A SYNOPSIS

OF A

COURSE OF LECTURES

ON THE

Elements of Historical Paleontology,

DELIVERED AT

CORNELL UNIVERSITY,

1885-86.

H. S. W.

ITHACA, N. Y.,
ANDRUS & CHURCH,
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Historical Paleontology.

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1. Fossils :

^aWhat are they? ^bFrom the geologist's point of view.
^cFrom the biologist's standpoint? ^dHow considered in present course of lectures. ^eImportance of the study of fossils.

2. ^aEarly knowledge of fossils. ^bIn what respects imperfect.
^cWhen were fossils first clearly understood?

3. Cuvier :

^aHis observations in 1796. ^bHis work of 1812-13, and its relation to the rise of the Science of Paleontology. ^cWhy was he specially fitted to interpret fossils.

4. Who immediately followed Cuvier?

5. When and where the term Paleontology was first used?

6. The supposed nature of fossils before Cuvier.

7. What progress in science was essential before Paleontology could arise?

8. ^aWhat were the striking features of progress in the study of Natural History in the early years of this century? ^bWho were the leaders in the study of invertebrates? ^cWho developed the study of plants? ^dThe results of their studies.

9. William Smith, 1816-20; his contribution to the Science.

10. Murchison & Sedgwick, 1839-55; their part.

11. The relation of stratigraphic geology to pure paleontology.

12. Paleontology :

^aIts true scope. ^bThe extent to which fossils are valuable in identifying strata and geological age. ^cPaleontology as an historical study. ^dPaleontology as a systematic science.

13. What preparatory study essential to its profitable pursuit?

14. Why separate it from Geology?

15. Why history of organism, and not ancient history?

16. Stratigraphy and Paleontology are intimately associated and should be studied together.

17. Organisms : what facts in regard to them of special interest to the paleontologist ?

18. The chief topics to be considered in these lectures :

^aThe method of study. ^bThe relative importance of the several kinds of facts presented. ^cNecessity of work outside the lecture-room. ^dUse of charts and specimens.

19. Text books ; qualities demanded, where to be found.

20. The scientific use of generalizations *versus* the superficial treatment of science.

21. Geologic time :

^aIts subdivisions, how determined ? ^bStratigraphical succession the fundamental criterion of length and order of time. ^cThe classification of the strata forms the basis for the chronologic divisions.

22. ^aThe system of nomenclature adopted by the International Congress. ^bHow different from that in common use in America as illustrated in Dana's Manual.

23. Reason for recognizing nine chronologic divisions, corresponding nearly to the Periods of the international nomenclature.

24. Relative length of duration of the Periods ; how determined ?

25. Diagrammatic representation of the relation between the duration of the Periods and the progress in rank and variety of form of the organisms inhabiting the globe. (See p. 5.)

26. Usage of the terms Horizon, Zone, Stage, Group, Formation, Period, Age, Fauna, Flora.

27. Fossils :

^aLyell's definition. ^bOrigin of the name. ^cIts later usage. ^dExamples of present usage. ^eHard-parts of animals. ^fClassification (of C. A. White) : (1) Fossils proper ; (2) moulds (or internal or external impressions) ; (3) casts ; (4) pseudomorphs. ^gThe occasional use of the term "cast. ^hCrushing and distortion of fossils. ⁱMetamorphism.

28. ^aImperfection of the fossils, and of the record. ^bWhat do they represent, ^cand in what particulars is the historical record necessarily deficient ?

29. The classes of the Animal Kingdom having fossil representatives. (See p. 6.)

DIAGRAM

Representing the relative length of the Geologic Periods, and the progress in the rank and variety of form of the organisms inhabiting the globe.

*List of the Classes of the Animal Kingdom represented in the
fossil state, with their Geologic Range.*

PROTIZOA.

1. Rhizopoda.

COELENTERATA.

2. Spongia.
3. Actinozoa (=Anthozoa.)
4. Hydrozoa (=Polypomedusa.)

ECHINODERMATA.

5. Crinoidea.
6. Asteroidea.
7. Echinoidea.
8. Holothurioidea.

VERMES.

9. Annelida.

MOLLUSCOIDA.

10. Bryozoa(=Polyzoa.)
11. Brachiopoda.

MOLLUSCA.

