MENDEL'S PRINCIPLES OF HEREDITY

By A. H. Marsh, M.D.

In considering this subject I must first disclaim any intention of contributing anything more than a 'causerie'—thoughts of a serious student—with the object of arousing a general interest amongst local biologists and students of genetics, in the hope that it may be possible by collective investigation to work out results of real scientific value in the large and exceptionally fruitful field presented by our local livestock.

Gregor Johann Mendel was born on July 22, 1822, in Austrian Silesia. His early education and home surroundings seem to have been calculated to develop an inherited taste for botanical research. He was admitted to the Augustinian home of St. Thomas of Brunn—an institution generally spoken of as the 'Königskloster'—mainly with the view of taking part in the educational work of that institution. In 1847 he was ordained a priest, and was sent to Vienna by the cloister for a three years' course of mathematics, physics, and natural science; finally, in 1868 he was elected Abbot, or prälat, of the Königskloster. His experiments were all carried out in the garden of the cloister (Bateson). One cannot help being struck by the evidence in all his work of careful, prolonged and exact investigation. His results were not arrived at by any brilliant flash of genius, yet conforming to the best definition of true genius, 'An infinite capacity for taking pains.'

And then the sadness of it all! He died in 1884, broken in mind, body, and estate, with his life's work entirely unrecognised and unrewarded, still confident to the last that his time would come.

Mendel's published researches were all botanical, but it is known that he made extensive investigations into the heredity of bees, although his notes are not to be found.

'It is one of the greatest tragedies in science that Mendel's "Experiments with Plant Hybrids," which was published by

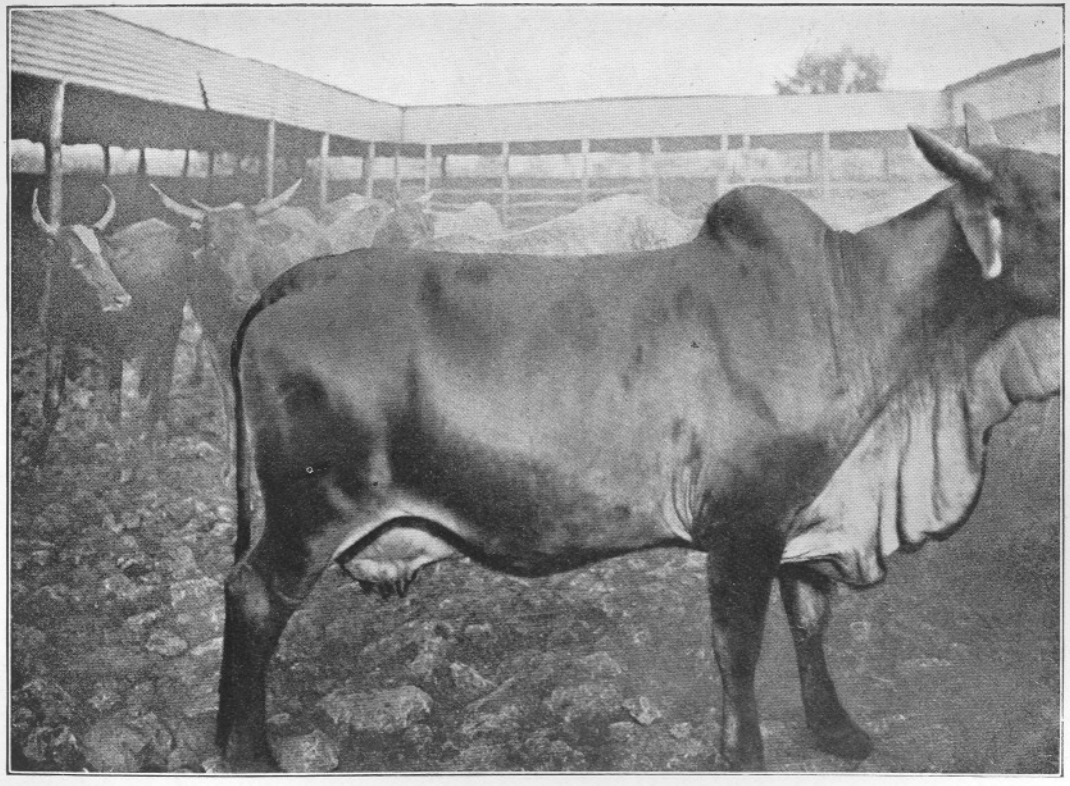


PLATE I.

