The MATTER of MENDELIAN HEREDITY

LEWIS & JOHN

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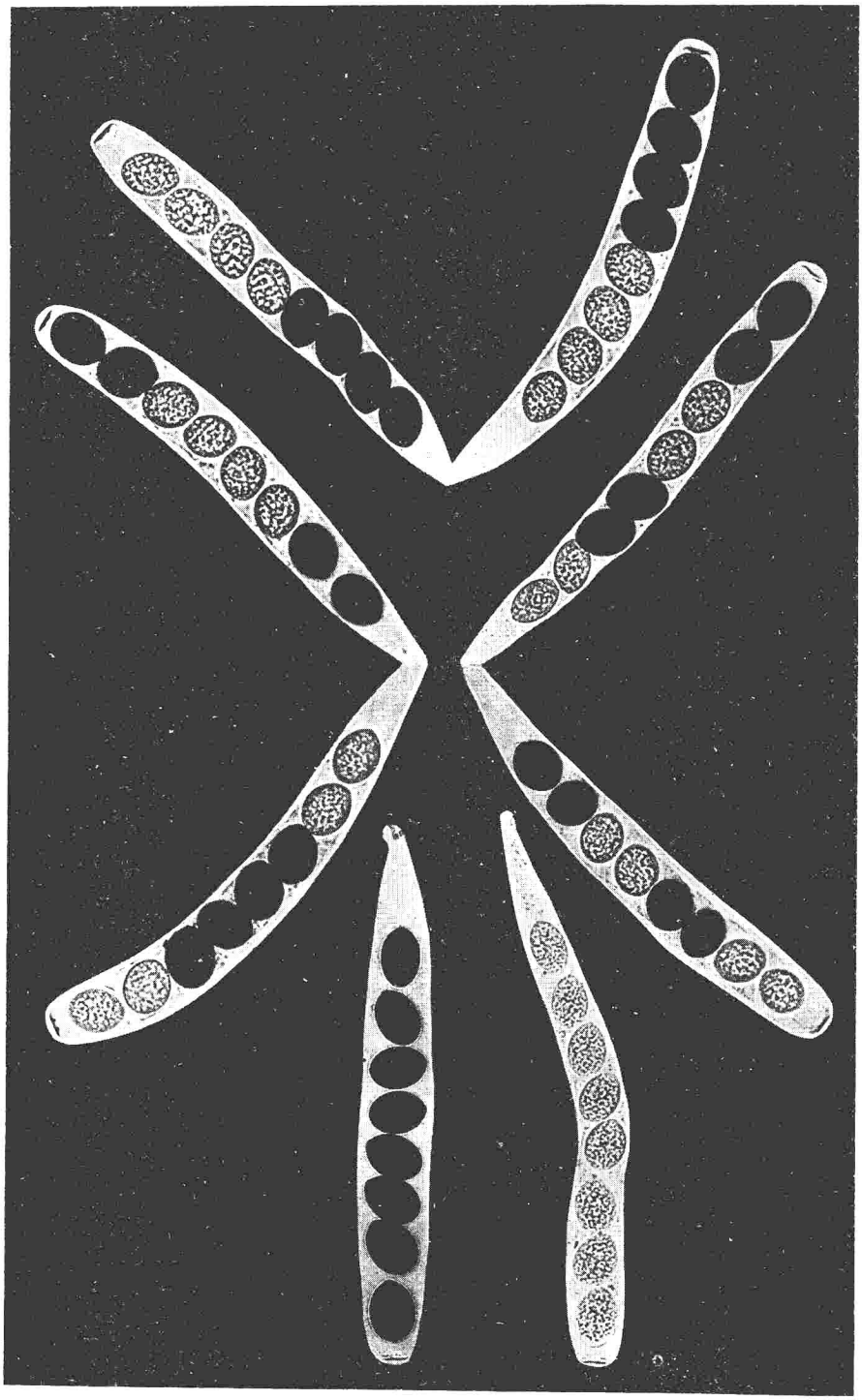
FRONTISPIECE

Spore segregation patterns in *Sordaria* (compare with Fig. 18, p. 60). Photographs kindly supplied by the department of Agricultural Botany, University College of Wales, Aberystwyth.



This book is for those who have yet to rediscover the particles and paradoxes of mendelian heredity and is dedicated to those who benefit by reading it.

"Mendel's clue has shown the way into a realm of nature which for surprising novelty and adventure is hardly to be excelled."

"Experimental breeding . . . enables us to put questions to Nature which never have been put before. She, it has been said, is an unwilling Witness. Our questions must be shaped in such a way that the only possible answer is a direct 'yes' or a direct 'no'. By putting such questions we have received some astonishing answers which go far below the surface. Amazing though they may be, they are nevertheless true; for though our witness may prevaricate, she cannot lie."

WILLIAM BATESON.

