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## CHAPTER XIV

### General conclusions

As these three books, *Age and Area*, *The Course of Evolution*, and *Birth and Spread of Plants*, form a more or less connected whole, representing much of a lifetime's work, we have given here a general connected account of our final conclusions, which are at least the result of over 40 years of work, devoted to finding out the laws that govern evolution and distribution, two subjects that are inextricably bound together; and they are arranged in sequence.

#### Evolution (1)

1. Evolution has not proceeded from below upwards in the way formerly supposed, except in the general way that the more complicated things are the more recent.

2. In its detail, it appears to have gone the other way, from larger down to smaller divisions of the vegetable kingdom, as first suggested by my friend Dr H. B. GUPPY, F. R. S. The work here described, especially that dealing with leaders of the various groups, seems to afford a very good proof of this contention.

3. It is working upon definite laws, which appear to have a largely mathematical basis, and is probably largely dependent upon chemical and electrical phenomena. It is thus coming into line with other mathematically based work.

4. It seems to have been a necessary consequence of the appearance of life upon the globe, which has been able to produce, by chemical and other reactions that do no harm to the living plant, all the variety shown.

5. It is now our task to find out how this has been done, to turn our activities into the most promising directions to quicken the process, and perhaps to learn to guide evolution to some extent.

6. We do not know whither nature by evolution is leading us, nor even if she has any definite aim in view. The former notion of "nature red in tooth and claw" is undoubtedly on the wane, and may perhaps be replaced by something of a more co-operative nature, as proposed by my friend Dr WHEELER (128), but evidence is not yet sufficient to decide so large a question.

7. Evolution did not go on by the casual picking up of new characters on the way by the selection of improvement in adaptation. The new characters were furnished according to law, probably the acquisition of one character making possible that of another on a later occasion.

8. YULE's work showed that the growth of a family or other group must be by divergent mutation with the *survival* of the parent, not its destruction, as formerly supposed. Hence our theory of dichotomous divergent mutation (DDM), whose essential features are given on p. 99.

9. The new form thus born was probably only a very few individuals, born from one or few parents. It would occupy but a small area, within or close to that of the parent (*cf. Ranunculus*, p. 65).

10. As the parent thus occupies much more area than the offspring, it will rarely if ever be killed out by any superiority that the latter may happen to possess.

11. The diminution of the emphasis and divergence of mutation as one comes downwards from family to species seems to suggest some kind of decrease in the energy available. It is perhaps best shown in large families, where the mutations have been more numerous. As my friend the late Dr Charles Balfour STEWART suggested, there may be some transfer of energy at every mutation, resulting in a small loss. This may have some bearing on Small's work on senescence and death of a species.

12. This type of evolution is so common and so well marked in all but a very few families (*cf. Monim.* or *Arac.*) that when it does not occur, one feels that there may be some simple explanation like polyphyly.

## Divergence

13. The first feature to show in evolution is divergence (p. 263). It is in fact one of the great marks of evolution. It often implies the acquisition of new characters in the child, seems to be automatic, and is probably electrically controlled.

14. Divergence shows right down to the smallest forms. We have seen it especially in Chaps. V, VI, and it shows in all characters, even in the most important (*cf.* fruit in *Ericaceae* pp. 368-9). It seems to become larger the further back into the past one goes. Above family level it seems to affect more characters at once, and it is very difficult to place a large family in its proper relationship to other large families.

15. The great differences of early days are more easily explained by large mutations. Natural selection could not make them larger upwards. Divergence was always one of DARWIN's great difficulties (p. 252).

16. On the other hand, the variety of divergence seems to increase downwards with the increasing number of characters. It is possible that each divergence makes others feasible.

17. Transition stages are few and far between. What are usually called such, like *Henriquezia*, are more correctly interminglings of complete characters, some of A and some of B, not intermediate stages between A and B in character. An alternate leaf seems usually to mutate directly to an opposite.

18. Mutations may be of any taxonomic rank.

19. The divergent features shown at mutation, like leaf alt./opp., anther extrorse/introrse, ovary superior/inferior, capsule/berry, and so on, *must* coalesce somewhere if one go far enough back into the ancestry (pp. 164-5). This means that the ancestor must have been carrying both the characters, or more probably, their potentialities.

20. Divergence is excellently well shown in the leading families, as is clearly to be seen from the lists of leading genera above. It also shows very well in the tables of endemics, WE in Chap. V, and WEE in Chap. VI.



