20 years cattle breeding and dairy problems the existence of which was hardly realized 30 years ago are to-day the subject of experiment and speculation. To focus the attention of our experts on the work which is being done in this direction in the different parts of India a Cattle Conference is to be held annually in future. At this conference ways and means of developing cattle-breeding and dairying wiil be discussed and recommendations made as to the policy to be pursued. Progress must needs be slow, for our leading landowners take but little personal interest in animal husbandry and the smaller cultivators are not in a position to do much towards its development. It is hoped that the training now being given at our Agricultural Colleges and at the Institute of Animal Husbandry and Dairying at Bangalore will in course of time tend to break down the apathy of India's landed aristocracy and that their sons who are now undergoing courses of training will play the part which our "gentlemen" farmers have always played in England as leaders in the field of animal husbandry and dairying;—("The Planters' Journal and Agriculturist" Vol: III, No. I.)

The Physical Basis of Heredity.

By A. D. B. Smith, B. Sc.

A great deal is known about the behaviour of heredity characters and the manner in which they are inherited. Take the example of a cross between a red cow and a black bull. All the progeny are black. By mating two of these we get a generation consisting of three black to one red; to account for this, it is suggested that two factors in the germplasm acting together form a character. The original red cow had two for red and the black bull had two for black. Now, no individual can have more than two, and each parent contributes equally to the breeding (genetic) composition of the offspring. Therefore, one factor goes from each parent. The factor for black, however, dominates that for red, and the animal appears black. Its breeding composition is not like that of its black father, but is mixed, having one factor for red and another for black. And so, if you mate two such animals together, you get appearing in the third generation, 3 black, only one of which has both factors for black and will breed true, the others being like their immediate parents (heterozygous); you get also one red, and this will breed true (being homozygous).

There are many elaborations and complications of this. A simple application in fowls is rosecomb, which is dominant to single. Another is the Blue Andalusian; here the black is not completely dominant. The mating of black by white gives blue. These blues give one black, two blue, one white. And so the subject gets more complicated, but one idea remains, *viz.*, the inter-action of two factors.

The Mechanism of Heredity. We must, then, find some mechanism that will explain this. Looking under a microscope at the germ cells we find in them rod-shaped things called "chromosomes." These go in pairs. And, further, when the cells divide so as to form a reproductive cell, the egg in the female, the sperm in the male, we find that only one of each pair goes into the egg or sperm, which thus have only half the usual number. The joining of the egg and sperm is called fertilization, and restores the full number of chromosomes. Each pair is again complete, and is composed of one chromosome from each parent. Here, then, we have a mechanism that corresponds exactly with the observed facts of inheritance.

I want to introduce to you the fly Drosophila Ampelophila, which is the martyr of this science. He has four pairs of chromosomes. Sometimes he has vestigial wings, and this character behaves exactly as rod in cattle. Let us put the factor for this one to one pair of chromosomes. Another characteristic is an ebony body colour. We put this on another pair. Another is the absence of eyes. We place this on a third pair. Yet another is a white eye. This goes on to the fourth pair. But there is still another, black body. What shall we do with it? Where can it go? All the four pairs of chromosomes have already got characters connected with them. This fifth character must therefore go along with another on the same pair. Let us place it on the same pair as vestigial wings. Now let us make a mating of a normal long-winged grey and a vestigial black. The first generation is normal long-winged grey. Back cross this to a vestigial black female, and instead of getting in the next generation the four independent types, we only get two, the normal and the vestigial black. In other words the factors for vestigial and black have clung together. This supports our idea that they are lodged in the same pair of chromosomes.

Supposing now, that we mate this heterozygous vestigial black to a vestigial black male. We find that we get 41·5 per cent. normal long-winged grey and 41·5 per cent. vestigial black, the two parent types. In addition, we get 8·5 per cent. long-winged black and 8·5 per cent. vestigial grey. Together they make 17 per cent. of unexpected types, for the factor of black has lost its connexion with that for vestigial. How does this happen? Looking at the chromosomes through a microscope, we see that before they separate they wind themselves round each other, and occasionally they break and the bottom half of one gets attached to the top-half of the other of the pair. If the linkage is broken very seldom, we assume that the factors are very close to each other. If it is broken frequently, we assume that they are far apart at different ends of the chromosomes. In Drosophila there are four, and only four, great groups of characters which tend to be inherited together, and there are four pairs of chromosomes. Another proof that the chromosomes are the bearers of hereditary factors.

