only an infinitesimal portion of which would ever come in contact with a receptive pistil. But on the other hand, the tree was under no necessity to develop large conspicuously-painted flowers. Nor need it produce nectar to feed its insect allies, since these had been renounced. The saving of energy effected might thus more than counter-balance waste through excessive pollen production. It was probable that the trees changed their allegiance from insect messengers to wind because of the nature of the conditions under which they grew. By raising their heads higher and higher into the air they were able to spread their pollen broadcast across wide stretches of territory. They had benefited by leaving the union.

There was another group of plants that had forsaken the plant-insect union, the cereals—wheat, barley, oats, rye—and certain vegetables—peas and beans. These plants were habitually self-fertilised, and it would be noted they were annuals. They did not know why those plants renounced the union. Possibly their ancestors might have fallen on evil days when there was a dearth of insect-messengers in the regions they inhabited. With trees and perennial plants, it was not absolutely vital that there should be a crop of seeds every year. But in the case of an annual plant, the matter was very different. Should plants fail to produce seed for a single season, the entire race would vanish. It was the flowers of the great brotherhood of insect-lovers that chiefly claimed the attention of the plant-breeder, because these were the varieties that made up the chief plants of the orchard and gardens. Whoever was interested in attempting to improve plants must familiarise himself with the mechanism of the typical flower and how it was fertilised.

Artificial Hybridisation.

The essence of hybridising was merely the transfer of pollen from the stamen of one flower to the stigmatic surface at the end of the pistil of another. If the flower had stamens of its own they must be removed before they were fully ripe. This emasculation of the flower was affected a day or so before the flower was ready for pollination. It was performed by removing the anthers with forceps. After emasculation the pistil should be protected from foreign pollen by covering the flower with a small paper bag or cotton wool until the stigma had become receptive and ready to receive the pollen. This stage of receptivity was easily judged by the operator with a little practice. When the stigma was receptive, which might be a few hours, a day, or two days, after the removal of the anthers, the covering was removed and pollen from the desired source was transferred to the receptive stigma. The necessary pollen for this purpose might be secured from a flower by shaking it on a watch glass or some small receptacle, and transferring the pollen with a small camel hair brush or a pair of small forceps. The receptive portion of the pistil should be covered fully with pollen. The flower was then covered for a few days with cotton wool or a light paper bag to prevent undesirable pollen from reaching the stigma. The plant was staked and marked with the details of the hybridisation. After a few days the covering was removed, and the fertilised seed allowed to ripen.

Importance of Genetic Research.

There were two lines of plant breeding work which were of importance to Australia:—1. The production of improved varieties of wheat which would be more prolific and resistant to drought and heat; and 2. The improvement in native grasses and edible forage plants. The work of William Farrer was a remarkable illustration of what might be done in respect to wheat breeding. He produced no fewer than 33 varieties of wheat during the 20 years in which he devoted himself to wheat-breeding. Of these, 15 varieties were still widely grown in Victoria and New South Wales, and one of his master creations, Federation, was by far the most popular and prolific wheat in Australia.

Native Grasses.

In native grasses and fodder plants Australia had a source of wealth of almost incalculable value. These native grasses and fodder plants formed the mainstay of the sheep and cattle of the country. They were, in fact, the basis on which the pastoral wealth of the country was dependent. These native plants were without rivals in the plant world in respect to their nutritious qualities and their resistance to extremes of heat and drought. Other countries had imported saltbushes and Danthonias, and were growing them extensively on their arid spaces. A wonderful opportunity existed for the application of the same systematic methods used by Farrer with wheat to the problem of the improvement of the native grasses. Here lay a virgin field of research, illimitable in scope and of the highest practical value to the State.

Whatever methods were followed for the improvement of wheat or native grasses or other plants, the plant breeder should have a clear conception of the goal towards which his efforts were to be directed. His aim would vary in the different countries, but his methods would be alike in all. The aim would be to combine into one variety those desirable characters which made the plant highly adapted to the environment in which it was to be grown. The methods available were selection and cross-breeding. The aim and action of selection was to detect the desired heritable variants in a variety, and, through them, isolate a race [illegible]

with the desired characters. When this was accomplished selection could do nothing more until Nature produced another desirable variation. Cross-breeding, on the other hand, enabled the plant-breeder to combine into one plant the unit characters of two or more plants, and thus create a new combination or variety. It was the most valuable instrument the wheat-breeder possessed for the creation of new types adapted to specific environments.

REGISTER. 29.7.25.

SCIENCE AND AGRICULTURE.

Creation of New Varieties of Plants.

Development of Scientific Methods.

No. 5.