21. Many divergences are so marked that they could only be formed by sudden mutation (pp. 105-7).

22. When a new divergence is added to preceding ones, it becomes of necessity one in a crowd that is continually on the increase, and so it is usually comparatively unimportant, like a single voter. But old characters that have been long handed down seem to become less liable to change with the passage of time, and become more important.

23. But any character is liable, so far as we can see, whether a family character or not, to change at any mutation, so that in a large family, one will hardly find any character that will certainly occur everywhere. Hence the constant use of such terms as usually, frequently, often, or, and so on, in taxonomic descriptions of families (p. 128).

24. The characters in use in small genera, not usually considered endemic unless their country of habitation is somewhat clearly marked off, are similar to those found in cases always admitted as endemic (pp. 129-32).

25. A divergence almost necessarily brings in a character not actually shown in the parent.

26. Every new genus, by reason of the divergence that occurs, is liable to need a new group for itself, but this is commoner in early genera than in late.

27. Divergent mutation is treated in more detail on pp. 164-194.

28. As a genus grows, therefore, it acquires a tail of satellites more or less resembling itself (p. 35).

29. We seem to have been trying to work evolution in a wrong direction.

30. The general relationship between members of the family at the same stage becomes closer the further back that one goes, though of course that between parent and child is the same everywhere.

31. The new form, by its divergence, will often be so structurally isolated from its parent that there will be no risk of loss by crossing, and it inherits local adaptation, so that it stands a very fair chance of survival.

32. On the whole, the largest divisions are the most ancient, being the first formed, and the smaller are the more recent.

33. Every firstborn representative of a family may be regarded as a genus, or a species, or both, at will.

### Selection and adaptation

34. Too much was left to chance in selection with adaptation. Evolution seems to be, not a matter of chance, but the result of a great thought or principle, which has worked itself out by law upon a definite plan like physics or chemistry.

35. Adaptation, advantage, and selection are discussed on pp. 317-22 more especially, and in many places elsewhere. Adaptation is born with a species (pp. 11-16) and improves later (pp. 13-14), and is primarily functional.

36. Selective adaptation has been made to explain everything, and has been worked too hard (p. 115).

37. The older theory now leads to little but speculation, and many difficulties are arising in its path (p. 42).

38. Adaptation and selection must now take a rather less important place than formerly.

39. Isolation becomes of more importance than hitherto, but at the same time the species begins with it.

40. Similar causes, acting upon similar plants, in similar surroundings, may produce similar results, as one may see in the cases of xerophytes or water plants.

41. Natural selection will not explain "success" or dispersal (pp. 11-14). The Mediterranean floras offer a formidable problem (p. 44), and it is very difficult under it to account for family or generic differences. It is primarily an individual problem; all As do not defeat all Bs (pp. 27-28). Gradual transition is needed with it (p. 98); it does not select species (p. 99), and could hardly produce the connections of characters seen (pp. 128-9).

### Struggle for existence

42. This is inevitable, by reason of excess of births.

43. It is not specific, and all As do not defeat all Bs, unless one species is composed, as in the case of a newcomer or a new species, of a very few individuals (p. 298).

44. A pioneer may gain a great advantage at the start, yet lose it again if something else turns up with a serious advantage (pp. 406-9).

45. One genus has little or no advantage over another, when they are taken in groups. Some may gain, or lose, by one quality, others by others.

46. Specific characters have evolved as a rule without relation to their possible value in the struggle for existence (de VRIES, pp. 254-5).

### Destruction

47. We have fought for a lifetime against the almost universal conception of wholesale destruction of transitions or intermediate types, which hardly seem to exist at all in the form of things showing intermediates in *characters* between two extremes.

48. The destruction of unnecessary individuals is one of a different kind, due to the inevitable struggle for existence, itself caused by the excess of births.

49. It is not a specific, but an individual struggle.

50. There is little evidence for dying out of species till they reach a great age, or are killed out by some catastrophe (pp. 35, 340).

51. Destruction cannot be called in in so light-hearted a way as used to be the case (pp. 231, 253).

52. There is, if anything, still less evidence for the extermination of genera, other than the very local ones that are the most common as fossils.

53. Destruction has usually been called in to account for the increased divergence at higher levels, but there is no good evidence for this. The great destruction is in the young species, before they have covered an area sufficiently large to make them fairly safe, and in the young of every species.

### Fossils

54. Fossils are dealt with on pp. 35-7, 57, 99, 169, 479.

55. Unless they are common and widespread, they cannot be considered as more than side-lines of evolution.

56. There is a remarkable absence among them of the innumerable transitions demanded under the conception of Darwinism.

## Evolution contd. (2)

57. One must remember now to reverse many of the directions in which we have been accustomed to look at the work of evolution. *Hieracium* and *Rubus*, for example, are not an exhibition of early stages in species formation, but the latest stages in it.

