number of cases, and the limitations of their use for that purpose are shown in an extended note in 35 L. R. A., 802, to the case of *Dederichs v. Salt Lake City R. R.* X-ray photographs have also been accepted in evidence, as shown by that note, and also by the case of *Geneva v. Burnett*, 65 Neb., 464; 58 L. R. A., 287; 101 Am. St. Rep., 628; 91 N. W., 275. Another new kind of evidence created by modern scientific developments is that furnished by telephones, and the right to put telephone conversations in evidence, though not universally conceded, has been upheld in a number of decisions, as shown in *Oskamp v. Gadsden*, 35 Neb., 7; 17 L. R. A., 440; 37 Am. St. Rep., 428; 52 N. W., 718, and the annotation to that case. Whatever restrictions or conditions the courts may impose on the use of phonographs in evidence, it is not to be doubted that they will ultimately come to be regarded by the courts as evidence no less reliable than photographs, X-ray pictures, and telephones.—Case and Comment, January, 1906.

PLOVER NETTING IN THE FENS.

Our first illustration represents some of the machinery for catching plovers, although at first sight it might pass for a picture of what they call a "promising city" in the Far West, with its mill-pump and solid-looking shanty in the foreground, and the illimitable prairie stretching to the horizon. But if your eye follows the trench which goes from the pump toward the horizon for about 60 yards, you will see that it ends in a small sheet of water. The next illustration gives a nearer view of this miniature lake, which has a long, narrow island in the center and a few tiny islets, scarcely bigger than molehills, sticking up out of the water. This is the plover decoy, and the object of the water-windmill, in the first picture, is simply to keep the lake, some 20 yards in diameter, full of water. It is upon the use of the tiny islets that cause for action, under the Protection Acts, may arise; for one need hardly remark that the snarer, crouching in his hut 50 yards away, does not periodically expose himself in the open, tramping across the 50 yards of open space between himself and the decoy, and pad-

chanced upon a hospitable land indeed; but from end to end stretches the fatal net, which falls just at the right moment to envelope the fluttering multitude.

For it is at this point that the utility of the substantial-looking shanty of our first illustration comes in. A nearer view shows it to be the snarer's hut, and if you look carefully at this last picture you will just see the line, which he is holding, stretching taut and

MACHINE FOR CATCHING PLOVER.

straight to the right, in which direction, at some 50 yards distance, is situated the decoy represented in the previous pictures. The hut, built solidly of turfs and trenched round to save the snarer from being washed out in case of rain, is fringed with dead stalks of rank Fen herbage, and, to the plovers' "bird's-eye" view of the landscape suggests only a solid mound, neglected and overgrown. But from it human eyes are watching their movements, and a ready hand grips the cord which controls the distant net. Thus the very caution of the bird delivers it helpless into the hand of man;

THE VICTIMS' LANDING PLACE.

dling in the water to ascertain whether the tethered plovers on their separate islets are becoming fatigued.

These illustrations exhibit well the terrible monotony of flatness in Fens, and it is on account of this feature of the landscape that the plover-snarers are able to make such large and frequent hauls as to recoup themselves for the outlay of their elaborate preparations. Wandering flocks of birds are always distrustful of strange landscapes. When the weary migrants reach our shores in autumn you may watch them drifting irresolutely across the sky, calling as they go. Presently a responsive call of their own kind arises from the earth below; and, at once, with a rushing sound of half-closed pinions the crowd of travelers swoop earthward toward the spot whence the welcome sound proceeded. Sometimes it was only the clever mimicry of a hidden shore-shooter, and two barrels are emptied into the thick of the close-packed birds before they discover the deception and wheel aloft to find a less treacherous resting place. And ground birds, like the plovers, are peculiarly liable to fall into such ambush. Perching migrants, such as fieldfares or redwings, can crowd with safety into the topmost branches of lofty trees and thence survey the landscape carefully before they descend to the ground. But for the plover there is no halfway house between sky and earth. So you may see him, circling and wheeling by thousands together, ere he dares to alight; now swooping down with a murmurous rhythm of wings like the folding of many newspapers, now shooting aloft with the momentum of his descent, and skimming obliquely over many acres, for the land bristles with perils, and instinct teaches the plover to beware of alighting where any chance of danger lurks. Only one circumstance will give him perfect confidence, and that is the presence of other plovers. So, when the wheeling myriads discover a welcome sheet of water, studded with islets, upon which members of their own kind are standing, they boldly drop toward them; and, in doing so, they discover that a long, low island in the midst of the water is the only place where they have room to settle near their friends. But it is the victims' landing place. It has been richly baited with worms, and, for a brief moment, the thronging wayfarers think that they have

for it is only because the plovers are so very careful not to alight except where it seems absolutely safe that man is able to decoy them within his reach.—Country Life (London).