12. Lamellibranchiata
13. Gastropoda.
14. Pteropoda.
15. Cephalopoda.

ARTHROPODA.

16. Crustacea.
17. Arachnoidea.
18. Myriapoda.
19. Insecta.

VERTEBRATA.

20. Pisces.
21. Amphibia.
22. Reptilia.
23. Aves.
24. Mammalia.

30. ^aRelation of habitat to the preservation of fossil remains.
^bMarine faunas. ^cBrackish water faunas. ^dFaunas and floras of land, and of fresh water.
31. Geographical distribution and provinces.
32. Geological range.
33. The relative completeness of the record for the several groups of organisms.
34. Special value of invertebrates for historical study.
35. Common and abundant forms as compared with rare and unique forms.
36. Facts worthy of particular note in regard to the organisms of each period : ^aDominant forms. ^bFirst appearance or initiation of new types. ^cDecrease and extinction.
37. Geologic periods not marked off by sharp lines.
38. The importance of the Paleozoic records in the study of the history of Organisms.
39. Most of the types of the Animal Kingdom begin in the Paleozoic era.

I, THE ARCHAEOAN.

40. ^aCharacter of the rocks. ^bThickness of the deposits in Canada. ^cHow deposited, and present condition. ^dThe names Archaeozoic and Eozoic. ^eSources of information in regard to the Archaeozoic record.
41. Evidences of organic life :
^aThe structure and character of the rocks. ^bThe limestones, their thickness and interpretation. ^cGraphite. ^dIron ores. ^eEozoon, its discoverer, when found, description, what it resembles, opinions as to its nature ; theory as to its mode of preservation. ^fOther supposed organisms.
42. The supposed successors and the systematic relations of the Eozoon.
43. Foraminifera as limestone builders.
44. Variability and persistence of the characters of foraminifera.
45. Summary.

II, THE CAMBRIAN.

46. ^aThe Cambrian system of Sedgwick. ^bThe Primordia Zone and Fauna of Barrande. ^cThe fauna and its limits. ^dThe interpretation of the Cambrian of America (Walcott). ^eThe grand cañon section and the Tonto group.

47. The two grand life-periods of the Paleozoic and their characteristics :

^aCambrian—Silurian ; abundance of Trilobites, Graptolites and Brachiopods, and absence of Vertebrates.

^bDevonian—Carboniferous ; abundance and variety of Fishes and Amphibians, the disappearance of Graptolites and Trilobites, and finally the abundance of cryptogamous terrestrial life, or Flora.

48. The subdivision of the Cambro-Silurian.

49. The Murchison-Sedgwick controversy.

50. Limits of the Cambrian in America.

51. Paleontologic reasons for including part of the “Canadian Period” of Dana in the Cambrian.

52. The number of species recorded.

53. The typical British series, and the order of first appearance of the several classes and orders.

54. The Swedish section.

55. The section in Bohemia.

56. Relative prominence of the several classes in the Cambrian fauna : (1) Trilobites, (2) Brachiopods—the Tretentenate division, (3) Pteropoda, (4) Crustacea, other than Trilobites, (5) Cystidians, (6) then follow other Brachiopods, Sponges, Annelids, Gastropods, Graptolites, and Cephalopods.

57. Tabular view of the Animal Kingdom, (See Chart, and p. 6.) shows that all the branches of the Animal Kingdom were represented in the Cambrian fauna, except the Vertebrates.

58. Trilobites ; description of the structure of the Trilobite.

(*Head or Carapace*, glabella, cheeks, eyes, facial suture, furrows, lobes, rostral shield, hypostoma ; *Thorax*, axis, pleura, facets, pleural groove, fulcræ ; *Pygidium*, segments, limbs ; *Appendages*, (of Walcott), ventral membrane, intestinal canal, hypostoma, mouth, head appendages, thoracico-abdominal appendages, ambulatory legs, epipodites, branchia.)

59. Classification (of Salter) based on facial suture and eyes.

60. Early views about Trilobites.

61. Their geologic range.

62. Their position in the Animal Kingdom.

63. Range of the various orders of Crustacea.

64. The Annelida of the Cambrian.

65. Representative Trilobites of the Cambrian :

(1) Paradoxides, (2) Conocephalites, (3) Agnostus, and their respective families ; characteristics of 1 and 2, and differences ; same of Agnostus.

