodumene crystal here obtained was thirty feet long. The granite veins have also been described by Van Hise.

Discussion followed concerning the occurrence of extraordinarily large crystals of other minerals.

The biographical notice of Professor Oliver P. Hubbard, prepared by Dr. Hovey, was read by the Secretary, and will be published with an accompanying list of Dr. Hubbard's publications, in the *American Geologist.*

Professor **Stevenson,** in behalf of the committee appointed to prepare a minute respecting the late Professor Hubbard, offered the following :

" **Oliver Payson Hubbard** was born in Pomfret, Conn., March 31, 1809, and died in New York, March 9, 1900. After graduating at Yale College in 1828, he remained in that institution as assistant to Professor Silliman until he began his study of medicine, which he completed in 1837, when he received the degree of M.D. from the South Carolina Medical College at Charleston.

" Prior to his graduation in medicine, he was made Professor of Chemistry, Pharmacy, Geology, and Mineralogy in Dartmouth College. In 1871, the Chair was restricted to Chemistry and Pharmacy, and no longer required his full time, so that he was able soon afterwards to make New York his home during much of the year. In 1883, he felt that he has already passed the age when one should retire from a professorship, and resigned his position, becoming professor emeritus. Thereafter he remained in New York.

" His youthful love of science led him to Yale that he might study under Professor Silliman, then the prominent teacher of science in our country. His first publication, entitled 'Geological and Mineralogical Notices,' having reference to localities in Northern New York, appeared in the *American Journal of Science* in 1837, and was followed in 1838 by a somewhat more elaborate article upon the White Mountains. He attended the 1841 meeting of the Association of American Geologists and Naturalists and read a paper of capital importance upon the slates of Waterville, Maine, in which he discussed the markings upon the slates, and indicated their organic origin, which he regarded as proving their great age. He was present also at the third meeting, and took a prominent part in the discussion of the 'drift,' so that he was appointed member of the committee to prepare a report upon that subject for the next meeting. He was elected Secretary of the Association for 1833, and, with Benjamin Silliman, Jr., served in the same office for 1844. His duties at Dartmouth were exacting, so that for many years he published few extended papers ; but he made many brief communications to societies, all of which were characterized by keen discrimination, and many of them were important contributions.

" Dr. Hubbard joined this Academy in 1874, and at once became so active that when Mr. Browne, who had been Recording Secretary from 1839, resigned in 1875, Professor Hubbard was chosen as his successor. He retained this office until 1885, when he became Vice-President. At the death of Dr. Newberry in 1892, he was made President ; but he served for only one term, declining reëlection because of his advanced years. From 1874 until 1893 he rarely failed to attend the meetings, when in the city, and he always presented something of interest bearing upon matters under consideration. His manner was courteous to the last degree, and he understood well how to discuss without disputing.

" Professor Hubbard's individuality was very decided ; though so gentle and considerate in his manner, he always held positive opinions, and, when necessary, did not hesitate to express them. His shrewd common sense made him a good counsel, and his advice was sought in many directions. He was a member of the New Hampshire legislature in 1863–4 ; but one year's experience in that kind of work sufficed, and he declined to be a candidate for reëlection. His quiet humor and his store of reminiscences made him a delightful companion. He retained his mental vigor to the last, and only two months ago he published an article correcting errors in a recently published work. When ninety years old, he attended the New York meeting of The Geological Society of America, and remained throughout an afternoon listening to severely abstract papers, with as much interest apparently, as though he were just beginning his work.

" Professor Hubbard was almost the last link binding our time with that of the early geologists. Hall and Dana died within the last half decade, and there remain only Boye and Lesley of those who attended the earlier meetings of the Association of American Geologists. He passed away in a ripe old age, his life full of good works, and his name absolutely unstained. This Academy owes him much, and here his name should be cherished.

"(Signed),

"J. J. Stevenson,

"Alexis A. Julien."

Theodore G. White,

Secretary.

SECTION OF ANTHROPOLOGY AND PYSCHOLOGY.

April 23, 1900.

Section met at 8:15 P. M., Prof. J. McK. Cattell presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Dr. **Livingston Farrand,** Recent Researches in Central Australia.

Dr. **Franz Boas,** The Eskimo of Cumberland Sound.

Summary of Papers.

Dr. **Farrand's** paper called attention to certain points of particular significance in Messrs. Spencer and Gillen's book, "The Native Tribes of Central Australia," which appeared last year. Special emphasis was laid on the suggested origin of the religious side of totemism as indicated in the "Intichiuma" ceremonies of the Arunta tribe, which are directed apparently solely towards the end of increasing the supply of the totem animals and plants of the district, each totem group being charged with the treatment of its own totem object and its multiplication for the benefit of the other members of the tribe. The well-known prohibition against killing and eating the totem seems to hold in this region, but tradition and ceremony point to a time when this was not the case. This economic explanation of the custom is he first satisfactory one yet offered and is plausible for the tribes under discussion even though it may not hold for other parts of the world. The social aspect of totemism with its marriage regulations still remains a problem.

The material on which Professor **Boas'** paper was based was collected by Captain James Mutch. A full version was given of the myth of the creation of land and sea animals, and a description of the beliefs of the people in regard to souls and in regard to a series of heaven and underground worlds which are the abodes of the deceased. A number of taboos were described, and their explanation as given by the Eskimos was stated. They believe that the transgression of a taboo prescribed after the death of an animal causes the transgression to become fastened to the soul of the animal, which goes down to the mistress of the lower world, where the transgressions make the hands of the deity sore. This enrages her, and she causes famine and misfortunes of all kinds.

CHARLES H. JUDD,
Secretary.

PUBLIC LECTURE.

APRIL 30, 1900.

Under auspices of Section of Astronomy, Physics and Chemistry.

Professor **William Hallock,** THE NATURE OF THE ATOM AS INDICATED BY RECENT SPECTRUM ANALYSIS.

This is the age of effects. Formerly people were discovering laws. The Zeeman effect is the one which has given most information recently on the subject of the nature of the atom. Chemical investigations brought us to the atomic theory. The complex nature of the atoms was shown by the spectrum analysis of Bunsen and Kirchhoff. They showed that in its number of modes of vibration, the atom was more complicated than a musical instrument. Faraday discovered the rotation of the plane of polarization of light by the magnetic field. He tried and failed to get any effect of the magnetic field on the source of light itself, the vibrating atom. Zeeman finally succeeded a few years ago in obtaining this effect called after his name. It shows itself as a splitting up of the lines of the spectrum into double, triple and more complex lines, when the source of light is placed in a strong magnetic field. The Zeeman effect, together with J. J. Thomson's experiments and speculations, give us the idea of the atom being composed, in part at least, of corpuscles, one of which, being detached, forms the negative ion of the cathode rays and other phenomena, while the part left behind, having a much greater mass, forms the positive ion. In these corpuscles we may have the primeval material from which all other matter is composed.

The lecturer showed a number of lantern slides of photographs of the Zeeman effect and of the various kinds of apparatus by which it is investigated.

