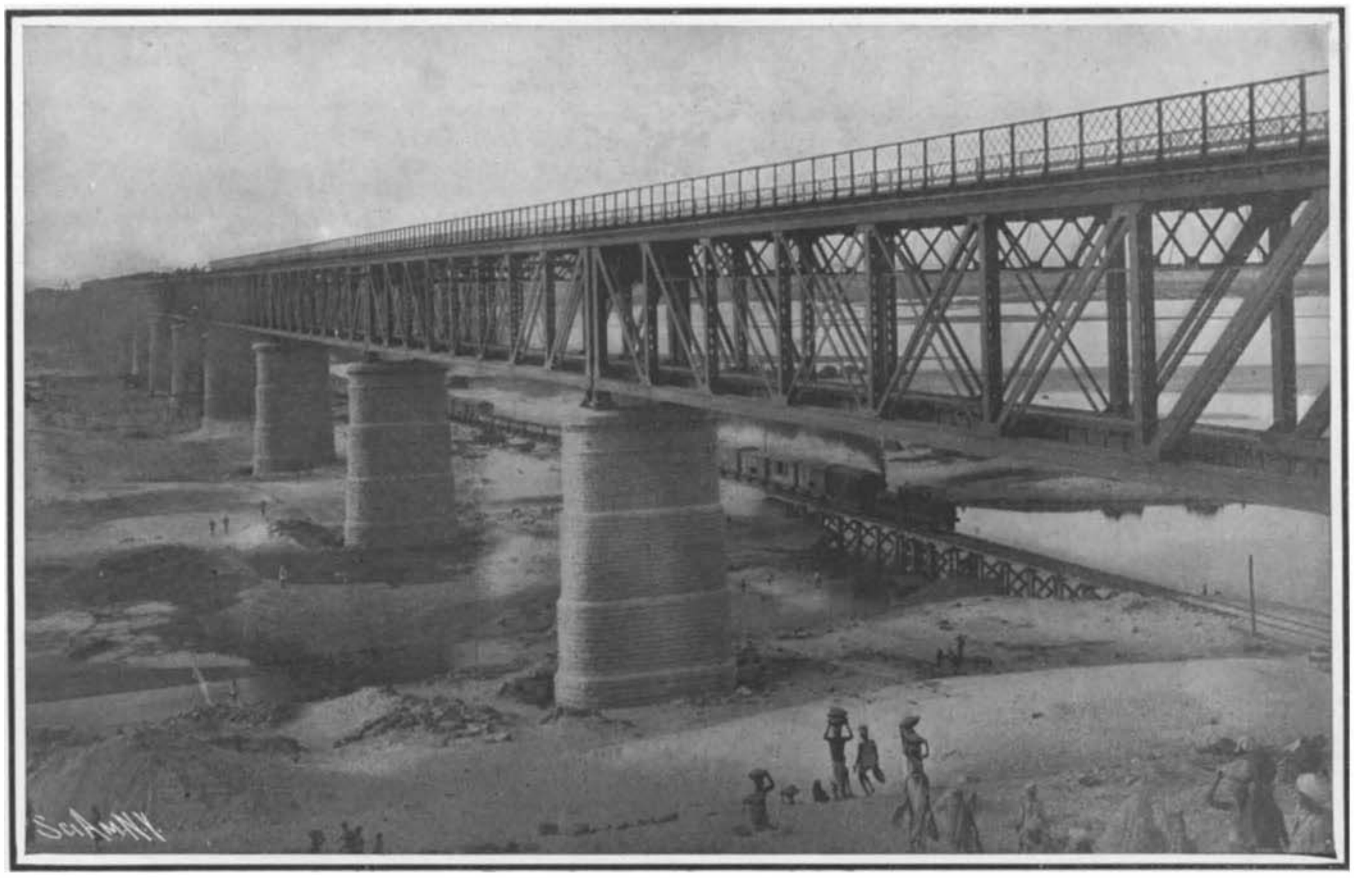
THE NARROWING OF THE GANGES AND CONSTRUCTION OF THE CURZON BRIDGE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