66. Historic laws deduced from the study of Trilobites.

67. Literature for fuller study of the subject.

68. Ostracoids and Phyllopods (Hymenocaris).

69. Mollusca and Molluscoida.

70. Brachiopoda :

^aTretenterata and Clistenterata. ^bCharacters of the whole class, distinctions separating the two orders, (equilateral, bivalved, with or without peduncle, alimentary canal, complicated brachial apparatus, " blood channels," " pseudo hearts," numerous muscles). ^cLingula and Discina still living. ^dClimax of the tretenterate Brachiopods. ^eClistenterata begin in the genus Orthis.

71. Gastropoda—characters of. See genera Pleurotomaria, Euomphalus, Murchisonia, belong to the " Vegetarian Repentantia " of Lankester.

72. Free swimming Mollusca :

^aPteropods, represented by Theca and Conularia. ^bCephalopods, by Orthoceras. ^cLankester's views of the relations of these classes. ^dTheir characters.

73. Lamellibranch's doubtfully represented.

74. Conclusions. The high character of the classes and the variety of forms presumptive evidence of previous life.

75. Absence of limestone may account for absence of some groups, viz., corals, etc.

76. Plants represented by Fucoids and Oldhamia.

77. Most of the classes represented by only a few traces, and begin in abundance in the Silurian.

78. Conspicuous law as to the rank of the early forms. The higher classes represented by their lower orders.

79. Prominent genera of the Cambrian: Paradoxides, Lingulella, Archaeocyathus, Obolella, Hymenocaris, Oldhamia, Sclerithus, Sao.

80. Important genera beginning in the Cambrian are Orthos, Discina Pleurotomaria, Hypolithes (Theca), Lingula, Leperditia, Agnostus.

81. Some doubtful forms referred to Cystids, Crinoids, Orthoceras, and Graptolites.

III, THE SILURIAN.

82. Characteristics of the life of the System; great abundance and variety of marine life; rocks richly fossiliferous.

83. Comparison between the history of the Trilobites and of the tetraterate Brachiopods.

84. The Silurian fauna:

^aThe great majority of its families and genera now extinct. ^bThirty-one of the ninety-seven orders of fossil animals are known to have appeared before the close of the Silurian. ^cRepresentatives of the majority of orders still living. ^dMostly marine. ^eDominant types—Mollusca and Brachiopods. ^fHighest types—Crustacea and Cephalopods. ^gNew types initiated—Actinozoa, and before the close, traces of Vertebrates, and a land flora (Lycopods).

85. Recent discovery of Scorpions and Insects.

86. The Silurian system of Murchison.

87. Character of the rocks in Britain, in America. Maximum thickness.

88. Approximate number of species, (in 1868):

Brachiopods, ...	1600
Trilobites, ...	1600
Cephalopods, ...	1400
Gastropods	900
Lamellibranchs, ...	700
Actinozoa, ...	500
Echinodermata, ...	500
Polyzoa, Heteropoda, Entomostracans, each between	200 and 500

Other classes under 200 each, total about 10,000 species.

89. Graptolites, Cystids, and Entomostracans, form a conspicuous feature of the fauna.

90. Range of the classes of the Animal Kingdom, (see list, p. —).

91. Irregularity in the usage of the terms Branch, Class, Order.

92. Genus the most satisfactory unit of systematic classification.

93. Graptolites :

^aInitiation in Cambrian ; climax in Silurian ; extinction near the close—(lower Devonian, Kayser.) ^bClassed near the Sertularians. ^cFound in “black” or “alum” shales or “slates.”

^dCharacters : polypary, “solid” axis, cellules, central disc, monoprionidian, diprionidian. ^eDictyonema.

94. Actinozoa (corals) :

^aRange of the main types of the Silurian. (Chaetetes, Favosites, Halysites, Syringopora, Cyathophylum, and the Rugosa.)

^bDistinctive characters : walls, septae, tabulae, perforations, corallites, simple, massive, or compound, fossula, dissepiments.

^cGeneric and specific differentia.

✓ 95. Echinodermata :

^aRange of the principal types : Cystidians, Crinidians, ✓ Blastoids, Asteroids, Echinoids—(Archaeocidaris, Cidaris, and the irregular Echinoids.) ^bTypical characters, and their modifications and homologies in the several orders. ^cEssential characters, anatomical, and of the hard parts, mouth and oral end, aboral end and anus.