SOME RECENT RESULTS OF STUDIES ON HEREDITY.

By J. PERCY MOORE.

THAT the progeny of animals and plants are fashioned each after its kind, and that in general the young resemble their parents more closely than any

organization, there are certain evident differences between organic heredity and the form repetition of minerals.

In the first place no two individuals of a plant or animal species are exactly alike. They vary in a more or less indeterminate way, and some of them depart widely from their parental type. These variations cannot usually be traced to any such simple influences as the mechanical pressures and interferences which produce alterations in the form of crystals. Many of them arise as the result of influences inherent in the organism which exhibits them; and in such a manner that we are forced to believe that they have been transmitted from a previous generation in which they arose.

A second important difference is that in sexual reproduction, through the medium of which the hereditary forces act, each parent contributes but a minute part of its body, in animals a single ovum or a single spermatozoan, to the formation of the progeny. The latter arises from a single fertilized egg cell; and by processes of growth and change through courses more or less indirect and devious gradually assumes the adult form of its parents. The nature of the successive forms which an organism takes on during its development is more or less influenced by the ancestral history, remote and recent, of its lineage. Nothing at all resembling this takes place in the formation of mineral crystals. Crystallization much more nearly resembles the processes of regeneration of lost parts or of vegetative growth in animals and plants.

It is this compression of the entire heritage of the race within the compass of a minute germ that has always excited the wonder of thoughtful minds, and has led to the drafting of numerous hypotheses to account for the mechanism by which qualities are transmitted. By what mysterious machinery are the potentialities of the hen and her lord concentrated within the fertile germinal spot of the egg and again loosed and unfolded in the developing chick? All of the painstaking labor which has been directed toward the solution of this question has resulted in establishing the fact that the bearers of certain classes of characters which have become so fundamentally fixed upon the organism that the germinal substance is thereby modified are contained in a certain substance localized in the nuclei of the germ cells. We are as far as ever from fathoming the real mystery of heredity.

There is, however, another side to the question and another and more promising line of investigation opens, namely, the behavior of specific characters in heredity and the course of their transmission from generation to generation. The human importance of this subject is so vast that efforts to find means of controlling or foretelling the course of heredity have been general and persistent. Sociologists foresee in success not only the elimination of disease and crime from human society, but the strengthening of the better physical, mental, and moral attributes, the amalgamation of the best qualities of various races, and in general the improvement of the human species. Less visionary, perhaps, is the outlook of the breeder, who has already "created" and controlled, to meet the ever-expanding needs of civilized man, many new and improved varieties of domesticated animals and plants, and whose claim to have been the most potent single influence in uplifting man from savagery is undoubtedly well founded.

The experience of breeders and other students of heredity has long since made familiar the fact that all characters do not exhibit a similar transmission behavior. Some possess a remarkable force and persistence, others are quickly suppressed, or appear only at long and irregular intervals, or in a minority of the offspring. Some are paired and alternative to others, with which they seldom or never mix. They appear to be antagonistic or mutually exclusive. Such are light and dark eyes in the human species. Of the children of parents who differ in this respect some will have eyes with the iris pigmented blue, some with it brown, but very seldom of an intermediate color. On the other hand certain characters blend in heredity, and

THE SNARER'S HUT.

other individuals are phenomena so constantly before us that most of us simply accept them as fundamental facts of nature. Heredity is a property or function of the living substance, protoplasm, as the crystallographic habit is a property of minerals. While this conclusion is doubtless true in the very broad sense that the inherent activities of an animal or plant depend in the last analysis on its chemical composition and physical

with respect to such the offspring are on the average a mean between the two parents and their accumulated ancestry. Children born to white and negro unions have the skin of an intermediate hue, and in crosses of whatever degree the depth of pigmentation is in general an expression of the relative amounts of white and negro blood present in the mixture. Stature as a rule behaves similarly. Again, parental qualities, while