THE MATTER OF
Mendelian Heredity

By

K. R. LEWIS and B. JOHN

M.A., Ph.D.
University Lecturer
Botany School
University of Oxford

M.Sc., Ph.D.
Senior Lecturer in Cytology
Genetics Department
University of Birmingham

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Chapter 5. Chance, Choice and Change

Prelude

> "The text is designed for the student beginning the subject. We trust that a study of it will bring him to the classroom prepared for a discussion of the topics and we also trust that this work of preparation will tax him to the full measure of his intellectual capacity. . . . Work that simply entertains or imparts information . . . can be of little permanent value or make for any considerable development."
>
> C. C. CURTIS

It is often claimed that mendelism was rediscovered at the beginning of this century. Certainly Mendel's results were confirmed and the importance of his contribution was proclaimed at this time by both Correns in Germany and von Tschermak in Austria. But even the immediate consequences for biology—to say nothing of the far-reaching sociological implications—were not appreciated for many years afterwards and, even then, only by the few.

Rediscovery for biology did not mean rediscovery by all biologists. Indeed, there are to this day many who have received an extensive instruction in biology —indeed, there are even those who give such instruction—and who know of, though not about, words like heterozygote and diplotene but have yet to discover the matter of mendelian heredity. This book could be useful to them. But, since one cannot learn what one thinks one already knows, we are more concerned with those who are new to the mendelian situation. In our experience, however, students, even when they arrive at university, feel they already know all there is to know about mendelian heredity, mitosis and meiosis—"we did them at school". We suspect that they even feel slighted when they find they are going to study these things again. This second helping is, however, necessary. And its principal function is not to convey additional information but rather to correct misconceptions. Admittedly unlearning is a part and prelude of learning and we are faced with it all our lives. But many of the things a young student has to unlearn should never have been taught him in the first place. And this is particularly true of much of the information he is given concerning mendelian heredity and its material basis. No aspect of biology receives a more shoddy treatment in schools, colleges or even universities. We hope this book will help to correct this state of affairs for the second helping should not be necessary. This book, then, is intended mainly for the student and those who teach him.

We realize that some of the matters dealt with here do not, unfortunately, find a place even in the university courses given by some departments of botany and zoology. The attitude that kept William Bateson out of a lectureship at Cambridge in 1909 still keeps the *matter* of mendelism out of many of our contemporary universities. But, except for the statistical material, the topics dealt with in

this book do not go too far beyond those included in the "A" level botany and zoology syllabuses of most examination boards. We realize, of course, that even these topics cannot be considered in schools to the same extent and in the same detail as they are described here. Consequently, the college and university student who has yet to receive an opportunity for rediscovering or unlearning heredity will find much here to concern him.

Some parts of the book will be of more value to the teacher who can then be discriminating and decide how much to convey to his pupils and how best to convey it. But it is our hope that even material which does not reach the student will make itself felt in what the teacher does choose to say and the way he chooses to say it. There is, however, much that the school pupil can accommodate for himself; and we would now like to review what we have included and attempted to do in this book so that the reader can learn how to get the most out of it.

This book is elementary. But elementary things are not always simple. In fact, they are usually hard—like the elements of heredity themselves. A page from an average text-book of biology looks, even superficially, quite different from one taken from a text-book of physics, chemistry or mathematics. Indeed, it is customary to expect a biology book to read like a novel and, except for diagrams and perhaps the occasional word in italics or heavy type, it frequently looks like one.

Those who want a book that can be read like a novel would do well to leave this one alone. As we have indicated, it is intended to reach the elementary student, directly and through his teacher. But it is not suitable for all such students nor for all those who teach them. It is for those who want something more in and from their biological teaching and training than a mass of descriptive information concerning living things, the accumulation of which requires little intellectual effort. Unfortunately, much of biology, as taught and learned, is of this kind—largely unconnected, uncorrelated and uninspiring information—and it makes demands only on the memory. It has become the science of the dead not the living. If there are pages in this book which the reader can read without having cause to pause and think then either he does not need that page (let him tear it out) or he has failed or else we have failed.

Let the reader who can benefit from this book begin, as we did, at the beginning. Here he will be given his terms of reference, he will meet the cells which make up the individual and the parts which make up the cell. He will meet also units composed of one or more individuals.

Much of the material in the first chapter is considered in schools. We have, however, included a short section on Johannsen's work on beans. This, for some reason, is rarely dealt with in schools. But we feel that since most natural variation is of this kind, since it illustrates the genetic and environmental components of phenotypic variation and since there are many who still regard continuous variation as owing only to the environment, its inclusion is more than justified.

We have considered both mitosis and meiosis in two parts. In the first chapter they are described with a minimum of cytological detail and the information given is the minimum necessary for an appreciation of their genetical significance.

The cytological details are considered later. Students often give very confused and inaccurate—even unworkable—descriptions of nuclear division and we hope that this method of dealing with it will enable the student to tell the wood from the trees.