96. Typical arrangement of parts in a sea-urchin :

^aAmbulacral rows, five pairs of two each. ^bInterambulacral plates, five rows of two pairs. ^cApical disc, genital, ocular and anal plates.

97. Ambulacra :

^aVentral position of, in Asteroids. ^bconfined to central disc in Ophiurans.

98. Crinoids :

^aStalk and calyx, openings all ventral and within base of arms. ^bGenetal system.

99. Cystidians—calyx irregular, arms wanting or rudimentary, valvular pyramid, hydrospires.

100. Blastoids—pseudoambulacra, regular plates few.

101. The generic and specific differentia of Crinoids and Cystids, and their classification.

102. Brachiopods :

^aThe two divisions Tretenterata and Clisterata.

^bRange of the principal families : 1. Lingulidae ; 2. Obolidae ; 3. Craniidae ; 4. Orthidae ; 5. Strophomenidae ; 6. Rhynchonellidae ; 7. The genus Spirifera, and the spiral bearing Brachiopoda ; 8. Productus and allied genera ; 9. Terebratulidae. ^cGeneric and specific differentia of Brachiopoda.

103. Law of the initiation of new forms, and the history of Brachiopoda.

✓ 104. Cephalopoda :

^aThe two orders, Tetrabranchiata and Dibranchiata.

^bProminent characters of the class and of the orders. ^cThe shell, its several parts, a chambered cone, septae, siphuncle, sutures, body chambers, aperture, sutures, lobes and saddles, (dorsal) external and (ventral) internal aspect of the coiled shells. ^dSubdivisions of Tetrabranchiata : 1. The Nautiloidea, (sub-order) mainly Paleozoic. 2. The Ammonoidea, mainly Mesozoic.

✓ 105. The Nautiloidea. For classification see Zittel.

^aFam. Nautilidae, proper, more conspicuous in later Paleozoic. ^bFam. Orthoceratidae, a dominant Silurian family. ^cThe characters and range of the genera : Nautilus, Lituities, Trochoceras, Clymenia, Orthoceras, Cyrtoceras, Phragmoceras, Gomphoceras, Endoceras. ^dGeneric and specific differentia.

106. Remarks upon the studies of Hyatt and others, and the forms Orthoceran, Cyrtoceran, Gyroceran, and Nautilian, and their historical importance.

107. Order of initiation, and range in time of the several types ; actual observed order, and order of prominence of each.

108. Trilobites :

^aThe differentia, generic and specific. ^bGeneral law as to the initiation of new types. ^cProminent Silurian genera : Acidaspis, Harpes, Calymene, Lichas, Asaphus, Bathyrus, Illaenus, Cheirurus.

109. Merostomata :

^aLimulus, a modern representative. ^bThe fossil sub-or-

ders : Eurypteria, its ordinal and sub-ordinal characters, and historical position. ^cXiphosura, characters and range.

110. Tentaculites—a pelagic form ; characters.

111. Lamellibranchs :

^aProminent Silurian genera : (Monomyaria) Avicula, Pterinea. ^b(Dimyaria) Modiolopsis, Ctenodonta, Orthonota, Palearca.

112. Gastropods :

^aProminent genera : Murchisonia, Platyceras, Pleurotomaria.

113. Relative importance, in the Silurian, of the different types of Mollusca :

^aCephalopods, Pteropods, and Heteropods, the more dominant groups. ^bProminence of pelagic forms, (as Bellerophon (?) Macluria, Ophileta, Theca, Conularia, Tentaculies.

114. Geographical differences in the range of species.

115. The Silurian system in different regions.

IV, THE DEVONIAN.

✓ 116. ^aThe upper limit of Murchison's Silurian system, and ^bConrad's application of it in New York, (1841), ^cVanuxem's (1842) Erie division of the New York System, ^dHall's usage, (1843-1846). ^eLower limit of Devonian, (1846). ^fOriskany sandstone, why the base of De Verneuil's Devonian, (1847)? ^gOriskany, why the top of Hall's Silurian, (1859)? ^hPresent usage.

✓ 117. The Devonian and the old Red Sandstone of English geologists.

118. These discussions illustrative of the importance of bringing lithologic, stratigraphic, and geographic facts to bear upon the interpretation of paleontologic history.