On Tuesday evening Dr. A. E. V. Richardson (Director of the Waite Agricultural Research Institute) delivered his second lecture on the subject of science and agriculture, in connection with the University extension lectures. He dealt with the creation of new varieties of plants. He said that a remarkable feature of modern agriculture during the past generation was the intense activity devoted to the improvement of farm crops. That had been largely due to the re-discovery of Mendel's work by De Vries, Tschermark, and Correns, the epoch-making work of De Vries on the mutation theory, and the great stimulus given to plantbreeding by the establishment of schools of genetics in the older universities. Every agricultural crop of importance had been subjected to a critical study with a view of determining the best lines on which specific and desirable improvements might be brought about. Systematic plantbreeding was a comparatively modern development. The reason was not far to seek. From the dawn of civilization, man's attention had been occupied with his animals rather than with his crops. Indeed, improvement in plants was hardly possible until Camerarius in 1691 discovered sex in plants, and it was not till a half-century later that the structure of the flower was properly appreciated. Thus, while systematic mating of plants could not have been practised for more than two centuries, the control of the breeding of animals had been undertaken by man for over twenty centuries. Though systematic plantbreeding was quite a modern development, the amount of data already collected and the remarkable results already achieved were sufficient to indicate the enormous possibilities that lay ahead of that work.

The great improvements wrought in the flocks and herds by careful systematic breeding were apparent to the layman. The remarkable development of the shorthorn cattle from the cattle of north-eastern England by the Collings brothers, and later by Booth and Bates was known to every cattle breeder. The improvement effected in the Leicester breed of sheep by Robert Bakewell, of Dishley, was familiar to every sheepbreeder. Other illustrations nearer home were the remarkable improvement effected in the merino sheep by Australian breeders during the last century. There was a great difference between the merino of to-day and the animals which landed in Australia in 1797. It was largely owing to the enthusiasm and energy of Capt. McArthur, one of the pioneer sheepbreeders of New South Wales, that the value of the Merino to Australia was demonstrated. Each State had had its pioneer sheepbreeders who braved the dangers of marauding natives, disease, and drought, to found flocks, the names of which were now household words in the sheep world. To-day they had the strong-woolled, robust types of Merino sheep characteristic of South Australia and Riverina, and the fine-woolled types characteristic of Western Victoria, the South-East, and Tasmania—types which were eminently suited to the climatic conditions of the regions in which they were found. The improvement, by systematic breeding, in the milk yields of dairy cows had been none the less remarkable. While the average yield of butter-fat from Australian cows was probably not more than 160 lb. per annum, one representative of the shorthorn breed—Melba XV. of Darbalara had given the phenomenal milk yield of 3,225 gallons per annum, and a butter-fat yield of 1,614 lb.; about ten times the yield of the average cow of Australia. Similar improvements had been effected, by single pen testing, and systematic breeding in the egglaying strains of poultry. From a sitting of eggs obtained from the Victorian Department of Agriculture, six white Leghorns were hatched which in the Burnley Egglaying Competition produced 1,699 eggs, or an average of 280 eggs per bird. That was still the world's record for egglaying. No one nowadays expressed the least surprise if a breeder of dairy cattle attempted to breed a herd of dairy animals giving heavy yields of butter-fat. But to set out with the definite intention of breeding farm crops with the object of improving them in certain specific qualities was still considered unusual enough to occasion surprise. The fundamental principles of breeding and inheritance, however, were the same whether they were supplied to animals or plants. The plant breeder had at least one immense advantage over the animal breeder. He could work with hundreds of thousands of individuals and could afford to make his selections with the utmost rigour and take full advantage of the variations of type which were the basis of all improvement. The animal breeder, for many reasons, of which not the least was the expense incidental to the breeding and feeding of large numbers, must of necessity confine his attention to comparatively few animals, and the probability of securing wide and valuable variations were thereby considerably lessened.

The possibility of improving plants depended on variation and heredity. Unless variations occurred no improvement would be possible. Unless some variations were transmitted from parent to offspring no improvement would result.

There was a close relationship between the development of theories of evolution and the development of scientific methods of breeding. They could be illustrated by referring to the work of Darwin, De Vries, and Mendel.

Darwin's Theory of Natural Selection.

The fact of evolution—that species arise by a modification of pre-existing species—was indisputable, and was supported by innumerable facts of classification, morphology, embryology, by the gegoraphical distribution of plants and animals, and their succession in the geological strata. The explanation of evolution, however, was not yet quite satisfactory. Darwin based his theory on the following facts:—(a) Variability; (b) struggle for existence; (c) natural selection; (d) heredity. So far as variability was concerned no two plants and no two animals were absolutely alike. To the man in the street each member of a large flock of merino sheep seemed precisely the same as each other member of the flock. To the enthusiastic stock breeder each sheep possessed certain peculiarities and attributes which distinguished it from every other sheep in the flock. Plants likewise were variable. Usually the variations from plant to plant were small. Occasionally quite large variations or departure from type were observed without any apparent reason. The large variations were usually stable, and were inherited. De Vries called them mutations. Darwin observed them, but he considered them relatively unimportant in the origin of species, because they occurred infrequently. Darwin considered that the small fluctuating variations were all-important in evolution, and were the material on which natural selection operated. The individuals of a species differed from one another, and those increased or decreased their chances of survival in th struggle for existence. Dealing with the struggle for existence, he said that it all the seeds produced in a year by a given species were to germinate there would be far too many plants to reach maturity. A fierce struggle for existence resulted between the individuals of the species, and the fittest survived and the unfit perished. As Darwin said:—"These plants in the long run survive which are best able to adapt themselves to their environment." Hence, the struggle for existence resulted in natural selection. The fittest individuals survived and leave progeny, the unfit perished. The forms which survived possessed characters better adapted to a given environment, and therefore these forms had an advantage over others in the struggle for existence. According to Darwin, the variations which survived in that struggle for existence were perpetuated by heredity. Thus variation produced the material on which natural selection operated, and heredity tended to perpetuate the variations. Darwin did not explain the cause of those variations, or the mechanism by which they were perpetuated by heredity. He recognised that there were two kinds of variations:—1. The chance, or fortuitous, variations, which caused a plant to be different from its neighbours. 2. Discontinuous variations, or "sports," but he considered the former of primary importance in evolution.