MAHARANEE.

Cross between Indian and A. E. bull, has six active teats.

(See p. 57)

the Natural History Society of Brunn in 1865, remained unknown to the present day. It is impossible to imagine where we should have been to-day in our knowledge of heredity had Darwin only known of Mendel's work. . . . The point for us is that while there may be variation in the Darwinian sense there are also sudden changes where animals of different characters are bred together, and under certain circumstances these changes are inherited. Mendel's theory explains both the changes and their inheritance' (Wilson).

The scientific world had to wait until the dawn of the twentieth century before it heard of Mendel's law. Since then much original confirmatory work has been recorded, but much remains to be done.

In approaching the study of heredity it is absolutely necessary to have a preliminary knowledge of botany, especially of the physiology of plant life. I would suggest Percival's 'Agricultural Botany' as a work for the study of any intending student. The scheme of this book carries one on by means of a charming series of simple experiments, which impress each fact upon the memory. My motto is 'Take care of the facts, the names will take care of themselves,' but sooner or later the terminology must be mastered, or one would be in the position of possessing a dispensary full of valuable drugs all without labels! I would suggest, in all humility, that a definite system of reading be carried out. One should have an indexed note-book in which to enter up and define every unfamiliar word, and never to pass a word without looking up the meaning when in doubt. Also a note-book for each work studied in which to enter up short notes of every paragraph; otherwise one is led away by the beauty of the style to read more than can be duly assimilated. Given a general knowledge of Darwin's works, a preliminary study of Romanes' 'Darwin and after Darwin' will be found of great utility. One is then in a position to study the whole question brought right up to date by Bateson's monumental work.

Mendel's papers are well described by Bateson as 'models of lucidity and expository skill. His success is due to the clearness with which he thought out the problem.'

Mendel laid it down as essential to start with pure-breeding

homogeneous materials, to consider each character separately, and to record separately the progeny from distinct individuals.

He first worked on the edible pea (*Pisum sativum*). In crossing the tall with the short variety he found that the first cross-bred generation were tall, to the exclusion of the short form. He therefore called the tallness a *dominant* character because it prevailed, the excluded character he called *recessive*. On self-fertilisation of the first cross family, the next generation proved to be mixed in the proportion of 75 per cent. dominant to 25 per cent. recessive. On the whole of these being again propagated, by self-fertilisation, it was found that the recessives bred true, while the dominants gave a proportion of talls breeding true to 'tallness' and a mixed generation in the proportion of two impure to one pure.

This is well expressed in the diagram reproduced from Thomson (see p. 59).

But note Bateson—'Dominance is no inseparable attribute of Mendelian inheritance' (p. 50).

A dominant character is due to the presence of a definite factor, while 'the corresponding recessive owes its condition to the absence of the same factor' (pp. 53, 54).

The fact of segregation (splitting) was the essential discovery of Mendel. Take the case of the F_1 family in the diagram :—

It is considered that here the germ cells divide into two kinds of egg cells and two kinds of pollen cells, one kind with the potential quality of tallness, one with the potential quality of shortness. The groups may be considered equal in size, and therefore on self-fertilisation the chances of any egg cell being fertilised by any pollen cell are equal. Take the case of four 'tall' egg cells, and four 'short' egg cells, impregnated by an equal number of similarly arranged pollen cells : the formula would express the result :—

$$2D + 4\,D\,(R) + 2\,R$$

and since tallness is dominant there appears six tall and two short.