The marine invertebrate fauna of the Devonian.

119. Stony corals, (Actinozoa) :

^aGenera : Cyathophyllum, Zaphrentis, Favosites, etc.

^bAbsence of the genus Halysites.

120. Hydrozoa :

^aDictyonema. ^bMonograptus recognized in lower Devonian in Prussia, by Kayser,

121. Crinoids :

^aNo great change in genera from the Silurian fauna.

^bCystids wanting. ^cBlastoids few.

122. Mollusca and Molluscoida :

^aAn increase in the numbers of Gastropods and Lamelli-branches. ^bCephalopods the most prominent group. ^cBrachio-pods the most common of invertebrates, as they were in the Silurian.

123. Prominent genera of Cephalopoda : Orthoceras, Cyrtoceras, and Gomphoceras, and Goniatites and Clymenia, which were characteristic of some zones and are essentially Devonian types of Cephalopods.

124. Brachiopods :

^aProminent genera : Spirifera, Orthis, Strophomena, (Hall's genus Strophodonta). ^bThe Productidae and Terebratulidae began to be conspicuous. ^cThe genera Terebratula, Cryptonella and Productus are new.

125. Crustacea :

^aTrilobites declining, prominent genera were Homalotus, Phacops, Proetus, Bronteus. ^bOstracoids abundant in some zones.

126. Vertebrates :

^aThe first age in which fishes were at all abundant, some traces of them below. ^bPlacoderms the most conspicuous type.

127. Land plants :

^aLepidodendron. ^bFerns. ^cConifers. ^dCalamites.

128. The marine invertebrates with substantially the same families as in the Silurian.

129. The grand features of Devonian life are seen in its Vertebrates and Land Plants.

130. Vertebrate life of the Devonian. (See Newberry's views and classification, Paleontology of Ohio, Vol. I. ; Nicholson's Paleontology, Vol. 2. See also chart of classification and range prepared for the class).

^aFish—slight traces below the Devonian. ^bDevonian fish large, abundant, and highly organized in some cases. ^cPlacoderms and some Elasmobranchs first became conspicuous. ^dGanoids most prominent between the Devonian and Jurassic. ^eTele-

osts most prominent between the base of the Cretaceous and the present. ^rThe very earliest fossil fish, (Q. J. G. S. XLI., p. 48), probably allied to modern Cestraciont Sharks. ^sThe Climerooids.* ^bThe Ganoids. ⁱThe Crossopterygidae. ^jDipterus. ^kHoloptychius. ^lCtenodont teeth. ^mThe Chondrosteidae. ⁿThe Cephalospidae. ^oThe Placoderms. ^pPterichthys. ^qDinichthys.

131. Devonian Plants : Classification of Fossil Plants and their range in the Paleozoic. (For general classification see Lesquereux, Principles of Paleozoic Botany, 13th Geol. Rep't of Indiana 1884 ; also, Zittel, Handbuch d. Pal. II., 1879-84).

132. Reasons for recognizing a special classification for the botany of fossils, and its necessity for the general treatment possible in these lectures.

133. Lesquereux estimates 6,000 fossil species, 150,000 living. Not over 50 species to square mile in the United States ; 140 to 200 species seen in some single coal beds.

134. Four epochs of successive development : 1. Reign of Thallasophytes, Silurian ; 2. of Vascular Cryptogams, Devonian—Carboniferous—Permian ; 3. of Gymnosperms, mid-Permian—Jura ; of Angiosperms, Cretaceous—recent.

135. Devonian Floras :

^aAlgae, Uphantenia, Dictyophyton, Spirophyton. ^bAcrogens ; (1) Equisetacea, (Calamites, Asteriophyllites, Annularia, Sphenophyllum) ; (2) Ferns, (Shimper's Brongniart's classification of fossil ferns) : Neuropterideae, Adiantideae, Sphenopterideae, Pecopterideae ; (3) Lycopodiaceae : Lepidodendron, Lycopodites, Ulodendron, Knorria, Sigillaria, Stigmara. ^cPrototaxites. Conifers. ^eCycads, (? in Devonian).

136. Insecta :

^aCentipedes. ^bSpiders. ^cScorpions (in the Silurian also).

137. ^aTribes of animals rarely seen above the Devonian : Cystids, Trilobites, Orthoceras, Halysites, Favositidae, Chaetetes.