The Mechanism of Sex. If the chromosomes are the mechanism by which ordinary characters are inherited, have they anything to do with sex? Let us take a look at them and see. Why, there is a difference between the chromosomes in the male and in the female. Not a big one but it is there. The female in Drosophila has two pairs of long, slightly curved chromosomes; so has the male. The female has one pair of very short chromosomes; so has the male. The female has a fourth pair of straight. medium length chromosomes, so has the male; but one of the chromosomes of this pair has a small hook at the end of it. We call this chromosome the Y chromosome, The other straight one without the hook we call the X. The female has two X chromosomes, and her constitution is thus XX. The male has an X and a Y, and his constitution is XY.

Looking down the microscope again, we find that the eggs given off by the female are of one kind, X; while the sperm given off by the male contains 50 percent which are like the female,

i. e. X; and 50 percent which have got the hook on the end are Y. When an X sperm fertilises an egg, the result is a female. With an Y sperm, it is a male. Thus, in a way, sex determination rests with the male. If you can manipulate and control the two types of sperm you will be able to control the sex of the offspring.

Certain characters are inherited by means of factors on these sex chromosomes. Therefore we would expect certain characters to be linked to certain sexes. This is the case. Cross white-eyed male and a normal red-eyed female. You get normal red-eyed offspring. In the next generation you get three reds to one white. This was expected. But, all the white-eyed ones are males. Make the opposite cross of a white-eyed female and a normal red-eyed male. Here all the females in the progeny are like their father, red-eyed, while the males take after their mother being white-eyed. To explain this in detail would take more time than is avaiable. Here again you have a very definite proof that the chromosomes are the mechanism by which characters are inherited.

This fact has been made of economic use in fowls. Here, as regards sex, the position is reversed, the hen gives two types of eggs, X; and Y; the male only one type, X. Cross a black cock such as the Leghorn, Orpinghton, Rock, Minorca, or Langshan with a barred hen such as Barred Rock, Scots Grey, or Cuckoo Leghorn, and you get all the cockerels barred and all the pullets black. As the barring can be distinguished at birth, it is possible in this way to eliminate the cockerels as day-old chicks.

There are many other proofs of this hypothesis that the chromosomes are the mechanism. One of the best is that any aberration in chromosome behaviour is followed by aberration in the characters affected. Accidents will happen even in the best regulated families. Sometimes one of the chromosomes forgets to separate and sticks by its brother in the pair. If, in Drosophila this occurs to the X-chromosome of the female, then, although the egg be fertilised by a Y-chromosome, the sex is that of a female for the genetic constitution is XXY. This is called non-disjunction.

It has not been possible to explain fully all the proofs of this hypothesis. There are many more. That they have been largely proved by work in plants and small animals such as flies, rats and guinea pigs, does not mean that it does not equally apply to our larger farm livestock. From what knowledge we have gained, we have proof that it does. It is our duty to apply this work along practical lines and thus "mak' siccar." (From the Scottish Farmer dated 14th November 25.)

Agricultural Education in the United States.

During the last half-century the importance of agricultural education has been increasingly recognised in America, until now every state has one or more Agricultural Colleges, forming a group of institutions occupying a prominent position in the field of education. During the decade 1910–20 development was extraordinarily rapid, and very large sums of money were appropriated in many states for the provision of new agricultural buildings, the purchase of land, and the endowment of educational programmes. The colleges have had a long struggle for recognition, but have demonstrated their value and are now in such a position, financial and otherwise, that their future usefulness is assured. The immediate need is for trained teachers, investigators, and administrators, and in response to this, graduate work in agriculture has developed with amazing rapidity during recent years, though in certain colleges it is still seriously handicapped by lack of funds and accommodation. At present the full agricultural course extends over 4 years, but there is a suggestion to extend this to five in some cases for the purpose of specialised training. In many colleges the curricula have been steadily changed in order to keep abreast of the modern requirements of agricultural education, though there are still some in which the work is too largely restricted to methods of production, resulting in a narrowed outlook.

The field of work covered is very wide, ranging over at least a dozen branches, which, however, are not rigidly separated but devetail into one another to some extent. All branches have developed from small beginnings shaping themselves according to the needs of the time, with the result that some subjects which were originally an integral part of one branch are now dealt with more fully and adequately by others. Agronomy was initially defined as covering that part of the general field of agriculture devoted to climate, soils, fertilisers, and farm crops, but it now tends to deal with the more fundamental and far-reaching problems of soil physics and chemistry, plant physiology and plant genetics. It is