WM. S. DAY,
Secretary.

BUSINESS MEETING.

MAY 7, 1900.

Academy met at 8:15 P. M., Professor William Hallock presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows:

The appointment of Dr. Theodore G. White as Acting Editor.

The establishment of a series of rules for publication.

The vote of the Council to secure photographs of past presidents of the Academy, to be hung in the Library.

The vote of the Council to extend their thanks to Professor Kemp for his valuable services as Chairman of the Exhibition.

The vote of the Council to send the thanks of the Academy to President Morris K. Jesup for his courtesy and kindness in allowing us to use the Museum for the Annual Exhibition, and through President Jesup to the employees of the Museum, for their cordial assistance and good will.

The Secretary also announced that Professor Henry F. Osborn had been made a Life Member of the Academy.

The following candidates for resident membership, approved by the Council, were duly elected:

W. J. Gies, Ph.D., 437 West 59th Street.

Charles Henry Davis, 99 Cedar Street.

RICHARD E. DODGE,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

MAY 7, 1900.

Section met at 8:30 P. M., Prof. Wm. Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered.

Bergen Davis, THE BERNOUILLI EFFECT IN STATIONARY SOUND WAVES.

R. W. Wood, COLOR PHOTOGRAPHS AND SOUND WAVE PHOTOGRAPHS, EXHIBITED BY PROFESSOR HALLOCK.

SUMMARY OF PAPERS.

The experiments described by Mr. **Davis** were in three groups, those with a sound wave anemometer, those with the use of empty gelatine medicine capsules instead of cork dust to show the Kundt figures, and those concerning the longitudinal motion of a cylinder closed at one end, across the stream lines in a stationary sound wave.

The stationary sound wave was that produced by a stopped organ pipe, provided with a glass panel for observation, when it was sounding its first overtone. A thin rubber diaphragm near the central node prevented air currents due to the blowing of the pipe. The cups of the miniature anemometer were made by dividing No. 2 gelatine capsules longitudinally so as to form half cylinders and mounting them on card-board arms, the anemometer rotated with ten revolutions per second in. the loop of the wave and came nearly to rest in the node. The rate of revolution at various positions along the wave varied approximately according to a sine curve. The maximum amplitude of the wave as calculated from the above rate was 0.57 cm.

The Kundt's figure experiment was performed by emptying a box of No. 5 gelatine capsules into the middle of the loop. They arranged themselves in rows across the pipe. Each capsule attracted its neighbor at the ends and repelled it at the sides. The experiment is quite striking.

The motion of a cylinder perpendicularly to the stream lines was obtained by using a capsule from which the cap had been removed. Such a capsule moved in the direction of the closed end with considerable force. This was also shown by making a small mill with a capsule at the end of each of four card-board arms. The rates of revolution in various parts of the wave made, when plotted, nearly a sine curve. The force acting normally to the closed ends of the cylinders was measured with a torsion balance. The square roots of the torsion deflection gave when plotted an approximate sine curve. The experiment was performed in air, illuminating gas, carbon dioxide, and hydrogen. The torsion deflections were directly proportioned to the densities of the gases. Prof. William Hallock first suggested the cause of this effect, showing that it was due to the principle of Bernouilli, that a gas in action is less dense than the same gas at rest. The vibrating air has considerable velocity while the air within the cylinders is nearly at rest. The force is due to the difference of density on the two sides of the closed end of the cylinder. The author used this principle to determine the amplitude of vibration. Prof. R. S. Woodward assisted him in applying the proper hydrodynamical principles, and he calculated that the change in density was such as to give a pressure of 21 dynes per square centimeter, while the amplitude was 0.33 cm. This agrees closely with the value obtained with the sound wave anemometer.

Professor **Hallock** exhibited some color photographs and some sound wave photographs taken by Prof. R. W. Wood, of the University of Wisconsin.

Wm. S. Day,
Secretary.

SECTION OF BIOLOGY.

May 14, 1900.

Section met at 8:20 P. M., Professor F. S. Lee presiding.

The minutes of the last meeting of the Section were read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-Laws.

The following program was then offered:

J. E. Kirkwood and **W. J. Gies,** Some Chemical Notes on the Composition of the Cocoanut.

Frederic S. Lee and **C. C. Harrold,** The Significance of Carbohydrates in Muscle.

Summary of Papers.

The authors of the first paper have carried on qualitative work on the ungerminated nut, preparatory to a study of the digestive processes during germination. The chief constituents are cellulose and fat. Some soluble carbohydrate is present, besides globulin and proteose, but no albumin or pepton. Only amylolytic ferments have so far been found. The milk of the nut is normally acid, probably due to acid phosphate. It contains an earthy phosphate, reduces Fehling's solution, sours on standing, and acquires much the odor and physical appearance of soured cow's milk. It shows only small quantities of proteid and fat.

The meat of the average nut contains from two to three grains of globulin, which may be obtained in crystalline form. The authors have made three preparations by the usual methods. The nitrogen averages for these were 17.91 %, 17.81 %, 17.68 %. The ash for the same, 0.13 %, 0.41 %, 1.05 %.

From the meat of twelve nuts it was possible to separate a little more than three grains of proteose by the usual method. The average of three closely agreeing determinations of nitrogen was 18.57%; of the ash it was 1.71%.

The quantitative relationships of these and other constituents will be subjects of combined investigation.

Dr. **Curtis** drew attention to the irritation of the mucous membrane of the bladder and urethra caused by drinking too freely of cocoanut milk. Dr. **Gies** in answer to a question stated that the food content of the cocoanut is small.

The second paper was a continuation of the senior author's study of the nature and causes of muscle fatigue. Of the two supposed causes of fatigue, loss of substance necessary to contraction and poisoning by so-called fatigue products, the present work deals with the former. It is well known that the drug phlorhizin causes the removal of the carbohydrates from an organism to which it is administered. The authors find that it induces decided evidences of fatigue in the muscles of fasting cats. A well phlorhizinized muscle is comparable to a normal muscle in the late stages of fatigue. This effect seems to be due not to a specific action of the drug on the protoplasm of the muscle cells, but to the loss of carbohydrate from the muscle. This conclusion is rendered probable by the fact that when an animal has been put well under the influence of phlorhizin, the administration of sugar (dextrose) counteracts the effect of the drug, removes the evidences of fatigue and restores the muscle. It seems probable that the loss of carbohydrate is an important factor in the early stages of muscle fatigue.

Incidentally some observations on rigor mortis have been made. A muscle well under the influence of phlorhizin may begin to go into rigor five minutes after death and rigor is complete very early. This confirms the conclusions of others that there is a close connection between rigor and carbohydrate. A muscle irrigated with dextrose is capable of giving fully as many contractions as, or even more than a normal muscle without dextrose.

The election of sectional officers resulted in the election of

Prof. C. L. Bristol, of New York University, as Chairman, and Prof. F. E. Lloyd, of Teachers College, as Secretary for the ensuing year.