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*NOTE.—The mention of a family or generic name in this synopsis, indicates the description and illustration of the essential characters of and the more important secondary characters which furnish specific differentia for the genus.

^bAmong Brachiopods, *Orthis*, *Strophomena* and their allied genera rarely seen above the Paleozoic.

138. Conspicuous features of ^athe Devonian Fauna are *Spirifera* and *Orthis*, in association with *Productus* and *Terebratula*, *Goniatites*, Placoderm Fish; and of ^bthe Flora, *Psilophyton* and an occasional *Lepidodendron*.

139. Dawson's conclusions from the study of Devonian Plants.

V, THE CARBONIFEROUS.

140. ^aThe nature of the transition from the Devonian. ^bThe general order of the series of deposits. ^cTwo groups of deposits with distinct character to their fossils. ^dSub-carboniferous or Lower Carboniferous. ^eCarboniferous proper or Coal measures. ^fPermian.

141. The marine fauna of the Carboniferous was conspicuous for Crinoids, certain corals, a few genera of Brachiopods.

142. Characteristic features of the fauna: Protozoa; Fusulina, Nummulina, Saccamina.

143. Corals: (1) *Rugosa* and *Tabulata* rare; (2) *Lithostrotion*, *Philipsastrea* and *Lonsdaleia* characteristic; (3) *Zaphrentis*, *Cyathophyllum* and *Amplex* occasional.

143. Fenestellidae (*Archimedes*).

144. Echinoderms: (1) *Melonites*, (2) *Archaeocidaris*, (3) Blastoids, (4) Crinoids,—*Platycrinus*, *Actinocrinus*, *Cyathocrinus*, *Poteriocrinus*, *Forbesiocrinus*. (Three hundred and fifty species of Crinoids recorded from the Burlington limestone, Iowa.)

145. Brachiopods: *Productus*, *Spirifera*, *Terebratula*, *Rhynchonella*, the prominent genera.

146. Mollusca:

^aProminent Lamellibranchs were *Aviculopecten*, *Leda*, *Nucula*, *Conocardium*, *Modiola*. ^bCommon Gasteropods were *Natica*, *Pleurotomaria*, *Loxomena*, *Euomphalus*. *Bellerophon* was frequent. ^c*Goniatites* conspicuous among Cephalopods.

147. Crustacea:

^a*Trilobites*, rare and small, few genera. *Griffithides* and *Phillipsia* the main genera. ^bOstracoids—*Beyrichia*, *Leperditia*, etc. ^cEutomostraca—Phyllopods, Eurypterids, and a few Xipho-

surra. ^aThe higher Crustacea represented by the macruran An-thrapalaemon.

148. Vertebrates :

^aSharks—cestraciont and hybodont. ^bGanoids less conspicuous. ^cA prominent feature, the general absence of the Placoderms. ^dSauropus, regarded as tracks, the earliest trace of an Amphibian.

149. Special flora of the coal measures :

^aThe character of the deposits. ^bPrincipal types—Equisetacea, Lycopodiacea and Ferns ; Conifers appear but are rare.

150. Permian flora adds the Conifers and Cycads as prominent features.

151. Fauna associated with the Carboniferous flora.

^aFresh water and land Mollusca,—Pupa, Anthracosia. ^bScorpions, Myriapods, Neuroptera, Orthoptera. ^cFish—Ganoids and Selachians. ^dReptiles — labyrinthodont Amphibians and Lacertilia (Eosaurus).

152. Permian, some new features in the fauna and flora :

^aProtosaurus, a thecodont reptile ; ^bWalchia, Psaronius ; ^cAnnularia and Conifers prominent : Conifers (Dadoxylon, Ullmannia, Pinites) ; ^dSigillarids rare ; ^eno Goniates.

153. Conclusions. (See Dana's Manual, pp. 382–389.)

VI, VII, VIII, MESOZOIC.

154. The Paleozoic-Mesozoic line not sharply defined in marine faunas.

155. Many prominent paleozoic genera cease to be conspicuous, are rarely, and in some cases never seen again. (See as examples Lepidodendron, Sigillaria, Calamities, the Trilobites, Graptolites, Cystidians, Goniates, the genus Productus, Tabulate and Rugose Corals, the Placoderms, and the genus Orthoceras.)