not actually blending, may mix in a mosaic or patch-work form, as occurs, for example, in the piebald distribution of pigments in the skin of circus ponies, certain fanciers' breeds of rats and mice, etc. Some characters are correlated with or bound to others in heredity, as are certain physical characters with the sex of the parent in reciprocal crosses between the horse and ass to produce the mule or hinny. Furthermore, a character may exhibit cumulative strength; or it may decline and disappear. A totally new character may appear suddenly and possess great transmission force from the start; or a long dormant ancestral character may as suddenly become apparent and then persist with remarkable tenacity, or quickly disappear from succeeding generations. The behavior of these various kinds is very puzzling, and until recently there has been practically no known method of analyzing them with certainty, and no scientific explanation of any one of them.

A great step forward in the understanding of the laws governing the course of heredity was undoubtedly made when Francis Galton, a cousin of Charles Darwin, showed that it is possible to express mathematically the average ancestral influence in heredity. By the application of purely statistical methods to the study of such blending qualities as human stature and the coat colors of certain breeds of hounds he secured data for the formulation of what is now known as Galton's law of ancestral influence in heredity. According to this law of the characters inherited by the progeny the two parents contribute in general one-half, the four grandparents one-quarter, the eight great-grandparents one-eighth, and so on. In general the influence in heredity of any ancestral generation is inversely proportional to the total number of individuals comprised in that generation. Later studies by Pierson and others have amplified this law and given to it greater precision for blended characters. Notwithstanding that it expresses an important truth, Galton's law has been and must be of very limited practical value to the breeder. It is retrospective in character, and, while it serves as an expression of the average ancestral contribution to the entire heritage of a descendant, it gives no clue to the part which any particular individual is likely to play in the determination of the characters of his prospective descendants. It merely teaches us more precisely what was well known before, that a descendant is the more likely to be tall as the average height of his ancestors exceeds the mean for the race, and the like.

It is in the field of alternative characters, however, that the application of careful experimental, statistical, and analytical methods has gained its great triumphs over the method of unguided observation. Working alone and unheeded in the garden of the Augustinian Monastery of Brunn, in Austria, the Abbot Mendel laid the foundations for this newer work forty years ago. But so busily occupied were scientific men with the Darwinian controversy then raging that Mendel's two modest papers were overlooked. Not until 1901, when others had reached the same conclusions, were they rediscovered and their contents made known to the world. No fewer than four different botanists engaged in plant-breeding in as many countries—De Vries in Holland, Correns in Germany, Tschermak in Austria, and Spillman in America—rediscovered the same principles independently. Both botanists and zoologists have been quick to see the importance of Mendel's Law, as the formulation of the principles discovered by him is now appropriately designated. It is not too much to say that the progress made toward a really scientific knowledge of the course of heredity under the stimulus of Mendel's work in the last five or six years is more important than that of the past centuries.

Mendel's experiments with garden peas illustrate admirably the new method and its results. His method differs from that of previous breeders in the care with which all the progeny from each cross were kept separate for a number of successive generations. He selected for observation a number of contrasted characters which are alternative in nature and never appear together in the same individual. Among these, were whether the cotyledons were green or yellow, the seeds round or angular, the pods wrinkled or smooth, the stems tall or dwarfed, etc. Taking varieties differing in respect to one or more of these characters he cross-pollinated the flowers and saved and planted all of the hybrid seed produced and those of the progeny of the latter for several generations. The characters exhibited by all of the offspring were carefully observed and the results tabulated. The result of his painstaking work was the discovery of two entirely new and unexpected principles which may be best explained by a simple illustration.

Let us follow the results in crossing peas differing only in the yellow color of the cotyledons of one variety and the green color of the other. All of the cross-pollinated flowers of the original cross produce yellow seeds only; none are green and none intermediate in color. The green color is totally suppressed as a visible character. This is Mendel's principle of dominance; the patent character he terms the dominant, the suppressed one the recessive. All of this first hybrid generation resemble the yellow-seeded or dominant parent. If all of these seeds be now grown and the plants in turn set seed, the latter will be partly yellow and partly green and always in the proportion of approximately three of the former to one of the latter.