FRANCIS E. LLOYD,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

MAY 21, 1900.

Section met at 8:15 P. M., Dr. Alexis A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The following program was offered:

George I. Finlay, A NEW OCCURRENCE OF NEPHALINE-SYENITE AND ASSOCIATED DIKES IN THE STATE OF TAMAULIPAS, MEXICO, WITH A REVIEW OF THE DISTRIBUTION OF THESE ROCKS IN NORTH AMERICA.

Benjamin F. Hill, A CONTRIBUTION TO THE GEOLOGY OF A PART OF SONORA, MEXICO.

SUMMARY OF PAPERS.

The rocks described by Mr. **Finlay** were sent by Mr. E. D. Self to Professor Kemp of Columbia University. The nephaline-syenite is a very light colored rock, containing, besides abundant nephaline and anorthoclase, small patches of the dark colored silicates. Under the microscope these are seen to be ægerine-augite intergrown with hornblende, and accompanied by magnetite and apatite. Titanite is abundant, with the faces (1–2–3) well developed and some zircon occurs. The tinguaite associated with this syenite is a holocrystalline porphyritic dike rock with large phenocrysts of orthoclase, twinned on the Carlsbad law, tabular in habit, parallel to the clinopinicoid. The ground mass, which gives the rock an even, dark green color, consists of a felt of tiny blades of ægerine and orthoclase. The ægerines are at times grouped together in bundles around small patches of biotite.

Mr. Finlay then briefly discussed the distribution of similar rocks in the various portions of the United States, and exhibited a very instructive series of comparative charts of the chemical composition of the rocks examined and those of allied groups, the charts being constructed on the principles of the graphic method devised by Professor Hobbs, as worked out by Mr. Finlay.

The second paper, that of Mr. **Hill**, also treated of Mexican rocks, and the same geographical maps were employed to illustrate both papers. Little has been written about the coal bearing rocks and their associated eruptives in the State of Sonora, Mexico. The work done by Professor Dumble and his associates has thrown considerable light on some of the problems.

In the district investigated are representatives of nearly all the formations from the Archæan granites to the Quarternary sands and gravels. The most important division, however, is the Triassic. The slates, sandstones, quartzites, etc., with coal seams, make up the lower or Bananca division of the Triassic, while an immense series of associated eruptives, including andesites, dacites, tuffs, andesitic conglomerates, etc., is considered the upper division. To the series of eruptives the name of Lista Blanca has been given. The Lista Blanca has hitherto been considered post-Cretaceous.

In addition to the pre-Cretaceous eruptives, there are numerous intrusives and flows of diorites, rhyolite and basalt, and in one instance, trachite. It is probable that these are mostly of Tertiary age. The diorites exert a very noticeable effect on the formation of the ore bodies of the region.

Specimens of all the eruptives were brought to New York and studied by Mr. Hill in thin section under the microscope. A series of chemical analyses of the type rocks was made and a very clear relation established between the magmas of the different flows. The remainder of the paper dealt with details of the petrographic characteristics of the rocks.

Both papers were discussed by Professor Stevenson, Professor Kemp, Dr. Julien, and Dr. White.

Theodore G. White,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

May 28, 1900.

Section met at 8:30 P. M., Prof. J. McK. Cattell presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered:

Dr. **G. B. Germann,** The Acquirement of Motor Habits.

Dr. **C. H. Judd,** Studies in Vocal Expression.

Summary of Papers.

The first paper reported some experiments in which the author measured the degree of perfection attained in rapid naming of one hundred color squares arranged in regular order, by the time required to read the whole series. Results were presented for the rapidity of reading at different stages of practice and after different intervals of discontinuance of practice.

The second paper reported changes in pitch during the articulation of single words. The pitch was determined by means of enlarged records of diaphragm vibrations which were compared with the tracings made by a standard tuning fork. Twenty records were reported. In general the accented syllable was higher in pitch than the unaccented syllables, though this was not true in such words as abhorrent and abnormal. The final syllable in the twenty records showed a very general tendency to fall off in pitch. The amount of change in such words as educing and illusion will appear from some cases of the former. The three syllables were as follows, case I, 161, 244, 171 (end of the syllable being at 131); case II, 157, 265, 185 (end of syllable 125); case III, 172, 248, 166 (end of syllable 123). Other records did not show such marked changes. One of the word abasement is as follows: 103, 130, 140.

Chas. H. Judd,
Secretary.

BUSINESS MEETING.

October 1, 1900.

Academy met at 8:15 P. M., President Woodward presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows :

The resignation of Mr. Gilbert van Ingen as Editor, and the extension on the part of the Council of a cordial vote of thanks to Mr. van Ingen for his successful services as Editor.

The adoption of a time limit for all papers presented before the Academy, said time limit to be printed on the announcements in each case.

The following Candidate for resident membership, approved by the Council, was duly elected :

Richard H. Cunningham, M.D., 200 West 56th Street.

Richard E. Dodge,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS, AND CHEMISTRY.

October 1, 1900.

Section met at 8:35 P. M., Prof. Wm. Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was then offered :

E. R. von Nardroff, On the Application of Fizeau's Method to the Determination of the Velocity of Sound. (Illustrated.)

J. K. Rees, Scientific Instruments at the Paris Exposition. (Informal report.)

W. Hallock, A Peculiar Lightning Discharge.

Summary of Papers.

Professor **von Nardroff** used as a source of sound a very shrill whistle giving sound of a short wave length beyond the limits of hearing. He overcame the effect of irregular disturbing reflected and diffracted waves by using sound of considerable intensity and a flame only slightly sensitive. The sound after passing between the teeth of a rapidly revolving wheel, fell on a concave spherical mirror made of wood some distance away, and was reflected back through the teeth at the opposite end of a diameter of the wheel, and came to a focus on a sensitive flame just behind the wheel. The author gave a neat demonstration of the working of the apparatus and showed with great ease how with increasing speed of the revolving wheel the flame was alternately shielded from and exposed to the sound. The slightest disturbance of the adjustment of the mirror threw the flame away from the mirror in a marked manner. He stated that the method could probably not be used to compete with other accurate methods heretofore employed, but it supplied a beautiful illustration of Fizeau's method of measuring the velocity of light.

Prof. **J. K. Rees** gave an interesting account of some of the scientific instruments at the Paris Exposition. The great telescope was not finished, although this fact was not yet generally known, and it was impossible to tell yet whether it was to be a success or not. The German exhibit was superb. The Germans had a method, which ought to have been generally adopted, of arranging the instruments with one kind by the different makers in one case, instead of a complete line by each maker in a case by itself. An ingenious modification of Foucault's pendulum was seen at the Paris observatory. It was only one meter long, but it showed the fact of the rotation of the earth after the lapse of fifteen seconds.

Professor **Hallock** described a peculiar lightning discharge he had observed at Lake Champlain. The flash came unexpectedly from a cloud about two miles from where the main shower was falling. It struck on a mass of rock, and on examining this it was found that instead of there being one or a few places where the lightning had struck, it was covered with innumerable little spots, each one indicating where a part of the flash had struck.