58. Evolution seems to go straight forward, but the vital and other factors cause deviations this way and that. It has no immediate adaptational basis (p. 109). Adaptation is by simple inheritance at birth, and not very different from that of the parent (p. 109). Once born, the new form slowly adapts itself to any necessary changes.

59. The appearance of characters is not a guiding cause of evolution, but a by-product (p. 131).

60. Mutation can cover any existing difference between parent and child.

61. Though evolution goes on as before after a mutation, it is not necessarily the same in detail after some deviation from the track caused by a vital or other factor.

62. There is no *necessary* reason that we can see why for example *Resedaceae* should be produced in a given line of descent, and if slight changes had been made in the ancestral processes by some outside influence, some now quite unknown family, the *Dubitaceae*, might have been evolved.

63. My working hypothesis, used successfully for 40 years, is given on pp. 96 (parent survives), 99, 310.

64. Selection is largely eliminated as a factor; it has never proved satisfactory.

65. The new form will often be so structurally isolated from its parent that there will be no risk of loss by crossing, and it inherits the local adaptation of its parent very closely.

66. The real evolution that is going on seems to be a case of internal rather than external reconstruction.

67. The latter is more of the nature of a compulsory change due to the former.

68. Each stage is a logical development of the preceding one.

69. The structural evidence for close relationship now loses some of its potency.

70. Each divergence seems to add new directions in which further divergences are possible, so that the number of possibilities is always increasing.

71. Evolution works by laws as yet not properly understood.

72. It is evident that formerly we have tried to a large extent to work evolution backwards, and we must now remember to look in a different direction at its work.

73. One must not yet expect to be able to predict the course of evolution, even in broad outline. One cannot even predict what will anywhere be the next mutation to appear. Cf. 62 above.

### Leaders and subleaders

74. We have pointed out in *Evol.*, Testcase XX, p. 134, that the largest genera tend to separate at the head of a family by an important divergence, and to go into different tribes. This has proved to be a practically universal rule.

75. The first mutation of the leader of a family usually produces a sub-leader, head of one of the sub-families or tribes. The early mutations of this tend to produce the leaders of sub-tribes, and so on right down to sub-species.

76. Each family, genus, or species, of more than very small size is generally broken up into sub-groups by structural, usually markedly divergent, characters, each group of course being led by its largest member.

77. A tribe or genus, therefore, begins with A, whose immediate progeny B more often than not belongs to another sub-group.

78. The formation of these sub-heads is usually an event that follows the formation of the heads as closely as may be, as may be seen in the many lists that we have given of the top-most parts of families and genera (list in Index under Leaders), like the *Compositae* on pp. 173-82, or the *Saxifragas* on p. 428. In the case of species, we must take the area covered as an equivalent for the size.

79. This fact is shown for all the larger families in the table on p. 173, which shows clearly that all the big early genera tend to be well separated, and so to give the characters to the sub-groups, as the parent did to the whole family.



Each tribe takes for itself some of the characters with which the parent began.

80. This system of the formation of sub-leaders from the early descendants of a leader is so universal that it may be called a law of evolution (p. 331).

81. It is incompatible with the view of evolution "Darwinism" that has been so long accepted, but harmonises well with the "downward" theory of evolutionary development that the author has put forward in his writings for many years.

82. The way in which tribes &c are headed by their earliest born in this divergent way is a convincing proof of the writer's deductions on the subject of evolution; *cf.* *Evol.*, p. 134 (Testcase XX).

83. The effect of this early formation of sub-leaders is seen in the widespread fact that in nearly all cases we find a great representation of these leaders (p. 173). In BRITAIN, for instance, we find eight tribes of the thirteen in the *Gramineae*, and in CEYLON twelve. The flora of any one country tends to show many of the subdivisions of families and of genera (p. 172). The newer genera tend to fall away from the standard type of the leader (p. 173).

84. Such dispersal, in the writer's opinion, *cannot* be determined by selection or by adaptation, but must be due to subdivision by divergence at the earliest opportunity, so that most sub-groups had the time necessary for wide dispersal.

85. The younger genera, being formed by early divergence from the leader, tend to fall away from the type set up by it, and to become less closely related to it, structurally, genetically, and geographically, the younger and smaller that they are (p. 175).