This illustrates the principle of the segregation of characters. The alternative characters separate in the germ cells in such a way that each germ cell carries either the dominant or recessive character of a pair but, under ordinary circumstances, never both. Thus

in the case of plants there are ovules which bear the dominant and those which bear the recessive character, as well as dominant pollen and recessive pollen. Now as each of these kinds is ordinarily produced in equal numbers and every seed results from the union of one ovule and one pollen grain it follows that in general each kind of ovule will be fertilized an equal number of times by each kind of pollen grain. This is most clearly expressed by the following symbolic formula, in which *D* represents the dominant and *R* the recessive character, the latter being included in parentheses when latent in the presence of its dominant. The hybrids of the first cross-bred generation will produce

$$\begin{array}{ccc} \text{Ovules} & \text{D and R} & \text{fertilized by} \\ \text{Pollen} & \text{D and R} & \text{resulting in} \\ \text{Progeny} & \text{DD, DR, (R)D and RR.} & \end{array}$$

That is, in the case of the cross between yellow and green peas, there result in the second hybrid generation progeny, one-fourth of which are pure recessives having green seeds, one-fourth pure dominants with yellow seeds, and one-half unstable hybrids with yellow seeds, but which contain the recessive green character in a latent form. The green-seeded peas may be separated, and if close-bred will never produce any but green-seeded progeny. The yellow-seeded peas are all exactly alike and it is not possible at this time to separate the pure dominants from the hybrids. This is, however, easily done by self-pollinating each of the plants produced from these yellow seeds. The dominant class will produce yellow seeds alone while the hybrids will again produce, as before, yellow and green seeds in the proportion of 3 to 1.

Some actual figures based on extensive experiments will give concreteness to these statements. Mendel, dealing with the characters employed in the above illustration, records that 258 hybrid plants grown from yellow seeds produced in the second generation 8,023 seeds, of which 6,022 were yellow and 2,001 green, the ratio being 3.01 to 1. In the next generation, of 519 plants grown from the yellow seeds, 166 yielded yellow seeds exclusively and 353 yielded yellow and green seeds, in the proportion of 3 to 1. The yellow seeds therefore produce hybrid and constant or pure dominant forms in the proportion of 2.13 to 1. The plants grown from the green seeds yielded green seeds only. Such experiments explain the well-known fact that hybrids bred *inter se* always tend to revert to the parent types from which they have sprung.

While the case of simple dominance in crosses differing by one alternative character fully illustrates the nature of the basic principles of Mendelian breeding, it can have no importance in the actual production of new varieties. The problem of the practical breeder is far more complex. Perhaps the simplest case with which he has to deal is the combination in one stock of two desirable qualities which have appeared in separate individuals or strains. Exactly the same principles apply to such cases, by however many alternative characters the varieties or species may differ, and for however many generations they may be cross-bred. They have been fully tested and verified in crosses involving 3 and 4 pairs of characters.

It is clear, however, that the number of possible combinations of characters and the number of visibly distinct classes of offspring must increase very rapidly with the number of differential characters. Thus in the second hybrid generation of crosses differing in respect to two pairs of alternative characters there will be sixteen possible combinations, of which seven are reciprocal and of identical nature, leaving nine distinct classes which behave differently in heredity. Four of these are pure, and represent the four possible combinations of the differential characters concerned. The other five are unstable hybrids of various compositions, but all containing in latent form one or both recessive characters, which on further breeding will appear in a definite percentage of the progeny. The history of all of these has been repeatedly ascertained and the formulae representing each worked out for both plants and animals.

In order to illustrate how the principles of dominance and segregation may be employed in practical breeding we may suppose a simple case, the data for which have been fully worked out by Dr. Castle. Let us suppose that a breeder of guinea pigs is desirous of producing a pure stock of rough-coated or "rosetted" albinos, and has available for breeding purposes only animals which exhibit these characters in the combinations of rough with pigmented coat and albino with smooth coat. The desired result can be attained much more quickly and certainly by the Mendelian than by the usual method of crossing and selection, which may fail to separate the pure stock.

Dr. Castle's experiments have shown that rough coat is alternative with and dominant over smooth coat, and that white coat is alternative with and recessive to pigmented coat. Crossing the rough-pigmented animals with the smooth albinos there are produced hybrids, all of which exhibit only the dominant coat characters of roughness and pigmentation. When these are bred *inter se* their progeny split into nine distinct (though not all immediately visibly so) categories, in some of which the latent recessive characters of albinism and smooth coat have appeared. Out of every sixteen of these progeny three on the average will exhibit the combination of characters desired. The white coat will also be present in latent form in some of the other progeny.