WM. S. DAY,
Secretary.

SECTION OF BIOLOGY.

October 8, 1900.

Section met at 8:15 P. M., Prof. C. L. Bristol presiding.

The minutes of the last meeting of Section were read and approved.

The evening was devoted to Reports of Summer Work by Members of Section.

Summary of Papers.

Prof. **E. B. Wilson** reported that he spent the summer at Beaufort, N. C., where he prosecuted experimental researches upon the eggs of Toxopneustes. Loco's experiments upon the eggs of arbacia were confirmed, and further facts of great interest were determined. Later in the season Professor Wilson visited Woods Holl, Mass., Mt. Desert, Me., and the Bay of Fundy. He drew attention to the very great difference between the Beaufort and Bay of Fundy faunas. The transparent pelagic annelid was collected in the latter locality.

Dr. **D. T. MacDougal** spent the summer in studying the flora of Priest Lake, which stands at an elevation of 3,000 feet in northern Idaho. He was especially concerned in studying the effect of air temperatures on the distribution of plants.

Prof. **H. F. Osborn** visited the British Museum and the Museum of Comparative Anatomy in the Jardin des Plantes, Paris. The latter has, under the hand of Dr. Filhol, reached a high degree of effectiveness. At the British Museum Professor Osborn examined the remains of the new Patagonian sloth Neomylodon, a form said by Ameghino to be still extant, though by some claimed to be extinct.

Mr. **F. B. Sumner** gave an account of experiments carried on at the Marine Laboratory at Naples. The work of Mr. Sumner was directed towards determining the validity of his confluence theory of the origin of the embryo in fishes. The results are regarded as confirmatory.

The work in the Bermuda Islands carried on in previous summers by the expeditions from the New York University under the direction of Professor Bristol was continued this summer. Mr. **F. C. Waite** was this year a member of the party, and reported the finding of much valuable and interesting material not heretofore collected.

Dr. **M. A. Howe** also worked in the Bermudas during the first half of the summer, going later to Edgartown, Marthas Vineyard, and to Sequin Island, Maine. He was especially concerned with the collection of marine algæ. Dr. Howe reported the collection of a large number of algæ, and described the general floral features of the islands.

Dr. **H. E. Crampton** stated that the summer session at Woods Holl had been a successful one.

Mr. **M. A. Bigelow,** while at Woods Holl, confirmed his results on *Lepas* and added a number of new observations. He, with Dr. Crampton, carried on a study of the ponds along the southern shore of Marthas Vineyard, with a view to studying the variation in their fauna.

Prof. **F. E. Lloyd** spent six weeks in company with Prof. S. M. Tracy in a preliminary study of the flora of the Mississippi sound, islands, and delta. A full series of plants was collected. Professor Lloyd described the leading features of the vegetation of that region.

Francis E. Lloyd,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

October 15, 1900.

Section met at 8:15 P. M., Dr. A. A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The names of two candidates for resident membership were read and referred to the Council according to the By-Laws.

The following program was then offered:

Gilbert van Ingen, Paleozoic Faunas of Northwestern New Jersey.

Theodore G. White, The Glens Falls, N. Y. Section of the Lower Ordovician.

Henry S. Washington, The Rocks of Lake Winnepesaukee, N. H.

Daniel S. Martin, Minerals Found at Haddam, Maine.

Alexis A. Julien, The Geology of Central Cape Cod.

Richard E. Dodge, Physiography of the Region of the Colorado Cañon.

Also notes by **J. J. Stevenson** and **E. O. Hovey**.

Summary of Papers.

Mr. **van Ingen** described the work of the party belonging to the Geological Survey of New Jersey, which, during the past two summers has been engaged in tracing the outcrops of the Paleozoic formations, and collecting fossils. Of this party, Mr. Kümmel, the assistant State geologist, traces the boundaries and works out the tectonics, while Dr. Weller, of the University of Chicago, collects fossils at localities indicated by Mr. Kümmel. During July, Mr. van Ingen spent a week with this party in the field at Newton. Newton is situated on the shales of the Trenton Group, there extensively quarried for slates. To the east is a low ridge of limestone which presents the same appearance as the Barnegat limestone along the Hudson river.

The upper part of this limestone has yielded trilobites, probably *Dikellocephalus,* indicating that this portion is of upper Cambrian age. At other localities a trilobite described by Weller as *Liostracus Jerseyensis,* shows that the rock there is also Cambrian, probably of the middle or upper division. In the vicinity of Franklin Furnace good specimens of *Olenellus cf. thompsoni* were found at localities described by Foerste. Further to the east of Newton, on the other side of the Cambrian ridge, is a wide belt of Ordovician rocks, Trenton limestone overlaid by a thick series of shales. The limestone contains the typical Trenton fauna, *Rafinesquina, Plectambonites, Pterygometopus,* etc., and is very like that found at Rosetown, Ulster county, and at Rochdale, Dutchess county, N. Y. The shale has few fossiliferous beds, but occasionally one of the more sandy layers contains *Dal-*

manella testudinaria, *Plectambonites* and *Rafinesquina*, the same combination found in the Hudson shales at Poughkeepsie and at Rondout. At one locality was found a fauna with *Ampyx* and *Harpes*. In eastern New York these genera of trilobites are found only in the Chazy limestone, and the discovery is of great interest in that it indicates the presence of this formation at a distance of almost 250 miles south of what has hitherto been recognized as its southern limit. Further to the northwest, along the Delaware river, were found the Silurian and lower Devonian formations. The finest section is seen in the face of the cliff of the old Nearpass quarry, about five miles south of Tri-States, where all the formations from the upper Ordovician to the Esopus shale of the lower Devonian appear, with numerous fossils. At Otisville the Shawangunk grit is finely exposed in a large quarry. All the evidence at hand points to the conclusion that this formation, of a thickness of at least a thousand feet, was formed as a flood plain deposit. Its characteristics, except color, are the same as the New Jersey and Connecticut valley Triassic sandstones. Ripple-marks, sun-cracks, cross-bedding, channel-fillings, etc., are abundant. In the railroad cut west of Otisville the grit lies upon the Hudson shales, with coincident dip. On the contact there occurs a few inches of clay, which next the shale is quite free of pebbles, while next the grit it is filled with quartz pebbles. This was interpreted to be residual clay caused by the decomposition of the shale, through subaërial agencies, before it became covered by the grit. The old notions regarding rock-formation required the presence of a body of water in which the sediments might be deposited. Several of the geological subdivisions showed characters which would not have been present had these formations been laid down under water, for this mode of origin results in a sorting of the rock-forming materials, and no sorting is detected in these grits. Flood plain deposits are very irregular, both as to stratification and sorting of materials, and these features are well exhibited in the grits. Other formations that are probably flood-plain deposits are parts of the Potsdam sandstone in eastern New York, the Medina sandstone, the sandstones of the Catskill group, and many of the sandstones of the coal measures of Pennsylvania and the Mississippi valley, in fact the greater part of the "barren Measures."