This, shortly, is the theory of *gametic segregation*; and explains the occurrence of pure and impure gametes. The Ds

and Rs breeding true, while the D(R)s split up in the proportion of 3 and 1; the recessive unit appearing again and again in each generation, and always in the same numerical proportion.

The same facts have been deduced in theory and proved by experiment, when we have to deal with several contrasting characteristics in the same organism.

Mendel's papers deal only with the Pisum family (edible peas), and with the Hieracium (hawkweeds); he also mentions Phaseolus (French bean) and Lathyrus (sweet pea). It is to be noted that the doubtful results in Hieracium were probably due to the more recently discovered fact that this family is frequently parthenogenetic or apogynous, that is to say, the egg cells may develop without union with the pollen cells.

Thomson will not admit that Mendelian phenomena are known in cases other than hybrids, but here he differs from other workers, and a considerable amount of evidence has already been accumulated to prove the occurrence of Mendelian principles quite apart from hybridisation.

'It will take many years before the far-reaching effects of Mendel's law have been investigated, and it is more than likely that results of considerable importance may flow from its application in various novel directions (e.g. in the elucidation of the differentiation of sex, tentatively worked out by Berry Hart)' (*Ency. Med.*).

'Mendel himself, indeed, admitted this possibility, and the work done since all tends to strengthen the view that sex inheritance follows lines very similar to those made familiar for other characters by experimental methods of breeding' (C. J. Davies).

Note again: 'The practical applications of Mendelian principles . . . will probably far exceed any limits we can yet perceive; amongst them we can foresee not merely advances in the art of breeding animals and plants, but a control over the destiny of our own species' (Bateson).

As to Sociology the same writer says: 'Genetic knowledge must certainly lead to new conceptions of justice, and it is by no means impossible that in the light of such, public

opinion will welcome measures likely to do more for the extinction of the criminal and degenerate than has been accomplished by ages of penal enactment.' A word as to unfixable types: there are of course such which cannot be fixed at all, for the reason that their special character is not represented in the gametes, but is a special consequence of the meeting of dissimilar types.

These extracts will illustrate the lines upon which modern thought is proceeding in the investigation of the extended application of Mendelian principles.

As to our local conditions, we have indeed a rich field for research. I will indicate a few subjects which could be worked out by means of collective inquiry:—

Cattle:
- Unimproved native breeds.
  - Horn formation, shape, size, present, absent (polled).
  - Colour of hair and skin.
  - General shape and size.
  - Milking qualities.
  - Milk percentage of fats, size of fat globules.
- Improved cross breeds.
  - Eastern crosses.
  - Western crosses.

Families to be traced through as many generations as possible, full details and photos to be obtained.

In the first place, a series of typical photos and descriptions should be obtained of all the distinct types of native cattle from the coast to the boundaries of Uganda.

I have reason to believe that a very remarkable local condition exists with reference to horn formation, but this requires careful confirmation. Shortly stated:—

Kilimanjaro district, a polled breed.
Wakamba, very short horned.
Masai and Kikuyu, a medium horned race of cattle.
Nandi and Sotik, medium horns but longer on average than last.

Lumbwa, long thick spreading horns, apparently an Ankoli cross.
Kavirondo, long, thin, lyre-shaped horns (Ayrshire type).
Ankoli, very long heavy horns.

Should this scheme from East to West be capable of proof, it discloses a highly interesting hypothesis.

Any references to literature bearing on the history of local cattle would be of value. I know of none with the exception of a short note in a recent number of 'Country Life' extracted from Buffon. Perhaps some member could verify this in the original.

With reference to quality of milk it is easy to compare samples by means of a drop on a coverslip examined microscopically in a fresh state. I hope to be able to record a series of photo-micrographs shortly. A blood smear (human) affords a ready test to compare the size of the fat globules.

As to hybrids from imported stock, my son has taken a few photographs to illustrate two suggestive cases in my own herd of cattle. I hope to be able to trace the complete history of these cases at some future time.

Plate I. 'Maharanee,' an Indian × native E.A. cross.