An inexperienced breeder would perhaps conclude

that his object had been attained, and would proceed to breed together indiscriminately the most vigorous individuals exhibiting the rough white coat, with the result that many of the progeny would have smooth white coats. As such individuals would be discarded, the pure stock desired would probably be secured sooner or later by the more or less lucky accident of crossing animals which are pure in the sense that they do not contain the recessive character of smoothness. To the Mendelian breeder several courses of procedure would be open. One of the simplest would be to test each of his rough-coated albinos for purity by crossing each with a smooth-coated albino, which contains the recessive characters only. The result would be that about one-third of the rough, white animals would produce to this cross only progeny similar to themselves, while the other two-thirds would produce mixed progeny in the usual proportions of three rough albinos to one smooth albino. The individuals which yield offspring of one kind only are the pure stock sought and will remain pure as long as they continue to be inbred. The test is as decisive as the chemist's tests for metals in a solution of unknown composition.

The theoretical explanation of Mendel's law receives strong support from the fact that there exists the germ cells, a mechanism by which the segregation of characters may be brought about in exactly the proportions described. A long series of careful researches have proved that certain qualities are transmitted through the agency of the so-called chromation or deeply straining substance of the nucleus. This material is arranged in the form of separate particles or chromosomes and is derived in equal parts from the male and female parent. When the germ cells are becoming ripe these chromosomes first unite in pairs and are then divided equally between two cells in the most precise manner. These remarkable processes afford the means for rearranging and then segregating in distinct germ cells the bearers of alternative characters in exactly the way that Mendel's law requires. While segregation thus finds its explanation, dominance remains totally unaccounted for. We have no clue whatever as to why some characters should appear in perfect development whenever their dominant partner is absent.

It is too soon to estimate the importance of the application of Mendel's principles in the practical breeding of animals and plants. Very much has been done in the garden and laboratory in establishing the essential truth of the law and its corollaries and in determining which of alternative characters is dominant and which recessive. Much valuable information has been gathered; but apparently few professional breeders have applied the new method to their art and until they do its value as a working method must remain undetermined. The opinion that has been expressed that, because the actual varieties handled by breeders differ in many characters, the Mendelian procedure will prove too complicated and cumbersome is probably not well founded. On the contrary it would seem that its application would tend to simplify greatly and to give precision to the work of the breeder. The really essential qualities by which desirable breeds differ are not many, and the minor characters are generally unimportant and variable. This is clearly shown by the adoption of sliding scales of values for the guidance of judges in awarding prizes at breeders' shows.

By the employment of Mendelian methods the breeder should be enabled quickly to separate these hybrid categories which alone embody the desired combinations of qualities. Complex hybrids can be analyzed and split into simpler combinations which can then be dealt with more effectually for the elimination of objectionable and the retention of desirable features. Latent characters can be more quickly detected and more certainly controlled than by the old methods. The true composition of a stock having been once determined the constituents may be recombined much more quickly and definitely than by the methods now in use, and in the simpler cases at least almost at will, as has actually been done already with peas, beans, wheat, cotton, various flowering plants, mice, rats, rabbits, guinea pigs, chickens, and perhaps a score of other plants and animals. The advantage of Mendelian breeding over the old practice is that of combining elements of known composition and behavior over that of mixing those of unknown composition and uncertain behavior.

While it is not probable that the employment of Mendel's method will result in any greater triumphs in the improvement of old varieties or the production of new ones than have present methods in the hands of such a genius in plant breeding as Luther Burbank, it seems probable that it will at least enable the breeder to fix his new types much more quickly and completely and save him much time and labor in the avoidance of futile attempts to hybridize impossible combinations. Although discovered and chiefly investigated by botanists, it seems probable that these principles will prove of even greater value to breeders of animals than of plants, because of the greater importance of maintaining purity in the former. In the case of perennial plants it is generally necessary to produce only a single vigorous individual of a desired variety. And no matter how unstable the germinal composition of a hybrid may be, it may be propagated indefinitely from cuttings, buds, and grafts, which are simply detached portions of the original plant. The grower need have no concern about germinal purity. Most of our fruit trees, roses, etc., are notoriously unstable and variable when grown from seed, which is evidence of their complex hybrid character. The same holds true for an-

nuals propagated from tubers, bulbs, and cuttings. For annual plants regularly grown from seed, and for all domestic animals the importance of germinal purity in order to maintain the standard of the race is obvious from the facts previously outlined.