86. The marking of a large group, to which we often give a special name like *Cynareae* or *Eu-galium*, is usually due to the formation at a far back period of some combination of characters that has since remained to a reasonable extent unbroken, and has thus formed the characters of a family, &c.

87. The oldest tribes, especially in large (old) families, do not show numbers and sizes of smaller genera to suit the leader, the suggestion being that this is due to many of these smaller genera having in their turn become the leaders of other and smaller groups (pp. 187-8).

88. If the family spreads into many and different types of country and conditions, as do *Compositae* or *Gramineae*, the real leader (the largest genus) is often left behind in various places, especially in markedly warmer or colder climates (pp. 192-3).

89. The leading families show very wide divergences from one another (pp. 330, 428-9).

90. The British families that lack their real leader are very largely tropical in origin (p. 193).

91. No selection or adaptation that one can conceive, it seems to the writer, could make the species of a genus behave as we have shown that they do on pp. 427-8, with the leaders of the sub-genera so closely following one another.

### Taxonomy

92. Classification of plants is dealt with on p. 322.

93. For practical purposes we must make some kind of grouping of the members of the vast dichotomous branching that has gone on, which is combined with the transmission of characters in such a way that the parental characters are the most likely to appear, though mixed with the divergences.

94. A really natural, genetic, structural, and geographic system of classification would be of much value, like a chromosome map, were we able to construct it, but we must remember that we need, for purposes of identification, the most convenient, practical, and easily handled system that can be devised, whether it be natural or not. The general principles that guide our present system are well described by HITCHCOCK (cf. p. 309).

95. The rules of taxonomy are of necessity different from those of descent (p. 308).

96. Much of our taxonomic classification is necessarily artificial, whenever a certain character or characters depart from the direct hereditary line, putting in an appearance somewhere else. It must also necessarily be artificial when it has to group together, as agreeing structurally, things that are really only horizontally and not vertically related, by the appearance of the same or very similar characters in both. A natural classification obviously cannot be constructed upon a structural basis alone (pp. 141-5).



97. Classification is based upon divergences within divergences. The first thing that nature does is to provide the divergences, the oldest being the most comprehensive and widespread, the youngest the least so (*cf.* Leaders). But the geographical divergences do not agree of necessity with the structural, nor either with the genetic, though it is becoming clear that all are of great importance.

98. Descent is vertical, and each genus in turn heads all its own descendants, though not, of course, those of its parent, which also survives, and has its own line of descendants. We divide all the descendants somewhat artificially by certain characters that appear with varying degrees of emphasis, of persistence, and dispersal. Classification, which to be natural should follow the natural genetic lines, is often compelled to follow horizontal lines of structural relationship. It cannot depend only on structure (p. 217), but must take note of geography, genetics, and divergence.

99. Structural alliance may completely ignore geographical difficulties, and very often the sub-divisions of families cannot be made to agree with their dispersal (pp. 339-40).

100. In spite of great splitting, no proper harmony can be made between structure and geography; it would need destruction inconceivably extensive and selectively efficient (pp. 150-1, 193, 272).

101. Arithmetic regularity (hollow curves) tends to disappear when a large group is taxonomically split up. *Cf.* p. 215 with the taxonomic division of *Acanthaceae*, and *cf.* also *Monimiaceae* and *Araceae*. The two leading *Monimiaceae* are widely separated structurally, but agree very well geographically. The discrepancy is often considerable in such cases; *cf.* *Rhamnus* and *Siparuna*, p. 353.

102. Taxonomy based solely upon structural relationships cannot be generally reconciled with DDM or with dispersal (pp. 150-1, 339).

103. It is of interest to look at the different groupings of the *Monimiaceae* (pp. 228-31 &c).

104. It is becoming clear that geographical and genetic relationships are as important as structural (p. 205).

105. There is no special relationship in the ecological communities (p. 7).

106. Classification is most natural in small groups like

the *Hieracia* or the *Rubi*, though even there we are no longer sure of our position (p. 264).

107. Relationship gets closer as one follows a family or a genus back to its head, much upon the same lines as in human descent, so that a natural classification would be too complicated for practical use.

108. The large families cover the taxonomic field very well by themselves alone, while the smaller, largely satellites of the large, squeeze in between them (p. 330).

109. The earliest genera trace out the lines of the taxonomic division of the family.

110. Above the family level the difficulty of making a natural classification of the families (into orders) increases, and shuffling is always going on (pp. 323-36).