Some years ago an official imported an Indian cow, pure bred. This cow threw a heifer calf to an ordinary E.A. native bull. The mother died, but the calf was reared, and in process of time calved a heifer calf to an E.A. bull. Again the mother died, but the calf was reared and is 'Maharanee,' the subject of the present illustration.

She is, as far as I can ascertain, pure Indian in type, showing the characteristic colour (brown with black points), general shape, and carriage, drooping ears, and thickening at root of tail. She has six active teats, as her mother had, but I cannot ascertain at the moment of writing whether this condition was a 'mutation,' or whether it is a common condition amongst Indian cattle, and therefore inherited. At any rate it is a very rare condition amongst local cattle, although one occasionally finds one or more supernumerary rudimentary teats.

Maharanee has thrown four bull calves to different bulls, but all the calves are dead. I have, however, one heifer calf out of a pure Sotik cow and sired by a young bull with parentage Maharanee × 1st cross-native-by-imported-Guernsey bull, and this heifer calf has six well-formed equal-sized teats.

A short pedigree will make this clear :—

Imported Indian cow × native E.A. bull	
1st cross cow × native E.A. bull	cow known to have had 6 teats.
Maharanee × 1st cross Gu. bull	ditto
Bull × Sotik cow	
Heifer calf	6 teats, pure Guernsey in type.

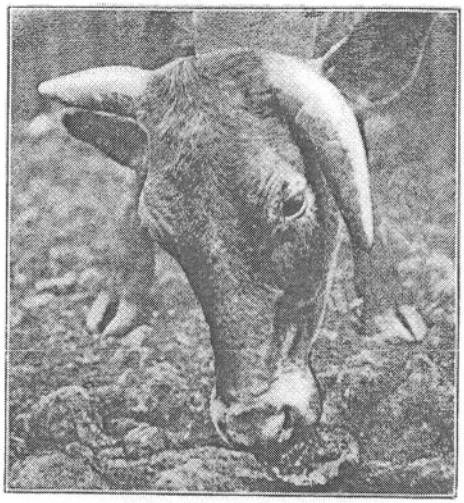
The points of interest here are :—

Pure dominance of Indian type over E.A. type.

Inheritance of 'mutation' (?) to third generation. At the same time this calf is humpless and shows Gu. characteristics, therefore dominance of Gu. over Indian × E.A. cross, *but* with maternal type of udder.

Plate II. Three heads of 1st cross cows with parentage Shorthorn-bull-on-E.A.-cows (not the same cow), showing a family type of horn deformity. These cows are all sired by an imported bull, 'Vale Royal Victor II,' red roan (Coats' Herd Book), but I cannot ascertain whether he had any horn deformity. I have eight adult cows sired by this bull, three show this deformity; there are many more in the country which could be traced. Of 1st cross shorthorns a large majority show shorthorn characteristics, but a minority are of a pure maternal type.

These cases would well repay careful analysis, and I hope on some future occasion to return to the subject with fuller knowledge.