Dr. **White** described his recent detailed study of the faunas of sucessive strata at Glens Falls, and their relations to similar studies along the lake Champlain valley to the north, and the Mohawk and Black River valleys to the west. The section forms a low anticline along the shore of the Hudson. At the base is seen the Calciferous sandrock, containing *Ophileta* and fucoids. Conformable upon this is a layer a few inches thick, of barren black shale, which is very much crushed, and then the same beds of the *ostracod-Liperditia*, and their associated corals and peculiar forms of *Strophomena*, as have been found in the lowest Black River zones on Button Island in Lake Champlain. The zones of *Parastrophia* and *Triplesia* occurring near this portion of the series in localities to the north and west, were not found here. The succeeding coral beds of *Columnaria* were well developed. Above these are the cross bedded gray beds, which in some recent reports have been considered to represent the Birdseye limestone, which seems to be lacking in this locality, unless met with at this unexpectedly high position. The upper portion of the section, which is of lower Trenton age, shows no unusual forms. The tendency of the lowest and uppermost portions of the Ordovician sections in the region to wear away and appear wanting, owing to their prevailing softness, was commented on.

The remarks of Dr. **Washington** were in the nature of a preliminary report on work done by Professor Pirsson and himself on Mount Belknap and Red Hill, near Lake Winnepesaukee, N. H. The rocks of Mount Belknap are shown to be prominently a quite uniform alkali syenite, which is cut by many dikes of camptonite and allied rocks, and of bostonites, aptites, and syenite porphyries. These dikes also cut the surrounding porphyritic gneiss. At one place, near the border, is a mass of basic hornblende-gabbro, with large, poikilitic phenochrysts of brown hornblende. A syenite breccia also occurs. At Red Hill similar syenite, formerly described by W. S. Bayley, occurs on the summit, while toward the periphery, nepheline appears as a constituent, and a true foyaite is developed. The mass is also cut by dikes, both camptonitic and syenitic. The region is to form the subject of a petrographic study by the two geologists in the near future.

Professor **Martin** described a visit which he paid during the summer to the noted mineral locality at Haddam, Maine, and the manner in which the choicest specimens occur there, in veins of albitic pegmatite, with tourmaline, muscovite, and quartz along the contact with the wall of gneiss. The mica plates along the contact are often two feet in diameter.

Dr. **Julien** briefly reviewed the observations and opinions of Mitchell, Davis, Shaler, and others on the geology of Cape Ann, with especial reference to the district from Chatham to Yarmouth. In the stratified deposits of sands and gravels which underlie the plain south of the morainal "backbone" of the cape, the more frequent intercallation of clays was pointed out, and their occasional disturbance and flexure. Striated pebbles, although much water worn, are quite largely interspersed. The discovery of true glacial silt at some depth, in one locality, indicates that the ice sheet rested there, instead of floating. The kettle-shaped hollows and pond basins were shown by the speaker to be largely connected with the damming of surface streams, and some observations on the pre-glacial drainage valleys and topography were discussed. The identification of certain transported fragments of quartz-porphyry with outcrops of the same near Marblehead indicate a pre-glacial movement from N.N.W. to S.S.E. To the fifteen changes of level which have been recorded, a final small elevation probably should be added, judging from the low terrace along this part of the coast. Examples of the faceted pebbles were exhibited and provoked considerable discussion among those present, as to the origin of such pebbles.

Professor **Dodge** recounted his pleasure in visiting the region of the Grand Cañon, in company with a party during the past summer, and in finding the physiography so graphically illustrated in the drawings in Powell's reports to be a most faithful and non-diagrammatic portrayal of the features themselves. He then described the striking examples of gigantic geo-physical results seen in the Great Kaibab monocline. He also described the appearance of the great basin of "Lake Bonneville."

Remarks on foreign localities visited by them during the last summer were made by Professor **Stevenson** and Dr. **Hovey.**

THEODORE G. WHITE,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

OCTOBER 22, 1900.

Section met at 8:15 P. M., Prof. J. McK. Cattell presiding.

The evening was devoted to reports of summer work by Dr. **Franz Boas**, Dr. **Livingston Farrand**, Dr. **A. Hrdlicka**, Dr. **F. W. Putnam** and Prof. **R. E. Dodge.**

SUMMARY OF PAPERS.

The papers gave accounts of anthropological investigations made during the summer in the Vancouver Islands, Oregon, New Mexico, Arizona and California.

CHARLES H. JUDD,
Secretary.

BUSINESS MEETING.

NOVEMBER 5, 1900.

Academy met at 8:15 P. M., Professor Hallock presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows:

The appointment by the Council of Prof. Charles Lane Poor as Editor of the Academy publications, in place of Mr. van Ingen, resigned.

That the Council had voted to formulate a budget for the ensuing fiscal year, and to recommend to the succeeding Council that there be no annual reception in 1901.

The following candidates for resident membership, approved by the Council, were duly elected: Prof. Charles Lane Poor, 4 East 48th street; Riccardo Bertelli, 409–415 Forsyth street.

RICHARD E. DODGE,
Recording Secretary.

SECTION OF ASTRONOMY, PHYSICS AND CHEMISTRY.

NOVEMBER 5, 1900.

Section met at 8:30 P. M., Prof. Wm. Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was offered:

F. L. Tufts, FLOW OF AIR AT DIFFERENT PRESSURES THROUGH GRANULAR MATERIALS.

SUMMARY OF PAPER.

The experiments described by Mr. **Tufts** were made in connection with others on the transmission of sound through the same materials. Three different materials were experimented on, composed of lead shot of three sizes, the diameters of the shot being respectively 4.37 mm., 2.79 mm., and 1.22 mm. The shot was placed in a tube and air was forced through at different pressures, the rate of flow of air being measured by a gas meter, and the pressure differences by a water manometer. It was found that for a given size of shot and a given pressure gradient, the rate of flow was independent of the length of the column of shot through which the air flowed. The rate of flow, however, in the three cases experimented with did not increase as rapidly as the pressure gradient. This was more noticeable with the coarse shot than with the finer. For pressure gradients of about 0.01 cm. water pressure per centimeter of length of material, the rate of flow through the coarsest shot was ten times the rate through the finest, while for a pressure gradient fifty times as great, the rate of flow was a little less than three times as great in the coarsest as in the finest. With each size of shot the space occupied by air was about 39 per cent. of the total space occupied by the shot.

WM. S. DAY,
Secretary.

SECTION OF BIOLOGY.

NOVEMBER 12, 1900.

Section met at 8:15 P. M., Prof. C. L. Bristol presiding.

The minutes of the last meeting of Section were read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-Laws.

The following program was then offered :

F. C. Waite, THE BERMUDA TOAD.

H. F. Osborn, THE PHYLOGENY OF THE RHINOCEROSES IN EUROPE.

H. L. Clark, FURTHER NOTES ON BERMUDA ECHINODERMS.

SUMMARY OF PAPERS.