156. The Terebratulids and the Rhynchonellids are the prominent families of Brachiopods.

157. The old type of Crinoids—Paleocrinoidea—ceases.

158. A few marine genera extend from the Paleozoic to recent time.

159. Relative length and importance of the subdivisions of the Mesozoic,—Triassic, Jurassic, Cretaceous.

160. Mesozoic Protozoa—Orbitolina, Nummulinidae, Globigerina, Textularia. (See also Diatoms and Desmids.)

161. The nature of green-sands.

162. Coelenterata :

^aSponges and ^bCorals, (Actinozoa)—Astracidae, Fungidae, Aporosa, Madreporae—Perforata.

163. Echinodermata :

^aCrinoids—Encrinurus, Pentacrinus, etc. The Pycnocrinoidea of Pictet. ^bStarfish. ^cEchinids, regular, as Cidaris ; irregular as Spatangus ; sessile forms, Marsupites, and free Saccosoma, like the Comatulas.

164. Brachiopoda were restricted, with few exceptions, to the families of the Terebratulidae, Rhynchonellidae, Discinidae, Lingulidae, and Crinoidae.

165. The prominent Lamellibranch families : Trigonidae, Ostreidae,—genera, Ostrea, Gryphea, Exogyra.

166. The Hippuritidae, (Rudistes, etc.).

167. Gastropods—all except a very few families were represented before the close of the Mesozoic.

168. Cephalopods—first order, Tetrabranchiata :

^aFirst sub-order, Nautiloidea, mainly Paleozoic. Only two families pass the limit of the Paleozoic, viz. : Orthoceratidae, (gen. Orthoceras), and Nautilidae (genera Nautilus and Aturia). ^bOrthoceras known in the Mesozoic in only a single region,—the St. Cassian beds—but is there associated with the Ammonoidea. ^cNautilus reaches its culmination in the Mesozoic.

169. Second sub-order, Ammonoidea, mainly Mesozoic.

170. Of the Dibranchiata—second order—the first sub-order, Decapoda, was mainly Mesozoic. One family, the Sepiophora, did not appear till the Tertiary.

171. The second sub-order, Octopoda—example Argonauta—left no traces earlier than the middle Tertiary.

172. Of the Ammonoidea a few families of ^athe Prosiphonata have been represented by species from the deposits, called Permian-Carboniferous in India, (the salt-range group, see Waagen's Report,) and ^bthe two retrosiphonate families—Clymenia and Goniatites—are confined to the upper Paleozoic, but ^cthe great mass of species and genera are Mesozoic.

173. Second order, Dibranchiata :

^aOf the sub-order, Decapods, all the families, except Sepiophora, began before the close of the Mesozoic. ^bThe sub-order Octopoda—Argonauta is not recognized below the later Tertiary.

174. The various characters adopted by different authors as criteria of classification, such as the position of the siphon, the degrees of coiling or curvature of the shell, the sutures, etc., their relative values, and their relation to theories of interpretation of the Ammonites.

175. The necessity, in studying the history of organisms, of taking note of the degree of plasticity the characters exhibit when found under the same conditions, and at a single stage.

176. Classification and range of the Dibranchiata.

177. The Phragmophora (Belemites, etc.).

178. Arthropoda of the Mesozoic :

^aLobsters. ^bShrimps. ^cCrabs. ^dBeetles. ^eButterflies. ^fGrasshoppers.

179. The cases of the Scorpion lately found in the Silurian, a Trilobite in the Mesozoic and a Cystid dredged from the deep sea, suggestive of caution in trusting negative evidence as to exact limits of initiation or extinction of groups of organisms.

180. Reptiles :

^aHuxley's Classification. ^bLabyrinthodonts, placed with Amphibians in the province Ichthyopsida. ^cSauropsida—a province including Birds and Reptiles. ^dChelonia. ^ePlesiosauria. ^fLacertilia. ^gOphidia. ^hIchthyosauria. ⁱCrocodylia. ^jDicynodontia. ^kOrnithoscelida. ^lPterosauria.

181. Characters important in classification and history :

^aOf the vertebrae,—amphicoelian, opisthocoelian, and procoelian. ^bOf the teeth—labyrinthodont, pleurodont, acrodont, thecodont, maxillary, palatine, pterygoid and vomerine teeth. ^cOf the jaw—(1) each ramus a single bone, (2) or of several bones anteriorly united by ankylosis, ligament or muscle, (3) joint in middle of ramus, (4) proximal articulation, by quadrate bone, or direct, (5) the occipital condyle, single in the Saurosida, two in Amphibia.