Mendel's experiments are described in most elementary text-books and they can be considered in various ways. One method is to give the observations and then the explanation—almost as though the two were not related. But, although this is the easiest way both for the writer and the reader, it is not, in our opinion, the best, for the matter is thus reduced to mere description. Indeed, it is one of the things which makes the second helping necessary. We have resisted this approach and tried to make the observations yield the conclusions, for in this way the nature of the arguments and inferences is revealed.

The later sections of Chapter 1 are devoted to the relationship between mendelism and meiosis. This, too, is commonly included in the school curriculum but it is rarely considered in a satisfactory way. Indeed, many errors—avoidable errors—are perpetuated. There are students and teachers who think they know and understand this relationship. But if they find, for example, that the diagrams used to illustrate these sections are unfamiliar to them then, clearly, they cannot already know how the chromosomes determine the mendelian laws.

There are those who will complain that we have gone into too much detail or that the material is too difficult for the "A" level student. Let us look at these objections. Only three variables are involved—the position of the chiasma, the orientation of the bivalents at first division and the orientation of the half-bivalents at second division. Far fewer variables, in fact, than the student is expected to accommodate when dealing with the factors affecting the rate of transpiration, photosynthesis, the law of limiting factors and so on. Indeed, the variables are so few that they can all be included in one diagram (Fig. 18). Anyone who cannot handle three variables should not be in a class, a large proportion of which are considered to be suitable candidates for a university education. In regard to the detail, we can say only this—either one knows what it is about meiosis that determines the principle of random assortment, for example, or one doesn't. There is no half-way stage where one can stop. And the truth is easier to learn and appreciate than the lie.

One of the commonest mistakes made by students—and presumably, therefore, by their teachers—is to say that independent assortment is a consequence of crossing-over. This completely wrong idea is held even by those who "know" that the so-called, second principle of mendelian heredity applies only to loci on different, non-homologous chromosomes—chromosomes which don't even pair! It is not easy to understand why this blatant contradiction is not self-evident to those who hold and perpetuate it, for it is revealed by a moment's thought. Presumably, therefore, the matter is not one for thought in the minds of those subject to the error. We hope the diagrams will make them think. The interested reader should not simply follow the diagrams; he should rather recreate them for himself. In this way he will realize how simple they are and once he has

mastered them there is no question of committing them to memory for they can always be reproduced from first principles. This, to our way of thinking, makes the situation simpler, not more difficult. It makes it impossible to commit and perpetuate silly mistakes for, as Agnes Arber put it, "no truth is truth for any man until he has rethought it for himself".

Many biologists are frightened by figures and formulae. But even if they cannot learn to love them they must learn to live with them. Biology is no longer the flower-collecting, walk-in-the woods subject it once was and, by many, is still thought to be. Nature-study is not the same thing as the study of Nature. Biology is becoming increasingly quantitative and analytical.

We realize that statistical techniques are not included in "A" level or even in many university courses of biology though some few schools do give instruction in statistical methods to biologists in the third year sixth form. In describing the methods, therefore, we have tried, where possible, to give the rationale behind them so that the student is aware of what it is he is doing. The arithmetic involved in making a statistical test can be laborious and time consuming, even when a calculating machine is available. Ratios, however, are very easily analysed and little knowledge of mathematics is necessary.

We realize, also, that time is limiting and short of dropping some of the more descriptive aspects of biology—which we ourselves would favour—there is little prospect of biometry being included in an "A" level syllabus. Nevertheless, we consider it desirable for the elementary student to read Chapter 2 if only to get the idea of sampling error and the realization that there are techniques available for dealing with it. It is our experience that an elementary student will try to explain every rise and fall he sees in a graph without ever asking himself whether the fluctuations are real. It is important for him, as it was for Mendel, to realize the errors introduced by sampling. Darwin, too, was aware of these errors, and he wrote "As only a moderate number of . . . plants were measured, it was of great importance to me to learn how far the averages were trustworthy. I therefore asked Mr. Galton, who has had much experience in statistical researches, to examine some of my tables. . ." We think it better for the student to learn to do for himself what Mr. Darwin was prepared to leave to Mr. Galton. However, except for parts of Chapter 3, there is but little to be found later in the book which requires for its appreciation a detailed knowledge of the methods described in Chapter 2.

In Chapter 3 we have tried to warn the student of the danger in over-simplifying the relationship between the determined and the determinant. From this alone stems half the unlearning he has to do.

Most of the material in Chapter 4 is dealt with in school courses of botany and biology. But to judge from the failure of students to correlate, or even associate, the information in this chapter, it is not considered from the point of view we have adopted here. We suspect, for example, that gametic dimorphism is taught in relation to the algae, heterospory in connection with the seed habit, dispersal in relation to colonization and fruit structure and so on. We, however, have tried