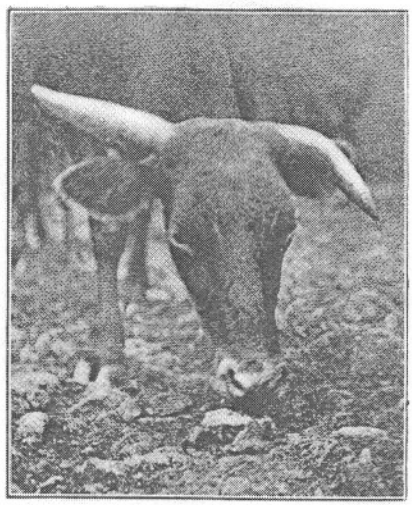
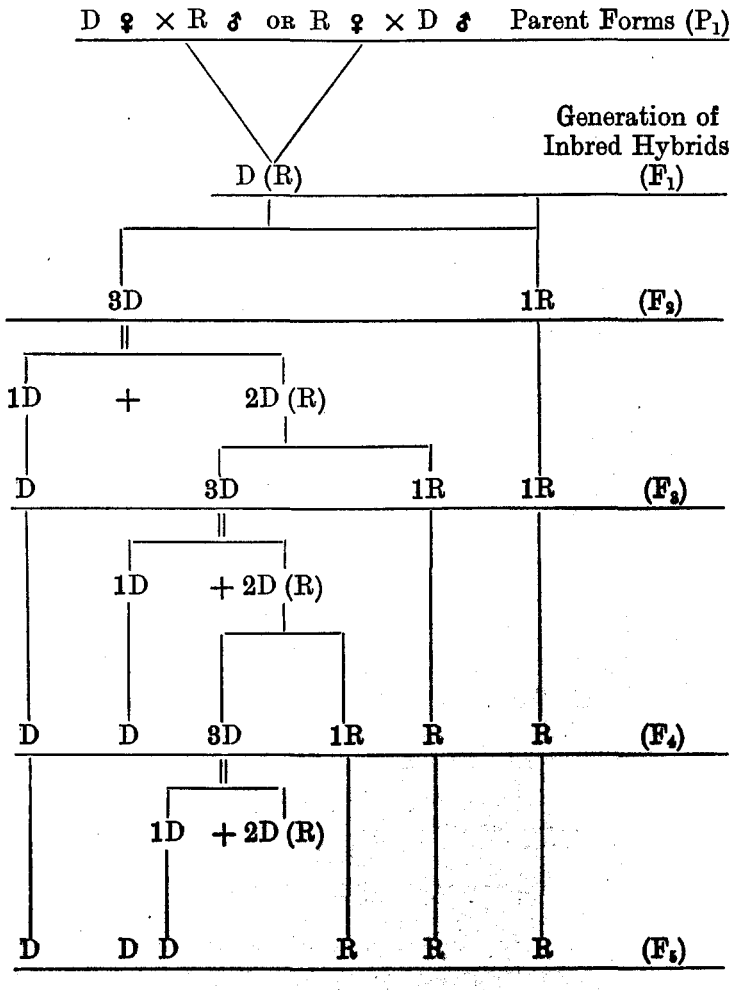


PLATE II.

THREE HEADS OF CROSSES BETWEEN SHORTHORN BULL AND EAST AFRICAN COWS, SHOWING PERSISTENCE OF A FAMILY TYPE OF HORN DEFORMITY



D = Dominant. R = Recessive.
D (R) recessive *apparently* absent.
♀ (the sign of Venus) female.
♂ (the sign of Mars) male.

Poultry again form a highly interesting group :—

History of native strains.
Hybrids from imported + native stock,
Inter-crossing of imported stock,
especially as to Comb.
Size.
Colour.
Egg production, &c., &c.

Sheep would well repay scientific study.

I will conclude with a reference to the more important literature :—

'Darwin and after Darwin,' Romanes.

'Agricultural Botany,' Percival.

'Mendel's Principles of Heredity,' Bateson (containing a reprint of the original papers, and much recent work of great interest).

'The Evolution of British Cattle,' Wilson.

'Heredity,' Thomson (not consulted by me in the original).

Many articles in 'Live Stock Journal' by C. J. Davies.

Article 'Heredity,' in 'Encycl. Med.' Vol. 15.

For a full bibliography see Bateson.

TWO FINDS ON MOUNT KENIA

By W. McGregor Ross, M.Sc.

This short article gives a bare statement, attended by but little attempt at explanation, as to a couple of unexpected finds made on Mount Kenia, which was visited by the writer in June 1908, in company with Mr. D. E. Hutchins, Chief Conservator of Forests of the Protectorate, and Mr. S. Neilsen, one of his foresters.

The valley which collects the numerous streams flowing down the north-west slopes of Kenia, and throws them through the forest girdle and out on to the Laikipia plateau as the River Buguret, has been named after Mr. C. B. Hausburg, who