111. The difficulty of placing a family increases with the size of the head (p. 357).

112. The history and taxonomy of a family is largely determined by the few genera at its head (p. 358 seq.).

113. The combinations of characters that mark families are largely "chance", though probably governed by a complex system of laws. Permutations and combinations of characters, polyphyly and other phenomena probably interfere largely with the simplicity of the matter, and the formation of complexes in the larger genera is another source of confusion (pp. 211, 299, 369, &c.).

114. There is now no special reason why the whole tree of a family should not exist upon the earth at the present moment (AA, 240).

115. There is no longer the need that existed formerly, to search for transitions (pp. 169, 298, 314, 332-3, &c.).

116. There is no need to call in geographical destruction as formerly (p. 118).

### Characters

117. The behaviour of specific and generic characters, about which so little is known, needs early investigation in detail.

118. Evolution seems to have been a vast dichotomy, with the characters either handed right down, or acquired on the way, largely as divergences, perhaps some by selection.

119. They seem to obey the rules of what may be a super-Mendelism (p. 134).

120. Until we can trace some laws, we are working in the dark (pp. 190, 355 seq.).

121. It is becoming clear that the acquisition of new characters was not casual by selection, but genetically, by law, from above (p. 263).

122. The incidence of character was governed by what at present we can only call chance, but which has law behind it (pp. 361-5); acquisition by selection was probably rare (pp. 298-9).

123. The characters of a family seem at present a chance lot determined by previous changes in the ancestral history, and that remained comparatively fixed in the heredity (p. 299-300).

124. The potentialities of all characters are handed down by heredity.

125. They are apparently developed by the action of conditions, probably mostly external, upon certain internal characters.

126. The distribution of characters at birth is evidently not unlike that at the birth of human individuals, and similar rules probably apply to animals.

127. The early mutations produce the most "important" characters (p. 336).

128. The larger a genus, the greater the range of its characters (p. 364).

129. Geographical separation also occurs with the same character (p. 209), and is frequently due to the presence of a linking overrider (cf. p. 232).

130. Species are more numerous than "important" characters, so that permutations and combinations of the latter are needed (pp. 189).

131. In larger families especially, one often finds unexpected characters turning up. Often they come from other families, date far back, and must have been carried as recessives.

132. Most characters found in a family may appear anywhere in it, and sometimes elsewhere, and at any time (pp. 131-6, 211-13), but most commonly in related forms.

133. Characters of one family may appear in another, though usually with less frequency. All, or their potentialities, are probably present in the leader (pp. 143-151, 367).

134. The first characters of division of *Acanthaceae* and others occur in other families, but with varying degrees of importance, due to different age, in each (pp. 193-5).

135. The larger the family, the greater the probability of exceptions among the younger members (p. 311).

136. There is a great lack of transitions between characters and often the differences are such that they could only have come by divergence (p. 367).

137. The value of a character depends upon its absolute age from its first appearance, and also even more upon the number of descendants that show it (pp. 128, 222-5). It is often confined to the family or group where it first appears.

138. It seems not unlikely that the increasing number and dispersal of characters is a law of the continual production of new characters, and the continually extending use of permutations and combinations of them, used kaleidoscopically.

139. The importance of a character in one family is no guide whatever to its age or importance in another, unless in a few cases where the families are closely related; and not necessarily even then.

140. Teratology (pp. 100-05), which brings up awkward difficulties for selectionists, seems to prove that any species may be carrying a great number of "recessive" characters, which may at any time appear unexpectedly in that family.

141. It is also a proof that a character, though not visible in the parent, may be given complete and perfect to the child (p. 104).

### Size in the world

142. The law of size and space is described on p. 19; its operations are shown on p. 201. Size in the world is a character of very great importance (p. 190). The system upon which the sizes in my *Dictionary* were prepared is described on p. 190.

143. The range of dispersal in BRITAIN goes largely with the size of the genera in the world. A comparison of the

sizes of *Cruciferae* and *Umbelliferae* in BRITAIN and in FRANCE, which shows features of interest, is upon pp. 50-51.

144. The first genus in the world in a family is on the whole about twice the size of the second (p. 191). Generic sizes are considered on pp. 333-6, 350.

145. The law of "to him that hath" is of importance in this connection.

146. Duplicates in size tend to run in different lines of descent (pp. 191, 219-20).

147. Very old families may be smaller by reason of lack of characters upon which to draw (pp. 336, 344). This may also account for the shrinkage in sizes sometimes seen as one gets near the top (p. 327-8).

140. Size of a genus has been completely neglected as a generic character, yet is proving (as marking age) to be one of the most important.

