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Introduction

Except in places where conditions are too extreme for growth, the world is covered with vegetation, usually showing much variety of density and form. Many problems are thus set before us. Why, how, where, and when did all these forms arise, and why, how, whence, and when, did they settle in the spots that they now occupy? Complete answers to all these complicated enquiries obviously involve great and varied knowledge of many branches of science, and can only result from long inductive study.

The present work is an attempt to answer some of these questions, in part at least, and to show that inductive methods may be applied here, as elsewhere in science, with promising results. The earlier history of many of these problems lies in the realm of evolution, the later in that of ecology, which has now become an almost independent science. Geographical botany, or geographical distribution, properly so called, has to fill up the gap in knowledge between these two, and to trace the how and the why, the whence and the when, of the movements of plants from the time of their conception and birth.

Each species (or other form) seems to have been born in some small and definite locality, in which there were certain conditions of life at the moment of birth, and they were of necessity adapted to these, or they could not have survived. It is in fact almost certain that this local adaptation to the birthplace must have been derived from the immediate ancestor, from which they showed at times a definite structural divergence, sometimes enough to give to the offspring a different taxonomic position, whether varietal, specific, generic, or even higher. This change probably happened under some special stress of conditions, which involved some genic change or rearrangement.

Obviously one of the first things that must be known, if one is to work out these problems satisfactorily, is how plants began life, or how and why, where and when, they were evolved. The pre-Darwinian view was that they were created for the localities where they were found. Some, the "successful" ones, had enlarged their area of distribution, some, the "unsuccessful", had lost some of it. With the coming of the Darwinian theory that evolution went on in response to gradual improvements in adaptation made by slow structural alteration, the creed of "Darwinism" sprang up, and FLEEMING JENKIN's criticism being accepted, it was assumed that species began upon considerable areas, rather than upon small ones. This view of the matter has been altered with the work of the writer and of others. Under it, it became usual to look upon things of very small areas as "relics" of former vegetation, the remains of things once covering large spaces. Endemics, though there are numerous exceptions, especially near those regions that were affected by the ice of the glacial periods, proved to be in general young beginners as species or genera. Their numbers, starting with a single leader at the top of a family, increase downwards, slowly at first, and then very rapidly in the smaller ones near the foot, ending there with a great proportion of ones, usually well above one third of the whole total. They thus form the familiar "hollow curve", for the number of possible parents increases at every stage, and the offspring must necessarily begin as "ones". The curve shows in many different kinds of distribution, for example that of farmers'surnames both in BRITAIN and in SWITZERLAND (*Evol.*, p. 35). On the same page are the figures of sizes of genera in the *Monimiaceae*, showing how they form the hollow curve, and one may see it in many tables in this book, for example the *Ranunculaceae* on pp. 30-1, or the many in *AA* or *Evol.*

The universal display of hollow curves was fatal to the idea of general relicdom. It showed that the formation and dispersal of endemics represented in nearly all cases simply the earliest stages in the history of individual species or genera. They began in one place, or possibly sometimes more than one, and their dispersal followed simple arithmetical lines, the area occupied, and the size (number of species) increasing with the age. From these two laws of age and area, and age and size, the third, of size and space, follows automatically, the three forming what we have called the laws of ASA, which are universal, and are fundamental in distribution. Area and size are simply functions of the time elapsed, but of course their rate of operation varies with the type of plant, and one can only use closely related and similar things for comparisons.

The leader of a family (its largest genus) seems to carry with it the potentialities of all the characters that may later appear in that family (and at times in other families also), but which characters shall appear seems to be largely determined by outside conditions. Divergence of structural character usually appears in one or more of the characters at every mutation, and may be said to be the mark of evolution. It becomes less marked, but more frequent (by reason largely of increasing numbers), as time goes on, and we come downward from the rare and great divergences that separated such things as ferns and mosses, or conifers and flowering plants.