Perhaps it will not be many years before the breeder, like the engineer, will be provided with his rule book, in which will be printed Mendelian tables of paired characters fully tested for dominance, recessiveness, and purity in various animals and under various conditions. Therein will be found Mendelian formulæ fully worked out for all possible combinations of the different types of homozygote and heterozygote in different animals, established Mendelian pedigrees and other equally valuable tables. The breeder will then be able, perhaps, to produce to order within a contract time, a new variety having certain specified characters with something approaching the certainty with which an engineer plans and builds a bridge, or a chemist produces a new synthetic compound. This is a vision inspired by the picture held before us by the most enthusiastic workers in Mendelian fields.

THE WRIGHT BROTHERS' FLYING MACHINE AND WHAT IT HAS ACCOMPLISHED.

IN a communication made last month to the newly-formed Aero Club of America, the Messrs. Orville and Wilbur Wright, of Dayton, Ohio, detail the development of their man-carrying, motor-driven aeroplane, and tell, in the following words, what they have accomplished with it:

"Though America, through the labors of Prof. Langley, Mr. Chanute, and others, had acquired not less than ten years ago the recognized leadership in that branch of aeronautics which pertains to birdlike flight, it has not heretofore been possible for American workers to present a summary of each year's experiments to a society of their own country devoted exclusively to the promotion of aeronautic studies and sports. It is with great pleasure, therefore, that we now find ourselves able to make a report to such a society.

"Previous to the year 1905 we had experimented at Kitty Hawk, N. C., with man-carrying gliding machines in the years 1900, 1901, 1902, and 1903; and with a man-carrying motor flyer, which, on the 17th day of December, 1903, sustained itself in the air for 59 seconds, during which time it advanced against a 20-mile wind a distance of 852 feet. Flights to the number of more than a hundred had also been made at Dayton, Ohio, in 1904, with a second motor flyer. Of these flights, a complete circle made for the first time on the 20th of September, and two flights of three miles each made on the 9th of November and the 1st of December, respectively, were the more notable performances.

"The object of the 1905 experiments was to determine the cause and discover remedies for several obscure and somewhat rare difficulties which had been encountered in some of the 1904 flights, and which it was necessary to overcome before it would be safe to employ flyers for practical purposes. The experiments were made in a swampy meadow about eight miles east of Dayton, Ohio, and continued from June until the early days of October, when the impossibility of longer maintaining privacy necessitated their discontinuance.

"Owing to frequent experimental changes in the machine and the resulting differences in its management, the earlier flights were short; but toward the middle of September means of correcting the obscure troubles were found and the flyer was at last brought under satisfactory control. From this time forward almost every flight established a new record. In the following schedule the duration, distance, and cause of stopping are given for some of the later flights:

Date.	Distance. Miles.	Time. Min. Sec.	Cause of Stopping.
Sept. 26....	11½	18 09	Exhaustion of fuel.
Sept. 29....	12	19 55	Exhaustion of fuel.
Sept. 30....		17 15	Hot bearing.
Oct. 3....	15¼	25 05	Hot bearing.
Oct. 4....	20¾	33 17	Hot bearing.
Oct. 5....	24 1-5	38 03	Exhaustion of fuel.

"It will be seen that an average speed of a little more than 38 miles an hour was maintained in the last flight. All of the flights were made over a circular course of about three-fourths of a mile to the lap, which reduced the speed somewhat. The machine increased its velocity on the straight parts of the course and slowed down on the curves. It is believed that in straight flight the normal speed is more than 40 miles an hour. In the earlier of the flights named above less than six pounds of gasoline was carried. In the later ones a tank was fitted large enough to hold fuel for an hour, but by oversight it was not completely filled before the flight of October 5.

"In the past three years a total of 160 flights has been made with our motor-driven flyers, and a total distance of almost exactly 160 miles covered, an average of a mile to each flight, but until the machine had received its final improvements the flights were mostly short, as is evidenced by the fact that the flight of October 5 was longer than the 105 flights of the year 1904 together.

"The lengths of the flights were measured by a Richard anemometer which was attached to the machine. The records were found to agree closely with the distances measured over the ground when the flights were made in calm air over a straight course; but when the flights were made in circles a close comparison was impossible, because it was not practicable accurately to trace the course over the ground. In the

flight of October 5 a total of 29.7 circuits of the field was made. The times were taken with stop watches. In operating the machine it has been our custom for many years to alternate in making flights, and such care has been observed that neither of us has suffered any serious injury, though in the earlier flights our ignorance and the inadequacy of the means of control made the work exceedingly dangerous.