In the bridging of such alluvial rivers as the Ganges, Chenab, Sutlej, etc., in India, it is not unusual to constrict the river's channel for the purpose of expediting and economizing the cost of bridge construction. Many of the more important waterways are extremely wide, the water during periods of flood having eroded its way unchecked through the soft banks on either side of its normal channel, until further expansion has been checked by the presence of inerodible soil. Under these circumstances the rivers assume great widths, and in the flood season form a body of water possibly three miles or more in width from bank to bank. In the dry season, however, when the river is at its lowest level, large tracts of sand are exposed where the water has receded. Under such circumstances the throwing of bridges across such unrestricted waterways is an expensive, protracted, and difficult undertaking, while the possibility of reclaiming the area inundated is impracticable. The most efficient and economical solution of the difficulty, however, which has yet been found is the construction of an embankment, or training-bund, parallel with the navigable channel at a selected point, so that the course of the waterway is a constricted passage, the flow of water on the inner side of the training bund being blocked by the approach bank leading to the training-bund and the bridge. This system was first employed by Mr. J. R. Bell in carrying the Northwestern State Railroad across the Chenab River at Sher Shah in 1888, and it proved so successful that such works are now extensively employed. The latest and largest example of such work is the left-bank training-bund of the Curzon Bridge at Allahabad. The Curzon Bridge is on the line of the new Allahabad-Fyzabad Railroad, 97 miles in length, which offers a direct route between the city of Allahabad, the Oudh province, and Bombay and Lucknow. It is of the double-deck type, the lower deck carrying the 5-foot 6-inch gage of the railroad, and the upper deck a thoroughfare for vehicular and pedestrian traffic. At the point where the bridge crosses the Ganges, the waterway is approximately 1.25 miles in width; but by the provision of the training-bund, the bridge section is reduced to about 3,000 feet, comprising fifteen spans each of 200 feet length, so that the bridge itself occupies less than one-half of the width of the river. In the neighborhood of the city of Allahabad the river flows between two high banks of hard clay, which even the flood waters have failed to erode, the distance from bank to bank being about three miles. This width is entirely covered with water during the flood season, the water thus filling practically the whole of the valley. Just below the city, however, the waterway, owing to the natural configuration of the country, is decreased in width to about 1.25 miles, and this site was selected as the most favorable for the construction of the proposed bridge. The normal width of the river channel in the cold weather, however, is only 600 feet, the depth of water being about 25 feet. During the flood season the river rises at this point as much as 31 feet, the volume of water being swelled by the discharge from the Jumna, the confluence of which with the Ganges is about seven miles above the bridge. As a result of the preliminary surveys, it was decided that the waterway could be advantageously guided through a channel 3,000 feet in length, by the construction of a training-bund on the left bank. The whole of the work was designed by Mr. Robert R. Gales, M. Inst. C. E., engineer in chief of the Coonoor Railroad, to whose courtesy we are indebted for the illustrations.


The Curzon Bridge Practically Completed, Showing Temporary Line in River Bed.

THE NARROWING OF THE GANGES AND CONSTRUCTION OF THE CURZON BRIDGE.

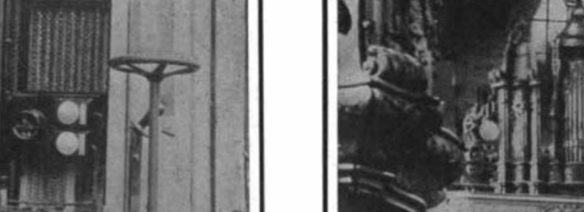


Fig. 1.—Diagram of Electric Motor and Tension Carriage.

The training-bund itself, which is over 4,000 feet in length, rises to 5 feet above flood level of the river. The upstream section is about 3,300 feet in length, measured from the center line of the approach bank communicating with the left-hand shore. The extremity of the upstream section has a sharp curve of about 570 feet radius. This was adopted in order to protect the training-wall from the scouring of the river, and the eddying currents which are produced when the extremity is straight. In the Curzon bund, however, the engineer anticipates that from the form of extremity adopted this destructive action, if not entirely overcome, will at any rate be considerably reduced; a result which appears to be borne out by the behavior of the bund during the short time it has been completed.

The bund, itself constructed of the sand which forms the river bed, is armored on the river side with stone pitching some 4 feet in thickness on the 2 to 1 slope, from the river bed up to flood level, while on the land side the sand bank is covered by layers of earth and broken debris, and planted with sarpat grass, the fibrous roots of which serve to hold the fabric together. The crown of the bank has a width of about 20 feet, and carries a 5-foot 6-inch gage railroad, so that in the event of any portion of the embankment being damaged, further supplies of stone may be readily brought up and dumped at the point of attack.