182. For each order—the prominent characters, an age of initiation, an age of culmination, an age of extinction.

183. Avian Reptiles, and Birds :

^aTriassic—Jurassic, Avian Reptiles, (1) Ornithoscelida—Dinosauria, Compsognatha ; (2) Pterosauria—Pterodactylus, Dimorphodon, Ramphorhynchus and Pteranodon (Cret.), Archaeopteryx. ^bCretaceous—Reptilian Birds and Birds ; (1) Odontornithes—Hesperornis, Ichthyornis and (2) a few genera of the swimming (Natatores), and of the wading (Gallatores), Carinatae. ^cTertiary—with the Tertiary the first initiation of the other orders of Carinatae—the Rassoires, the Scansoires, the Inessoires, the Raptores, as well as most of the families of the Natatores and Gallatores, also the non-flying birds—the Ratitae.

184. Ornithoscelida :

^aTracks in Triassic regarded as Dinosaurian. ^bBird-like characters seen in the anterior extension of the Ilium, the slender and backward prolonged Ischium, and in several characters of the hind limb bones.

Toothed Birds :

185. Odontopteryx, only serrated bill, no true teeth.

186. Hesperornis, lower jaw fully toothed, upper jaw, back part toothed, front part bill, teeth in sockets.

187. Ichthyornis, carinated sternum, amphicoelian vertebrae. (Pteranodon, a flying reptile,—Cretaceous—with bill, no teeth. See 191.)

Flying Reptiles :

188. Pterosauria, teeth and wings, “patagium” as in bats, pneumatic cavities in bones as birds.

189. Pterodactylus, fully toothed.

190. Ramphorhynchus, only back part toothed.

191. Pteranodon, no teeth. (See 187.)

192. Birds ; class characters and classifications.

193. Archaeopteryx.

194. Odontornithes.

195. Ratitae. (? Dinornis, etc.)

196. Carinatae :

^aNatatores—Albatross, Swans, Cormorants, etc. ^bGall-

latores—Sandpipers, Rails. The other orders, ^cRasores, ^dScansores, ^eInsessores, and ^fRaptores did not appear till the Tertiary.

IX, THE TERTIARY.

197. Mammals, ^aexcept Marsupials, begin in Cenozoic. ^bEssential characters of the class. ^cOrdinal characters, i. e., differentia seen in various modes (1) of birth and early care of young, (2) of progression,—feet and limbs, (3) of defense and attack,—teeth and horns. ^dSignificance of milk secretion ; of hair ; importance of characters of the occipital condyle. ^eStudy of the chart of classification and history of Mammals.

198. Monotremes—bird-like in some points of structure, and in function of ovaposition—first trace of in Post Pliocene.

199. Marsupials—the first mammals, appear in early Trias, prominent in Mesozoic ; significance of Marsupium.

200. Cetaceans, (*Zeuglodon*) marine.

201. Ungulata, both Perissodactyls and Artiodactyls, first appear in Eocene, and with modern families of Rhinoceros, Tapir, Horse, Swine, Musk-deer ; the other families nearly all represented before Pliocene.

202. Dinoceras, etc.

203. Proboscidiens, the three types appear in Miocene.

204. Carnivora ; first in Eocene, the perfect cats among the first ; almost all its families in Miocene.

205. Before the close of the Miocene all the orders of Mammals except Man have appeared.

206. Review of the history of Organisms :

^aProgress in organic structure coördinate with the geological development of the environment, ^bearly inhabitants purely marine, ^cthe presence of coasts, of fresh water from lands, of dry land, of air, each recorded in an increased complexity of structure, and a fuller specialization of organs for special functions.

207. The law of plasticity, and the consequent adaptability of organisms to environment.

208. The law of heredity, and the perpetuation by generation of ancestral characters.

- 209. Food and population, the survival of the fittest.
- 210. Death the natural result of performed function.
- 211. Gradual evolution of new forms by intensification of varietal peculiarities.
- 212. Initiation of new types of organisms.
- 213. All Nature, inorganic and organic, studied historically, points to an origin and a Cause.