HEREDITY.

By LUTHER BURBANK, *Santa Rosa, Cal.*

The word heredity has a familiar sound to us now, though less than fourteen years ago it could not have been found in Webster's Unabridged Dictionary. It conveys a meaning which no other single word can express and refers to the laws by which living things repeat their characteristics in their descendants.

A knowledge of the laws of heredity, or more accurately, the interaction of the hereditary forces and environmental conditions, without doubt gives man more power in guiding and molding the creative forces of Nature than any other knowledge has yet, or can ever give, and as one looks back further and still further towards the beginning of things and the laws, or more properly, forces which have led up to the present order of Nature, and which perhaps exceed all others in complexity, he can get a broader view in which beautiful harmonies appear where before discord and apparent contradictions seemed to reign supreme.

But at first sight one is almost paralyzed in making any attempt to harmonize the various views which have been held on the subject during the last half century, and it is heart-rending to think of the energies wasted on theories which had no foundation in fact, some of which Nature herself would have refuted at once if approached by actual experiments with the life forces, and, though wrong deductions may be made from actual experiments, yet by these alone can the facts be finally verified and a clearer general knowledge obtained.

Heredity may be said to be the sum of all the effects of all the environments of all past generations on the responsive ever-moving life forces, or, in other words, a record kept by the vital principle of the struggle onward and upward from simpler forms, not vague in any respect but indelibly fixed by repetition. What the vital principles are we do not yet fully know, but we do know that, when simple cells become joined together, mutual protection is secured and that they then exhibit organized forces in new directions which were impossible by anyone of the individual cells not associated in a cell colony with its fellows. These cell colonies will, if environment is favorable, increase in strength while colonies less favorably situated may be crippled or destroyed. We see this natural selection in all life every day around us. But this is only one of the many forces at work in the upward, outward, and onward movement of life. It is necessary for the continued existence of any species that it should have not only perseverance but pliability, for new conditions appear where perseverance on the old lines would mean extinction. The life forces in their march meet obstacles around, under, over, or through which they must pass, various individuals having a slightly differing sum of environment or heredity secure in their progeny greater pliability in the union.

Nearly all late writers seem to overlook or even to ignore the vast importance of natural crossing. The human intellect may well be amazed at the numerous and surprising variety of the means employed for this purpose, which alone should suggest its paramount importance in the evolution and perpetuity of life.

Crossing is the grand principal cause of all the species and varieties of earth, sea, and air. Crossing these differing lines of heredity caused by the action of past environments on the life forces produces a vast complication of vital movements, habits, tendencies, or memories if you prefer, some of which are fixed by ages of repetition, while others are of later acquisition, each of these like drops of various chemicals in a pool of water changing by so much the heredity of the subject, all being blended into the whole as we see it in its present state. But past tendencies must fade somewhat as the new ones are added, and as each individual has ancestors in untold numbers, and as each is bound to the others in close symbasis, like the numerous threads in a fabric, individuals within a species, by thus having very numerous similar lines of heredity, are very much alike, yet no two are just the same. Thus in the bundles of individuals having similar heredities—which for convenience are called species—we seldom find wide variations, and for the reasons just given; but cross two of these species and see what the result will be. Sharp variations and mutations will appear, not in the first generation, as the two are bound together in a mutual compact which, when unloosed by the next and succeeding generations, will branch in every direction as the myriad different lines of heredity combine and exhibit themselves in various new directions as if the bundle of hereditary tendencies were burst asunder by the impact and mutually arranged themselves in new and often wholly unexpected forms. Many static tendencies become dynamic under the new form of government thus produced.

A study of animals or plants belonging to widely different species and even genera, which have been under similar environments for a long time, will always show a similarity in many respects in the various means they are compelled to adopt for defense in the preservation and reproduction of life.

Desert plants often have thorns, acrid qualities and reduced foliage surface, while in moist climates thorns are seldom seen, and foliage more abundant and not so often acrid or distasteful. Similar environments produce similar results on the life forces, even with the most distantly related plants or animals. This fact alone should be proof enough, if proof were required, that acquired characters are transmitted, even though in opposition to numerous popular theories. *All characters which are transmitted have once been acquired.* The life forces are constantly pressing forward to obtain any space which can be occupied, and if they find an open avenue, always make use of it as fully as heredity can adapt itself to them.