Bufo agua was introduced into the Bermudas from British Guiana about 1885, and is now common throughout the colony. This is the largest Anuran known, specimens 155 mm. in length having been taken in Bermuda. It breeds there in brackish marshes ; elsewhere in fresh-water pools. The spawning time in Bermuda is not known, but young were found in July.

Bermuda is the northern limit of its range, which includes many of the Lesser Antilles (introduced), southern Mexico, Central America, and South America south to Ecuador on the west coast, and to Argentina (38° S.) on the east coast.

There is a general belief that it is venomous. The secretion of its cutaneous glands causes ulceration of mucous membrane, and opaqueness of the cornea. Subcutaneous injections cause convulsions, followed by death in frog, fowls and dog.

During the discussion which followed, the facts were brought out that this toad is a clumsy animal, jumps high rather than far, and is very active at night. It is destructive to insects, and is a pest in Bermuda, where it attacks cats and dogs fatally.

Professor **Osborn** reported a continuation of his investigations upon the PHYLOGENY OF THE RHINOCEROSES OF EUROPE. These animals appear to fall under the law of early divergence, and to constitute at least six separate series or phyla which, so far as known at present, are not genetically related to each other, but undergo a more or less parallel development as follows: *Diceratheriinæ*, *Aceratheriinæ*, *Brachypodinæ*, *Ceratorhinæ*, *Atelodinæ*, *Rhinocerotinæ*. The chief criteria in distinguishing rhinoceroses are the proportions of the skull, whether dolichocephalic or brachycephalic, the proportions of the limb in reference to cursorial or aquatic habits and the position of the horns; subsidiary to these features are the types of tooth structure. The origin of the rhinoceroses is still obscure, although it appears to be possible to derive the *Diceratheriinæ* from certain Eocene Hyracodontidæ. This study will be published in full in the *Bulletin of the American Museum of Natural History*, and it constitutes a part of the continuation of the author's memoir on the extinct rhinoceroses.

Mr. H. L. **Clark's** paper was read by Professor C. L. Bristol. In this paper Mr. Clark gave an account of the Echinoderms collected by the party of zoölogists from the New York University in the summer of 1899, together with a summary of his own observations during April of that year. It is to be concluded from an abundance of observations that the distinctions hitherto thought to exist between *Stichopus diaboli* and *Acanthomela* are not to be regarded as valid, and the forms described under these names must be referred to *S. Mobii*. Twenty-nine species are listed.

Mr. **Waite** called attention to the fact that the madreporic body in *Asterias tenuispina* branches forming 1–4 bodies in each animal, thereby making orientation difficult.

FRANCIS E. LLOYD,
Secretary.

SECTION OF GEOLOGY AND MINERALOGY.

NOVEMBER 19, 1900.

Section met at 8:15 P. M., Dr. A. A. Julien presiding.

The following program was offered:

J. F. Kemp, RECENT PROGRESS IN INVESTIGATION OF THE GEOLOGY OF THE ADIRONDACK REGION. Illustrated with specimens and diagrams.

A. A. Julien, NOTES ON THE ORIGIN OF THE PEGMATITES FROM MANHATTAN ISLAND AND FROM NORTH CAROLINA. Illustrated with specimens and diagrams.

SUMMARY OF PAPERS.

Professor **Kemp** outlined the area of crystalline rocks in the northern part of New York State and illustrated its distribution by means of maps. Three principal classes of rocks are present. First, those certainly igneous in their nature, including the labradorite rocks, the basic gabbros and the trap dikes. Second, those certainly sedimentary, best illustrated by the crystalline limestones. Third, great areas of gneiss of uncertain origin. Regarding the first class, we now know quite accurately their distribution and the results obtained by the speaker, by H. P. Cushing and C. H. Smyth were briefly reviewed. A short description was given of the augite-syenite first discovered by Cushing near Loon Lake, but which has since been found to be widely distributed in the regions further south. Some notes were also given regarding the ages of the trap dikes and their distribution.

Recent additions to the knowledge of the sedimentary rocks, involve the recognition of quite large amounts of quartzites in a considerable number of new localities. Besides these, small beds of limestone have been discovered in the southern areas, especially in Warren and Washington counties, which are thoroughly interstratified with the gneisses and which leave no escape from concluding that the gneisses are also sedimentary in their origin and that a regularly stratified series of rocks is present.

This conclusion removes many of the gneisses from the group of uncertainties.

The speaker also briefly enumerated the discovery of new outliers of Cambrian and Ordovician strata in the midst of the crystallines; taking up the small but early discovered area at Wellstown, Hamilton county, he added some new and important facts and interpretations. He also noted the distribution of the glacial striations throughout the eastern mountains and noted their nearly uniform bearing to the northeast. In conclusion, he described the physiography as being due chiefly to a series of faulted blocks which afford a very characteristic saw-toothed sky-line.

Dr. **Julien** opened his paper with a discussion of several of the later theories of the origin of pegmatites in common acceptation. That of igneous intrusion, urged by Brögger, seems to cover facts which are not met with in the pegmatites of Manhattan Island, western Massachusetts nor western North Carolina. Brögger's theory and the pneumatolytic theory of Lehmann, Williams and Crosby, explain but imperfectly the most important occurrences of pegmatite occurrences in schists, especially evidences of their development *in loco*. Dr. Julien then summarized his own theory of metasomatic aggregation which he originally advanced at the meeting of the American Association for the Advancement of Science in June, 1900. In this he attributed the origin of the pegmatites of Manhattan Island entirely to molecular rearrangement of the material of the schists by the action of mineralizers in the vicinity of lamination planes and of fissures.

After a description of the main features of the pegmatites of Manhattan Island, with the help of specimens and diagrammatic drawings of outcrops and cross-sections, the speaker advanced the following chief conclusions:

1. The existence of a certain series of pegmatite development, at least two, but probably indefinite in number, marked by a succession of intersections. Of these the oldest is by far the most extensive, intercalated among the pliation-seams, and coincident with the strike. These pliation-seams cut the schists in

all directions and inclinations, but their courses are mostly comprised in the northeast quadrant. A few, which are gathered in partially concentric groups of curved planes, also present their convexity toward the northeast.

2. Every pegmatite occurrence on the Island, without exception, retains more or less structural evidence of having begun its existence as a vein, segregated from a magma or igneo-agueous emulsion. Even the notable dike near 205th Street, crossing the dolomite, retains the vein structure, perfectly in places and imperfectly throughout.

3. Contact-phenomena are confined mainly to the earlier alteration along seams, to projection of veinlets rather than intrusion apophyses, and, at one dolomite intersection, to a thin selvage of phlogopite and tremolite.

4. The vein-structure, often well preserved, presents distinct lamination, correspondent deposits on the two walls, comb-structure, passage from less to more acid minerals toward the centre, and final concentration of minerals of the rarer elements in association with the significant matrix, smoky quartz, along lenticular bands, often near a central suture.