### Mutations

149. The mutation that is going on seems, so far as we can see at present, to be a casual choice of characters (p. 324).

150. There is probably some general law at the back of incidence of mutations (p. 226).

151. Early mutations in a family &c seem to be of higher rank, or at least they have more descendants, and so are of more "importance", than the later (p. 170-1).

152. The mutation division of the cell is probably electrically controlled (C. Balfour STEWART), p. 164.

153. Mutation is easier (more change), apparently, in water plants, saprophytes, and other such things as have a more plastic consistency (p. 240).

154. Larger size of a genus offers more opportunity for change (p. 302).

155. Usually the result of a mutation appears to be neutral as regards its reactions to the outside world, but if the change of conditions is going on in a definite direction there is usually a definite tendency in the mutations to be in directions favourable to that, but whether this is due to compulsion, to encouragement of favourable mutations, or to the killing off of unfavourable, we do not know (p. 302).



156. Kaleidoscopic mutation is considered at p. 376 and elsewhere.

157. What seems to go on in mutation at birth of a new form seems suggested by the phenomena of a kaleidoscope. The differently coloured pieces of glass continually take up different relative positions, as if it simply happened so.

158. A very slight accidental change in the formation of A might result in a more different B, and so on. Except that some character is furnished to every organ, the characters of a species seem a casual assortment, except when under certain stresses of conditions, such as increasing dryness, evolution is going in a certain direction.

### Hollow curves

159. Hollow curves are formed, both for number of species and for area occupied. They appear to increase by compound interest, inasmuch as the parent survives, as well as the offspring (p. 192). This is the necessary result of DDM, as YULE showed (158). Cf. also pp. 305-9.

160. An accumulation of young genera forms at the foot, by reason of the continually increasing number of possible parents.

161. As the family grows in size, the curve lengthens at both ends (p. 34). The great bulk of the species are in the large genera at the top, and there are wide gaps between the top genera, increasing with the age of the family. A good example may be seen in the *Podostemaceae* (*Evol.* p. 19) where the local genera must be the younger, and are most dorsiventral; plagiotropism is always hard at work, and its results show best in the youngest genera.

162. See also Testcases I-VIII in *Evol.* and Chaps. XII, XIII.

### Genetics

163. The rules of genetic descent are necessarily different from those of taxonomy (p. 322).

164. The closest genetic relationship is at the top of a family, where the structural divergence is the greatest (pp. 188, 206-7).

165. So long as taxonomy tries to be genetic, it lays itself open to criticism that is extremely difficult to meet (p. 341).

166. A genetic system of classification would be too complicated for practical use (p. 175).

167. Something of a "super-Mendelian" nature is indicated as a probable line for a discovery of the laws of incidence of characters (p. 134). Pollen patterns (p. 210) suggest themselves as useful material for such a study.

168. Old ideas of relationship based solely upon structure will have to be revised.

### Polyphyly

169. Now that the former facile explanation of so many features of evolution, that they were due to destruction of intermediate or transition forms, seems no longer to be available for universal use in difficulty, polyphyly, or development from different, though usually allied, ancestors, is the most feasible.

170. But it is very important that this explanation should not be used until all others possible have been tried, and inductively tested, otherwise it will soon fall to the same level of disrepute as its much overworked predecessor.

171. Possible cases are given on pp. 41, 151, 157, 196-7, 354, 369 seq. &c. And it is very probable that both *Monocots* and *Sympetalae* are made up of two or more groups each of different ancestry.

172. Some characters of allied families may appear at times in other families, but are less frequent and perhaps less important than the appearance of the same character in different places in the same family.

173. If mutation be kaleidoscopic, one will expect fairly frequent polyphyly.

174. Overriding genera probably produce many cases.

### Distribution

175. Distribution is a dynamic subject, and is always going on. There is no proof that leaders missing in BRITAIN, like *Hibiscus* for example, cannot reach there in time (p. 49).



176. Time, or age, is the essential feature of distribution.

177. The laws of geographical distribution, and some of its general features, are discussed on pp. 480 seq.

178. The subject must now be treated in consonance with the newer conception of evolution that we have brought up.

179. Dispersal is much more mechanical than has hitherto been supposed. Evolution and dispersal seem to proceed in a simple arithmetical way by law.

180. The vital factors make continual deviations in the straight line of evolution, but their action is much more local and variable than that of the mechanical factors.

181. Spread is largely mechanical, depending upon how rapidly each species can overcome the barriers that hinder its dispersal; and it becomes more rapid as time goes on (*AA*, p. 34).