"The 1905 flyer had a total weight of about 925 pounds, including the operator, and was of such substantial construction as to be able to make landings at high speed without being strained or broken. From the beginning the prime object was to devise a machine of practical utility, rather than a useless and extravagant toy. For this reason extreme lightness of construction has always been resolutely rejected. On the other hand, every effort has been made to increase the scientific efficiency of the wings and screws in order that even heavily built machines may be carried with a moderate expenditure of power. The favorable results which have been obtained have been due to improvements in flying quality, resulting from more scientific design, and to improved methods of balancing and steering. The motor and machinery possess no extraordinary qualities. The best dividends on the labor invested have invariably come from seeking more knowledge rather than more power."

The facts contained in a letter of Orville Wright to the Aeronautical Society of Great Britain, written under date of November 17, 1905, will also be of interest:

"All these flights were made at about 38 miles an hour, the longest occupying over half an hour. Landings were caused by the exhaustion of fuel or by heating of the bearings in parts of the motor to which oil cups had not then been fitted. Before the flight of October 5, oil cups had been fitted to all the bearings, and the small gasoline can had been replaced with one which carried enough fuel for an hour's flight. Unfortunately, we neglected to refill the reservoir just before starting, and in consequence the flight was limited to 38 minutes. The machine passed through all these flights without the slightest damage. In each of these flights we returned frequently to the starting point, passing high over the heads of the spectators."

It will be noted that although a complete description is here given by the Wright brothers of what they accomplished, nothing whatever was said of the means by which they have succeeded in flying. We understand, however, from other sources, that their motor-driven machine is very similar to their original glider, with which they experimented during the years 1900-1903. The motor-driven aeroplane consists of two long, rectangular, superposed planes some 40 feet in length by 6 feet wide, and having a space of 6 feet separating them. These planes are connected by vertical posts, and are stayed and reinforced by diagonal piano wires, thus making a very strong and rigid connection. A four-cylinder, four-cycle, vertical, air-cooled motor of about 24 horse-power is placed at the rear part and in the center of the lower plane. It drives, by means of chains, two propellers mounted about half way between the upper and lower planes and placed some 10 or 15 feet apart. Behind each propeller is a vertical rudder, the two being connected together so that they will move in unison. The operator lies flat upon the lower aeroplane at its center part, and directly in front of the motor. His head is immediately below two superposed, horizontal, guiding planes, the angle of which he can alter and thus control the inclination and elevation of the aeroplane. The motor is said to weigh some 250 pounds, and a balance weight of 50 pounds is said to be placed in the front of the machine, in order to counterbalance the weight of the motor at the rear. The total weight of the machine and operator is 925 pounds, and the weight per horse-power which it is possible to sustain with it at speeds ranging around 40 miles an hour, has been found to be in the neighborhood of 60 pounds.

The aeroplane rests on runners when it alights upon the ground, and when starting it is placed upon a small carriage which runs on wheels on an ordinary rail some 40 feet in length. This rail is laid horizontally upon supports which raise it about 6 inches from the ground. With the aid of two men to steady and push the machine, its propellers will cause it to rise from the rail after it has traveled about half the length of the same. The machine is so substantially built that it can alight at a considerable speed on soft earth without being damaged. In view of the fact that the motor and all parts of the machine are much heavier than they need necessarily be for strength, it seems probable that in a short time one of these machines little if any larger in size will be able to carry two people as readily as it now carries one. The solving of the problem of stability of this type of aeroplane (which is about the most unstable of all types), even though it has been as thoroughly done as would appear, makes it seem probable that other forms of aeroplanes, which have greater inherent stability but less lifting power, will soon supersede the elongated planes now used by the Wrights.

The Aero Club at its last meeting passed this resolution:

Whereas, The Messrs. Wright brothers, Wilbur and Orville, of Dayton, Ohio, have developed an aeroplane type of flying machine that many times has carried a man safely through the air at high speed, and continuously over long distances, and, therefore, of practical value to mankind; therefore, be it

Resolved, That the Aero Club of America hereby ex-

presses to them its hearty felicitations on their great achievement in devising, constructing and operating a successful man-carrying dynamic flying machine; and be it further

Resolved, That a copy of these resolutions be addressed to Messrs. Wilbur and Orville Wright, at Dayton, Ohio.