5. Some of the most prominent features, and those by which the simplicity of the problem has been disguised, are the results of pressure upon the original veins through organic movements of the stratum of schists, viz., fissuring, faulting, crushing, shearing with development of mica (aptite), re-fusion and development of new phenocrysts (granite-porphyry), and generation of reaction borders outside of each wall of a vein. When flowage has taken place and some transference of the crushed vein material along the plane of the vein, the appearances of a dike begin. Many of these results may be distinguished along the course of the same vein at intervals of a few yards or rods, but in the most characteristic dikes the vein structure is rarely, if ever, completely obliterated.

Both of the papers presented were discussed by Professor **Martin**, Dr. **Hovey**, and others.

THEODORE G. WHITE,
Secretary.

SECTION OF ANTHROPOLOGY AND PSYCHOLOGY.

NOVEMBER 26, 1900.

Section met at 8:15 P. M., Prof. J. McK. Cattell presiding.

The minutes of the last meeting of Section was read and approved.

The name of one candidate for resident membership was read and referred to the Council according to the By-laws.

The following program was then offered :

R. S. Woodworth, PARIS CONGRESS OF PSYCHOLOGY.

Clark Wissler, CORRELATION OF ANTHROPOMETRIC TESTS.

E. L. Thorndike and **R. S. Woodworth**, EFFECTS OF SPECIAL TRAINING ON GENERAL ABILITY.

C. H. Judd, MOVEMENTS OF WRITING.

SUMMARY OF PAPERS.

The report of the Paris Congress presented by Dr. **Woodworth** was more detailed than the published accounts, and also suggested certain questions in regard to the enlargement and control of American representation at similar congresses in the future.

The paper by Mr. **Wissler** reported some results of a series of mental and physical tests upon students in Columbia and Barnard College. The young women of Barnard College were found to be superior to Columbia freshmen in the tests for time of perception, naming of colors and resistance to pressure ; they were equal to the freshmen in rate of fatigue, perception of weights, sensation areas, perception of size and logical memory ; they were inferior in size of head, strength of hand, reaction time, association time and auditory memory. There is some probability that the young women are superior in perception of pitch and inferior in movement time. With the freshmen who repeated the test in their senior year an improvement was found in all except sensation areas and perception of size, though the difference in some cases is slight. It was also found that the seniors showed a decided tendency to hold the same relative rank as when freshmen, thus indicating a general advancement of the group during college life. In correlations it appeared that logical memory and length of head are related characteristics, but length of head also correlates with lung capacity and strength of hand. The work has not gone far enough to say which of these has the most weight. Attempts to correlate reaction time and the other tests of quickness gave no results.

Dr. **Thorndike** presented the results of certain experiments on the Effects of Special Training on General Ability. These experiments were performed jointly by Drs. Woodworth and Thorndike. The results of a number of experiments show that when any mental function is trained in connection with certain data, the improvement is not of the function in general. If different data are used there will be less or even no improvement shown. The general theory that the mind equals a number of special abilities, independent to a degree hitherto unsuspected, was supported further by the great variability in our judgments of slightly differing magnitudes.

The fourth paper was on the Movements of Writing. These movements were analyzed by means of tracers attached to the hand, back of the fingers, and to the arm, back of the wrist. The written words give the sum of all the movements of arm, hand, and fingers. The hand tracer gives only arm and hand movements, omitting finger movements. The arm tracer shows arm movements only. The general result of this analysis shows that the arm carries the hand forward and participates only to a very small degree in the formation of the letters and words. The gross movements, especially those which are upward and forward, in the formation of the letters, are performed by the hand. All the finer curves and more delicate lines of the letters are formed by the fingers. The muscular coördinations of the different individuals tested, while differing greatly in detail characteristics, all show this general type of movement. No results were presented from subjects who write naturally with a full arm movement.

Charles H. Judd,
Secretary.

BUSINESS MEETING.

DECEMBER 3, 1900.

Academy met at 8:15 P. M., Professor Wm. Hallock presiding.

The minutes of the last business meeting were read and approved.

The Secretary reported from the Council as follows:

That Professor Poor had taken active charge of the editorial work of the Academy; also that the Council had appointed a committee to secure, if possible, a publication fund.

The following Candidates for resident membership, approved by the Council, were duly elected:

O. P. Hay, American Museum of Natural History.

E. O. Hovey, American Museum of Natural History.

(Dr. Hovey to become a life member.)

RICHARD E. DODGE,
Recording Secretary.

ASTRONOMY, PHYSICS AND CHEMISTRY.

DECEMBER 3, 1900.

Section met at 8:20 P. M., Professor William Hallock presiding.

The minutes of the last meeting of Section were read and approved.

The following program was offered:

E. R. von Nardroff, DETERMINATION OF THE WAVE LENGTH OF SOUND BY THE GRATING METHOD. (Illustrated.)

W. G. Levison, A METHOD OF PHOTOGRAPHING THE ENTIRE CORONA ON ONE PLATE, EMPLOYED AT NEWBERRY, S. C., FOR THE TOTAL SOLAR ECLIPSE OF MAY 23, 1900. (Illustrated.)

W. G. Levison, THE ACTION OF CANADA BALSAM ON PHOTOGRAPHIC GELATINE PLATES.

SUMMARY OF PAPERS.

As a source of sound the author of the first paper used a miniature steam whistle made of brass and operated by a current of air from a tank of compressed air. The sound produced in this way was inaudible on account of its high pitch, the wave length being only about three-eighths of an inch. The whistle was placed at one of the conjugate foci of a parabolic metallic mirror, a sensitive flame being placed at the other conjugate focus. A transmission grating made of wood and resembling somewhat a portion of a picket fence was then interposed in the path of the reflected sound waves, and it was found that when the sensitive flame was shifted to one side, as many as four positions of maximum effect were obtained on each side of the central beam of sound. With this apparatus, the wave length of sound, when the waves were short like those used, could be measured within one per cent.

Mr. **Levison's** method consisted in the use of a specially constructed color screen most dense at the centre and fading off to clear glass at the edges, which was placed close to the photographic plate. The size and density of the screen was adjusted as nearly as possible so that the image of the inner corona made by a suitable lens fell on the part of the plate covered by the screen while the image of the outer corona passed through the clear glass. The color screen was made from a lens of colored glass with sharp edges, which was cemented into a recess in a plate of clear glass ground to receive it. Two screens were made, one of orange-yellow glass and one of dark greenish-blue glass. In testing these screens at the time of the eclipse, an arrangement of telephoto-lenses was used, but unfortunately the exposure was not long enough to give any image at all of the outer corona through the clear glass, although a considerable impression of the inner corona was produced through the orange-yellow glass, but none through the bluish-green glass. This should give some idea of the relative actinometric intensity of the light from the inner and from the outer corona.