182. Dispersal is largely governed by the laws of *ASA* (pp. 23, 50, 87, 303).

183. Age is largely accompanied by size in the world (pp. 25, 85). It is a factor of very great importance (p. 321), as it allows the time necessary for any change. It makes real as opposed to structural discontinuity. It makes the importance of a character. It allows increase of area occupied. It provides more choice of characters. Age in the family is dealt with on p. 218 seq.

184. Younger genera follow the laws of *ASA* most closely, as in their case there has not been time for the effects of great geological and other changes to show to their full extent (p. 256-7).

185. Dispersal of a new form will in general be regulated by the laws of *ASA*, but it is safer to take several species together, to cancel out the effects of local factors.

186. There is no question that the simple mechanical explanation provided by the laws of *ASA* does much more to explain the facts of dispersal in long time on large areas than any vital cause.

187. Plant dispersal is coming into line with human, and they should be studied side by side (cf. *GUPPY* in 162, *WILLIS* on names in *Canton VAUD* (153, p. 35 foot), and the work especially of *PEARL* and others in *AMERICA*).

188. Discontinuous dispersal, real and structural, is dealt with on pp. 89-94; also 66. Some may be due to polyphyly.

189. Barriers are among the most important factors to be reckoned with in distribution. Though negative, they have very great influence upon the rate at which plants travel and they tend to have a different effect in each case (p. 45, and *AA* espec. Ch. V).

190. The things left behind at a barrier are the smaller and more local things (p. 46).

191. The British flora is mainly a reduced French flora, the Irish a reduced British, and so on (p. 48).

192. It is clear that delay, and not acceleration, of spread has been the general rule (*AA*, p. 53).

193. Migration to and fro in regions towards the poles probably killed out many smaller things that could not move quickly enough, or that had very limited areas (p. 36), Mrs. REID's Pliocene flora gives an idea of some of the replacements effected (p. 36).

194. If we take things by geographical relationship, we get a good deal of taxonomic scattering, if by taxonomic of geographical. Roughly speaking there is little or no selection of one character as against another, so that geographical propinquity with close structural similarity commonly means real relationship, though overriding genera may bring in some confusion.

195. Taxonomic relationship, on the other hand, depends upon structure, which may be divergently changed at any single mutation, so that it must remain, almost of necessity, more or less artificial in various places, while to bring in all geographical and genetic characters would make it too cumbrous for practical use.

196. The effect that may be produced by an overriding genus is described on p. 147 seq.

197. The facts of distribution clash violently with the Darwinian explanation (p. 28).

198. Large genera tend in any country to overlap the smaller in area of distribution, whether in large or in small size of area, *e.g.* in *Arac.* pp. 267-72.

199. Outlying genera tend to be the largest, because the oldest (pp. 29, 45-6).

200. The bulk of the species of small dispersal occur in the larger genera (pp. 21-2).

201. Small dispersal usually means late arrival, or recent birth (pp. 11, 21-2).

202. YULE's description of a geological "cataclysm", which is referred to on p. 219, should be read.

203. A genus usually thins out to a leader, not necessarily *the* leader, at the edge (p. 45-6).

204. Examples are given under *Acanthaceae* (p. 198), and on pp. 444-6 of the way in which we have treated families under the new rule of ASA.

205. Migration from one country to another is generally by means of land transport. Water transport is almost negligible (*AA* pp. 14, 17, 36).

206. British species are usually very widely distributed, BRITAIN being an outlying and also young island in which there has been no time for the formation of local endemics, so that it is mainly populated by the oldest species of any genus except those of warm climates. The dispersal of the British flora is mainly regulated by the laws of ASA.

207. The British flora includes numerous leaders, and shows a high average of size, while the floras of FRANCE and SPAIN are definitely lower in average size, with many more small genera (pp. 51-2).

208. Distribution in BRITAIN goes largely with the size in the world of the genera concerned (pp. 83-5).

209. The dispersal of the British flora is largely mechanical (p. 38).

210. BRITAIN, FRANCE, SPAIN and the BALKANS are compared on p. 47.

211. A number of interesting facts are brought out about islands, on pp. 464-78.

212. One of the most interesting is the proof of how largely the SEYCHELLES flora (p. 469) shows leaders, especially in *Rubiaceae*, one of the oldest families, if not the oldest, present.

213. Mountains (pp. 458 seq.) also show many interesting features. The ascent of a high mountain, with its rapid alteration of the flora, gives a picture of the rapidly increasing and changing stress of the changing conditions. The climb to the summit reminds one of what one sees on a journey very far north.