Santos Dumont, who is a member of the Aero Club of America, and who is to be one of the club's representatives in the coming international balloon contest in France, is at work on a machine with which he expects to win the Deutsch-Archdeacon \$10,000 prize for machines heavier than air. According to the SCIENTIFIC AMERICAN, this machine is to be a helicopter, or screw flyer, that is to say, an apparatus which will raise, support, and propel itself through the air solely by the powers of horizontal and vertical propellers. The frame and the rigging, like those of the dirigible balloons of the same inventor, are made entirely of bamboo, silk, and piano wire; and only the motor and the mechanism for the transmission of power are formed necessarily of heavier metal parts. This machine will weigh 352 pounds, and it will be furnished with a 24-horse-power air-cooled motor weighing 77.16 pounds, or about ¾ pounds to the horse-power.

"The helicopter is formed of a rectangular frame of bamboo," says the SCIENTIFIC AMERICAN, "which carries at its ends the vertical shafts of the upper or lifting propellers. In the middle frame is a third vertical axis, which, prolonged downward, serves as a support for the motor platform. A driving propeller is attached to the bow of the skeleton craft and a rudder to the stern. The total length of the apparatus is 41 feet and the total height 19.68 feet. The motor drives by bevel gear a vertical shaft, carrying at its upper end two small pulleys which transmit the motion, by belts, to two bicycle wheels 3.93 feet in diameter, mounted horizontally on the shafts of the lifting propellers. One of the belts is straight, and the other is crossed, so that the two propellers rotate in opposite directions. A bevel pinion which can be thrown in and out of gear permits the horizontal shaft to be started and stopped at will. Finally, the whole apparatus is stiffened by shrouds of piano wire, so arranged as to resist deformation stresses. A yard, attached at right angles to the lower side of the frame and fastened firmly by stays to the other pieces, assures transverse stability.

"Two details are of sufficient importance to deserve special mention. In the first place, in order to prevent deformation of the lifting propellers and to make possible their extraordinary lightness of construction, M. Santos Dumont drives them, not by the motion of the shaft on which they are mounted, but by means of wires which connect various points of their blades to the bicycle wheels to which the power of the motor is transmitted. In the second place, the rudder presents a peculiarity of being movable about a horizontal axis.

"The motor is of the eight-cylinder type, and M. Santos Dumont, in order to reduce the weight of the machine to a minimum, will employ for the operator's seat an ordinary bicycle saddle attached to the platform of the motor.

"The complete apparatus, manned and equipped, weighs 352¾ pounds, of which 231½ pounds represents the weight of the helicopter and 121¼ pounds that of the aeronaut and a few indispensable instruments.

"These figures show how far M. Santos Dumont has gone in eliminating everything that appears to him superfluous. With a lifting power of 22 pounds per horse-power, the 18 horse-power which the inventor expects to develop at the propellers should produce an ascensional force of 396 pounds, or 44 pounds more than the total weight of machine and operator."

THE PERFECTING OF THE AEROPLANE FLYING MACHINE.

By LIVINGSTON WRIGHT.

THE originality of the Wright brothers' machine, the particular point at which lies its chief departure from previous usage, is in the invention and application of a practicable system of control over the apparatus when it is once in the air. The working out of a new system of control is the great initial advance made by the Wrights over all their predecessors. This step, when once taken, enabled them by practice to attain complete success.

Theoretically, the balancing and guiding of a flying machine is simple enough, consisting merely in controlling the relation between the center of gravity and the center of pressure. If the two are coincident, the machine driven through the air will remain level. It will tip neither forward nor back, to the right nor to the left. In actual practice, however, the two centers will not remain coincident for a single second. The center of pressure particularly will shift and vary its position constantly and in all directions. The first thing the Wrights did was to remove the smaller aero-curve, or rudder, from the rear and place it in front. The angle at which this secondary aero-curve is presented to the wind can force the center of pressure for the entire contrivance in front of the center of gravity, thus raising the front end and causing the machine to soar, or it can allow the center of pressure to drop behind the center of gravity, thus depressing the front end of the airship and directing it to earth. But the chief advantage of this rudder and front arrangement lies in the increase it affords in stability. The center of pressure in an aero-curve moving for-