(To be continued.)

REGISTER. 29.7.25

VICTORIA LEAGUE LECTURE.

A large attendance is expected at the Public Library Lecture Room this evening when Professor Brailsford Robertson will lecture on the life and work of Jacques Loeb, under the auspices of the Victoria League. An intense idealist of the school of the French Encyclopaedists, Loeb was bitterly opposed to German militarism, and his political views were those which inspired the earlier phases of the French Revolution. From the scientific point of view he owed his chief inspiration to England, and Sir J. J. Thomson, of Cambridge, was the scientific author whom he most admired. The lecture will be illustrated by lantern slides, and the chair will be taken by Professor Mitchell. Further particulars appear in our advertising columns.

SCIENCE AND AGRICULTURE.

New Varieties of Plants.

Methods Used In Their Production.

No. 7.

In the continuation of his lecture before the Adelaide University extension lectures class, on the subject of new varieties of plants, Dr. A. E. V. Richardson (director of the Waite Agricultural Research Institute) said there were two general methods by which new and improved varieties of plants might be obtained, by selection, or by hybridization. Both methods had in the past been very fruitful of results. Selection was based on the isolation and propagation of a heritable variation. No two individuals were absolutely alike. Among a million plants in a field of wheat, there were bound to be some individuals possessing a useful character in excess of the average. It was the object of the plant breeder to secure crops of such individuals by selecting and isolating the improved form from its neighbours and cultivating it. Some of those variations might be due to good environment at critical stages of the plant's growth—the plants might have been favoured by having more space to develop than the majority of the plants. Those variations were not inherited because the germ cells were not in any way affected. Other variations might arise which were the result of a change in the reproduction cells. The variations were found to breed true to type. They formed the basis for improvements by selection. The selection of spontaneously occurring individuals exhibiting improved characters had provided them with the best of their cultivated plants. The figurative description of them given by the ancients, as gifts of the gods, expressed the truth, for they had been found ready-made. All that man did was to select, isolate, and propagate these new forms. The aim and action of selection was the detection of heritable variants among the useful commercial plants, and through them the isloation of a race with the desired characters.

Selection was not creative in its action—it was preservative. Nature produced a desirable heritable variation—man isolated and propagated it. Selection played no part in the origin of desirable variations—it merely preserved and propagated them.

Examples of Selection.

A few illustrations of the improvement effected by selection might be considered. There was first of all the cabbage and its cousins. There was a wild plant growing along the seacoast of southern Europe called Brassica oleraceeae. It was not unlike a weed that was very common in their wheatfields, known as charlock. In past ages one of its progenitors was a plant that gave rise to many variations. Some of those variations affected the root, others the sprouts in the axils of the leaves, others the leaves, and still others the stem and the inflorescence. Man had been selecting that highly changeable plant for many centuries and he had obtained a number of interesting and useful varieties. From it had been developed the cabbage, cauliflower, kohlrabi, Brussels sprouts, kale; the kohrabi being a selection of a variety in which the root swelled nito a fleshy turnip-like mass, the Brussels sprouts a variety in which all leafbuds developed small heads, the cabbage in which only the terminal buds formed a head, the cauliflower in which the flowers became succulent, and the kale in which the stem became greatly lengthened and succulent. All those plants, though so different in appearance, had flowers, seedpods, and seeds that were practically identical and, therefore, the systematic botanist classed all those vegetables and the original wild plant of the Mediterranean as Brassica oleraceae.

Then there was the evening primrose. In 1886, the celebrated botanist, DeVries, found a variety of evening primrose at Hilvershun in Holland, from which a large number of very distinct species had been obtained. From 63,000 seedlings which he raised in his garden at Amsterdam, he obtained seven new species, all of which he was able to breed pure. The species differed very considerably in leaf, flower, seed, and bud characters, and it was unquestionable that if such varieties had been found under natural conditions any systematic botanist would have classed them as distinct species, yet all those species were obtained from one variety which had been self-fertilized for generations. DeVries called them "sports" or "mutations," and largely on the behaviour of the evening primrose he founded his famous mutation theory to account for the origin of species. The opponents of the theory assumed that evening primrose to be of hybrid origin, and pointed out that upon such a basis the so-called mutations were merely recombinations of characters. At least one of the mutations was known not to be the result of recombination for the mechanism of [illegible]