214. Owing to the possibility of further transport being destroyed, there tends to be an accumulation of species at the top of the list of the flora of a country (pp. 23-4).

## Endemism

215. No explanation of distribution that does not explain endemism is of value (p. 63).

216. Endemism is not a casual phenomenon, but obeys definite laws, and is open to inductive study (p. 76).

217. We have now studied endemism for 50 years, and have no doubt whatever that in the great majority of cases endemics are simply the early stages of dispersal of species that as yet have not had the time or the opportunity to spread far. They are simply young beginners as species or genera (p. 64).

218. They are discussed in Chaps. V, VI, p. 95, and the genera in Chap. VII, p. 137. These follow the same rules as species.

219. The characters of an endemic must have come from its parent, whether there shown *or not* (p. 106). The divergences between the wide and the endemic offspring are well shown in CEYLON in the contrasts given in the lists on pp. 111-113 and 121-7.

220. No two people agree as to what shall be the upward limit of size for an endemic.

221. No line can be drawn to separate a "wide" from an "endemic" (p. 139). The tables of *Acanthaceae* show how difficult it is to do so, and the table of *Cynareae* shows how the wide genera at the top pass gradually into the endemic genera at the foot (p. 445).

222. Endemics show no inferiority whatever to other species, whether of small or of large genera. They occupy smaller areas on the whole because they have had no time, or sometimes no opportunity, to spread further. They are more common in the large and widely distributed families (p. 75), and are much more common in mountainous or broken areas, where conditions readily differ from point to point.

223. A plant newly arrived in a country will behave there like an endemic, with slow establishment and dispersal.

224. Small genera everywhere usually agree with endemics in all respects, except in such special cases as water-

plants, where the uniformity of conditions allows of very wide spread with very few species.

225. Endemism in the old world largely ends at the great mountain boundary from the PYRENEES to the mountains of CHINA. The boundary is much less marked in the new world and in the southern hemisphere. North of the great transcontinental range the floras are in general too young to have had the time for development of endemism.

226. Real relics are rare, and are mostly in places that were sufficiently near to the ice of the glacial period for the cold to kill out some species and to leave others untouched. They are discussed upon pp. 106, 114, 129, 254, 257-8, 318.

227. There is a definite relationship between one Mediterranean country and another, or between CEYLON and MADRAS, or other places not too far apart (pp. 64-87).

228. Relationships between southern endemism and the composition of the British flora are well marked (pp. 82-3).

### Chemistry and economic botany

229. Chemical analogies, which are very suggestive, are dealt with (with the assistance of my cousin the Comte de CHANAZ) on p. 372. The laws that seem to do much of the government of matters are so simple that one might expect that they originated in laws of the chemical and other phenomena going on prior to the advent of life, that were modified to suit the new conditions.

230. There are certain parallelisms with what goes on in chemistry (p. 374).

231. A good deal of importance in regard to the much neglected subject of economic botany seems to attach to the reversal of the direction of evolution. If we can get an approximate idea of the course followed by the evolution of any plant producing something economically valuable, like rubber for example, we can begin to study the chemical evolution of it, and trace out ways of making it artificially. We have already brought this subject up in *Evol.*, pp. 8, 89, 169 (top), 177 (middle).



### Final

232. We have, we think, now shown the value which inductive study may have when applied to geographical distribution, which has for so long been simply a happy hunting ground for the speculatively inclined.

233. We are also inclined to think that our study of this subject, together with its associated subject, evolution, has not been altogether fruitless, but has shown many promising paths in which useful work may be done, as well as placing geographical botany upon a path in which progress seems possible without speculation.

234. Our theories, now well supported by facts, explain easily many of the difficulties whose pressure has been increasing, like the apparently purposeless nature of many differences, the wide structural discontinuities often seen between species living near together, the increase of divergence as one goes upwards, and so on.

235. Our work proves the general truth of *AA* and of *Evol.*, and of the laws of *ASA* and of *DDM*, which prove to be the chief laws that govern the whole subject, and whose acceptance brings about a very noteworthy change in our ways of viewing it. Other laws are also added to them, but they seem to be the chief laws of dispersal and of evolution.

236. The success of all the predictions made by the aid of the sub-conscious mind (pp. 97, 248-9, 482), at least a thousand in number, has added enormously to our confidence that in this work we have been working upon sound lines, and this confidence has also been added to by the fact that illustrations of anything under discussion could always be obtained from any book that happened to be lying upon the table (pp. 97-8), without any need to search for examples.