Mr. **Levison** also presented a short note on the action of Canada balsam on photographic plates. In making the experiments with color screens he noticed that Canada balsam that had been baked hard, when placed in contact with a sensitive plate, or separated from it by a layer of carefully selected black paper and allowed to remain a week or more, affected the plate in the same manner as light, the part affected developing black. He verified this effect by a number of experiments. In the author's opinion, this effect seemed likely to be caused by true Becquerel rays, as it passed through the black paper which is perfectly opaque to ordinary light.

William S. Day,
Secretary.

SECTION OF BIOLOGY.

December 10, 1900.

Section met at 8:15 p. m., Professor C. L. Bristol presiding.

The minutes of the last meeting of Section were read and approved.

Professor **Lloyd** offered his resignation as Secretary of the Section, because he is soon to leave for Europe on a leave of absence from Teachers College. On the motion of Professor Wilson, seconded by Dr. Calkins, a vote of thanks was tendered to the secretary for his interest in furthering the work of the Section.

The following program was then offered :

G. N. Calkins, Some Interesting Protozoa from Van Cortlandt Park.

H. E. Crampton, Elimination in Lepidoptera.

E. B. Wilson, The Chemical Fertilization of Sea-Urchin Eggs.

Summary of Papers.

Four genera of Protozoa which are usually regarded as intermediate forms between the classes of Protozoa were considered. These were : *Nuclearia*, intermediate between the Rhizopoda and the Heliozoa ; *Mastigomœba*, intermediate between Mastigophora and the Rhizopoda ; *Multicilia*, intermediate between the Mastigophora and Ciliata, and *Actinobolus*, intermediate between the Ciliata and the Suctoria. The method of feeding in the latter form was also described for the first time. All of these forms, together with 54 other genera and a great many species (100 to 150) were found in the waters of Van Cortlandt Park during the past fall.

The second paper was designed to be the first of a series dealing with the problems of variation and selection in Lepidoptera, and especially in the Saturnid moths. The particular questions here considered are as to the relative variability of eliminated and surviving pupæ and moths of *Philosamia cynthia*, and as to the relative variability of males and females. From a lot of 1,090 cocoons from a restricted locality, 310 living and 632 dead pupæ were obtained, the remainder being shrivelled or abnormal larvæ and pupæ. The living pupæ were compared with an equal number of dead pupæ with reference to certain body-characters (length, length of bust, width, depth, frontal stature and sagittal stature of bust), and to certain characters of a typical organ, the left antenna (length, breadth and stature). It appears that the surviving males are slightly less variable than the eliminated males, and that the surviving females are far less variable. From the living pupæ but 180 perfect moths were obtained. The males were from pupæ which were far less variable than pupæ producing abnormal moths ; but the females were from relatively more variable pupæ, though the latter were much less variable than eliminated female pupæ of the preceding group. The paper will be published in full.

Professor **Wilson** presented the results of a study of the phenomena of development in the unfertilized eggs of *Texepneustes* when treated with solutions of magnesium chloride by Loeb's method. The results confirm Loeb's conclusion that the embryos arising from these eggs are produced without fertilization by spermatozoa, conclusive proof being given in the fact that during cleavage the number of chromosomes is half the usual number, namely, 18 instead of 36. The mitotic phenomena differ in many details from those occurring in fertilized eggs, but show a striking general parallelism to them. The asters may be only two in number (cleavage asters), but as a rule there are many other asters (cytasters) that have no connection with the nucleus. Like the nuclear asters, however, the cytasters contain centrosomes and may progressively multiply by division. Cytasters and centrosomes are formed also in enucleated fragments obtained by shaking unfertilized eggs to pieces before treatment by the magnesium solution, and these asters may likewise multiply by division.

These facts seem to leave no doubt of the formation of functional centrosomes *de novo* and independently of the nucleus. Evidence was adduced to show that the asters may operate as centres of cytoplasmic division, independently of the nucleus. It was also shown that the magnesium eggs show numerous gradation in the mitotic process between complete division and partial mitosis.

FRANCIS E. LLOYD,
Secretary.

GEOLOGY AND MINERALOGY.

DECEMBER 17, 1900.

Section met at 8:15 P. M., Dr. A. A. Julien presiding.

The minutes of the last meeting of Section were read and approved.

The following program was offered:

E. O. Hovey, EXHIBITION OF LANTERN SLIDES ILLUSTRATING SOME OF THE QUARTERNARY DEPOSITS OF THE HUDSON RIVER VALLEY, AND SOME MISCELLANEOUS SUBJECTS.

D. S. Martin, NOTES ON THE GEOLOGY AND MINERALOGY OF THE VICINITY OF BALTIMORE, MARYLAND.

W. G. Levison, MINERALS FROM THE JONES' FALL QUARRIES, NEAR BALTIMORE, MARYLAND.

SUMMARY OF PAPERS.

Dr. **E. O. Hovey** exhibited several series of slides on geological subjects recently prepared by him for Professor Bickmore. The first series illustrated the clay deposits of the Hudson River Valley, and the process of manufacturing those clays into bricks; the second series comprised the outcrops of the Cortland series of rocks along the Hudson, the included schists, and the Tompkins Cove Limestone quarries. The third series illustrated the character of the sand dunes of Newburyport and Plum Island,—the dissected drumlin at Great Boar's Head, New Hampshire, and the gneissoid granite with dikes at Isle of Shoals.

The slides were further discussed by Professor Kemp, Dr. Julien, and Dr. Levison.

Professor **Martin** discussed the geology of the Jones' Falls valley, north of Baltimore, Md. The rocks are principally white hornblendic gneiss, cut by pegmatite dikes,—the latter containing many minerals. The crystallines decomposed with great rapidity, forming a reddish soil. Professor Martin also commented on the excellent museum of local geology maintained by the Maryland Academy of Sciences, which illustrates all the formations of the State from the base of the Archean to the Catskill. The use of the term Catskill in describing the rocks called by that name in Maryland was called to question, and was discussed by Drs. Call, Hovey, Julien, Kemp, White, and Professor Stevenson, the latter defining the Catskill as a condition arising at the closing period of the Chemung in certain localities, and not marked by characteristic fossils nor worthy of a position as a division of the geological time scale.

Dr. **Levison** exhibited a number of minerals from the pegmatitic development in the Jones' Falls quarries near Baltimore, Md. Among them were albite, laumontite, garnet, epidote, thulite, and zoisite.

The meeting adjourned at 10 P. M.

THEODORE G. WHITE,
Secretary.

General Index to Volume XIII.

Names of authors in **heavy face type**.
Generic and specific names in *italics*.

SPECIAL INDEX OF SPECIES FOR THE PAPER ON "THE SEQUENCES OF PLUMAGES AND MOULTS OF THE PASSERINE BIRDS OF NEW YORK" BY JONATHAN DWIGHT, JR.

VOL. XIII PART I

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SESSION, 1900–1901

The Academy will meet on Monday evenings at 8 o'clock, from October 1st to May 27th, in the rooms of the American Society of Mechanical Engineers, at **12 West 31st Street.**

VOL. XIII PARTS II AND III

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