Our work also indicates clearly that evolution, as we have already shown in *Evol.*, works *downwards* from larger divergences to smaller, and not, as hitherto supposed, in the upward direction. The leader of a family (its largest genus, as a rule) is the first to appear, and is early followed by the leaders of tribes, these by leaders of sub-tribes, and so on down to sub-species. Dichotomous divergence appears at every mutation, but with a gradually decreasing emphasis. We have therefore called this law the law of DDM, or dichotomous divergent mutation, and we look upon these four laws of ASA and DDM as those which have chiefly guided the appearance and the dispersal of the various plants that cover the world. Evolution, which seems as if it might be electrically controlled (thus accounting for divergence) seems to be more or less completely independent of selection. Structural changes rarely have any serious adaptational importance, and distribution goes on in a more or less mechanical way, with little reference to adaptation or selection, but with the importance of these increasing as time goes on, and the ground gets more and more occupied by a variety of plants. The vital factors, unimportant in early days, assume great importance in the last stages of distribution.

As the deductions which the author formed from these four fundamental laws, largely by aid of the subconscious, always proved to be correct, within reasonable limits, when tested on the actual facts, the writer's confidence in the general correctness of his work has been much strengthened. For example, it was deduced that the early mutations of the leader of a family should tend largely to head large divisions of that family, and the same in the case of a genus. This proved to be an almost universal law, which is illustrated here by many tables (list in Index under Leaders). Incidentally, it shows how taxonomic division, which must of necessity follow the structural divergences, is not, and cannot be, always quite natural, in the genetic sense. Coming downwards, the divergences diminish, and close relationship is more easily made out, while parent and child, at the top of a family, may easily be separated by a divergence of sub-family rank.

In this book we have not tried to apply any of our conclusions to the animal world. But that they may probably be so applied, perhaps with some necessary alterations or modifications, is very likely. We have seen in *AA*, p. 200, that the principle of the hollow curve seems to apply to zoology as well as to botany, and this seems to render it likely that the other more or less mechanical laws which we have worked out for the vegetable kingdom will also apply to the animal; but this question must be left to the zoologists.

Some interesting facts, again, are brought out in the section upon island floras in Chap. XIII. The *Rubiaceae* are obviously one of the oldest families in the world, and especially in the tropics, and it is very striking to see the way in which the leader of the family, and the leaders of the sub-groups, are so marked a feature in the floras of islands in the warmer parts of the world, where in general the island floras must be among the oldest of all. There are 13 genera of *Rubiaceae* in the SEYCHELLES, and they include seven leaders of tribes, one of which is *Psychotria*, the leader of the whole family. Of the other six, five are either second or fourth in one of these tribes, and there is only one small genus (of MALAYA) that can possibly be put down to accidental introduction, most likely by water. Other tropical islands show the same kind of thing. CEYLON, a much more recent island, shows eleven leaders, eighteen genera from second to ninth in their tribes, and sixteen smaller ones. This phenomenon, which is a rule in tropical islands, seems to the writer a final and striking proof of the origin of sub-families, tribes, genera, and species by the downward evolution that he has postulated for 40 years, and makes a little change in our methods of viewing the phenomena of the plant world.

Many other things of interest have come up in the course of this work, and it is evident that the acceptance of our conclusions will open up many new avenues for research. In the first chapter, for example, a number of new problems appear in regard to the British flora, and much the same may be said of most of the other chapters. Perhaps the most obvious thing that needs detailed and far-reaching investigation is the incidence of characters, with its diminishing emphasis as one comes down from the far past to more recent times. This, with the evidence that we have given of the probable commonness of polyphyly, and of the very frequent occurrence of the same character in widely separated places, rather indicates that the evolutionary tree requires a good deal of pruning, not to say coppicing. The facts suggest that there are some important discoveries to be made in the region of genetics.

There are many directions in which useful work may be done. Once one has become used to treating evolution the other way round, so to speak, one realises that many subjects need a considerable revision to bring them into line again with evolution in its new aspect. In this connection, it is worth while to read the chapter in *AA* by Dr GUPPY on p. 101, especially his remarks upon p. 104, and the sentence on p. 105, where he says that " new and unexpected fields of research will be opened up all around him ".

The writer, who will reach 81 in the following February (1949), and is now too old for hard work, has collected great masses of statistics during his lifetime, and if good secretarial help can be obtained, hopes to put them into good shape, and to leave copies to the great botanical institutes of the world, with a view to saving labour in the future. Revision, and not first collection, will be all that they will need.