Fluctuating variations and mutations in animals and plants are all due to the combination and interaction of the various life forces or tendencies and the environmental aids or obstacles which

they have to meet. The life forces may be compared to a river constantly pressing forward; environments are the river banks which guide these forces as the banks guide the river. A rock may make a ripple turning a part of the flow aside for a moment, yet the river keeps right on its way; but, if enough rocks are placed on one side of the stream, or if a new and better channel is found, the whole river is turned. This may illustrate the difference between the fluctuating variations and mutations of which we have heard so much of late. Mutations are only fluctuating variations carried beyond the critical point. Other similar illustrations of the actions of these forces can be drawn from the motions of ions, electrons, atoms, or planets.

Second only in power to crossing for producing variations, are abrupt changes of environment such as superabundance of food, sunshine, moisture, and freedom from competition. Some of these are found by plants and animals from time to time in Nature and always when under domestication.

Still another force leading to variations is struggle and hardship, but these are rather negative, only bringing out and making use of force acquired when ancestral conditions were more favorable, and this brings up another matter which has always been the chief stumbling block to a clearer knowledge of heredity, and one of the most difficult to understand and to trace. Sometimes we may, for instance, plant a pure white bean, and reap a full harvest of black ones, or vice versa. These experimental facts seem to contradict all laws of heredity, but not so, such cases only the more verify them. We have generally only to trace the matter back to find that some of the ancestors were of the same color as the strange freak which appeared without apparent cause, but still more complicated will it be when no such ancestral type can be found, and even in such a case careful study may, and often does, reveal the fact that tendencies, like threads in a web of cloth, had so long been pressing for expression that, when the critical point has been reached, the strong tendency which had long been overwhelmed by still stronger ones, came to the surface, but never by chance, the latest tendencies were inherent, and by crossing were doubled in strength or by more favorable conditions were allowed to express themselves.

Bud sports have also been a source of almost endless discussion and have never been in any manner satisfactorily explained by any theory until the parallelism of grafting and hybridizing was pointed out, and a knowledge of dynamic and static forces in life obtained.

Grafting or budding may be called a bio-mechanico-chemical combination. While crossing by seed is more of a bio-chemical union, yet this last union is often more truly mechanical than chemical, as in the case of mosaic union, which is not unusual when the cross is too abrupt. In fact, every graduation from a purely mechanical union to one of perfect chemical blend is a common every-day occurrence with those who have carried out field experiments on a broad and comprehensive scale.

Under the views of heredity expressed above the two schools—the Lamarckian, which claims direct response of organization to

environment, and inheritance of useful acquired characters, and the Darwinian, which claims the working out of useful structures by the influence of selection on small fluctuating variations—are perfectly harmonized, also the gap between Darwin and Wallace is closed. And now that harmony can be secured between the champions of these three great masters, we may well turn to some more useful work. And right here, the words of Auguste Comte, though written seventy-eight years ago, apply so well to what I have said that they are here quoted, and I fully and freely indorse them and am quite sure that Darwin, Wallace, and Lamarck would all have done the same. He writes:

If we conceive all possible organisms to be successively placed during a suitable time, in all imaginable mediums, the greater part of these organisms would of necessity finally disappear and leave only those surviving which could satisfy the general laws of this fundamental equilibrium. It is probable that after a succession of analagous eliminations, the biological harmony must have established itself little by little upon our planet, where we still see it continually modifying itself in a similar manner.

I have here given only a passing glance over some of the most prominent features of the action of these forces of heredity which too often seem not to have been placed in the right perspective to obtain a comprehensive view of the subject, and in closing would say that the intricate and most perplexing laws of evolution and heredity are now being traced out with great rapidity, especially since the advent of the more general plan of direct study and experiments of the biological forces themselves, the generalizations drawn from very numerous useful and painstaking special experiments on widely different subjects, and a more general knowledge that all motion, all life, all force, all so-called matter are following the same law of heredity found in plants and animals—a forward movement towards attractions through lines of least resistance.

COÖPERATIVE BREEDING.

By Prof. OSCAR ERF, *Manhattan, Kan.*

Glancing over the farm animals to-day one cannot help noticing a large percentage of inferior animals. They lack character and quality in general. This condition is due largely to the unstable attitude of breeders not selecting wisely and not staying with a particular type or breed. Furthermore, the purpose for which the animal is bred is oftentimes not clearly fixed in the minds of the breeder, and, even if this is true, it is often diverted by popular sentiment. Successful breeding depends on stability to remain with and to work for a fixed and clearly defined purpose. Animals of old, well-established breeds reproduce themselves with more uniformity than do those of breeds of more recent origin. To breed a certain