The construction of the training-bund presented several difficulties, the greatest of which was the shortness of the season in which the work could be carried out. Consequently, the greatest advantage had to be taken of the period available, especially as the whole of this work was being undertaken in the river bed. Owing to the magnitude of the undertaking, it was found impossible to place this section of the work in one contract, and it was accordingly divided into sections and distributed among several contractors. When the time approached convenient for commencing operations, at the middle of November, the labor was crowded upon the spot, until as many as 7,000 coolies were engaged in building the approach bank and training-bund at one time, the whole of this work being carried out by native labor. When it is remembered that some 7,000 feet of embankment, comprising 3,000 feet for the approach bank and 4,000 feet for the

(Continued on page 206.)

Fig. 2. Machine Which Saws Through Stone Walls and Inserts Sheets of Lead to Protect Buildings from Dampness.


Fig. 3. Interior of Church Showing Machine in Position.

SAWING BUILDINGS IN TWO.

pulley, and returns through the same holes to the shaft in front of the building, and thence ascends to the bridge at the top, and passing round a second wheel *B* returns to the motor wheel *P*. In front of each pier, at the level of the lower or cutting part of the cable, is placed a fine jet of water carrying fine sand in suspension. The sand gradually wears away the stone, the cable serving only to convey it. As the work advances, the pulley frames are lowered by turning the winch, the tension of the cable being maintained constant by means of the carriage *C*.

As a rule, the vertical cut through the line of piers was deepened at the rate of about 5 inches per hour. As the cable returned through the cut, it was abraded very rapidly, so that although it was more than 300 feet long, it was found necessary to replace it at the end of twenty hours of work, which corresponds to an aggregate surface of cut equal to 121 square feet. In the concrete bases of the piers the process was reduced to 3.2 inches in a day of eleven hours by the heterogeneous character of the concrete and the sand and flint which it contained.

When the piers had thus been sawn from top to bottom, the sawing cable was raised to its initial position, immediately beneath the iron bedplates, and a horizontal cut, 2 inches deep, was made by shifting the pulleys laterally to this distance, and forcing the cable against the masonry by a series of iron bars. A second vertical cut, extending to the bottom of the piles, was then made. In this way a vertical slice, 2 inches in thickness, was removed from each pier, on each side of the building.

A slice of the same thickness was removed from each side of the façade by a similar series of operations, in which the cable was pressed obliquely against the façade by means of the pulley X''' (Fig. 2). When this oblique cut had advanced so far that the top of the wall was cut through and the cable had begun to attack the middle of the height, the upper pulley was drawn back, the pulley at the base was pushed forward, and the lower half of the wall was sawn obliquely in a similar manner. Then the remainder of the cut, involving the whole thickness of the wall at mid-height and a thickness gradually decreasing above and below this point, was made with the cable vertical. A second cut, 2 inches distant from the first, was made by a similar series of operations, and the intervening slice of wall was removed.

The work of sawing this building in two with a wire cable was accomplished both rapidly and cheaply.

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THE NARROWING OF THE GANGES AND CONSTRUCTION OF THE CURZON BRIDGE.

(*Concluded from page 204.*)

training-bund, representing a total quantity of some 50,000,000 cubic feet of earthwork, had to be handled, the magnitude of the task may be realized.

The construction of the bridge proceeded simultaneously with the building of the earthwork revetments, operations being commenced from the right-hand bank. To facilitate these operations and the transportation of the necessary materials to the sites of the foundations for the piers, a temporary railroad was laid on piles on the river bed as soon as the water had receded sufficiently. As already mentioned, the bed of the river is composed of fine sand, which extends on the average to a depth of 100 feet, where impermeable clay is encountered. The pier foundations had consequently to be carried down to a great depth, and this work was carried out upon the well-sinking principle. In executing this part of the work, the engineer made a series of calculations, by means of which he was able to deduce the weight of well required to sink by open dredging to any required depth through sand and the relationship of skin friction to the increase in depth. This is probably the first attempt to indicate such data in advance of operations. In the course of an exhaustive paper, recently communicated to the British Institution of Civil Engineers concerning the construction of the Curzon Bridge, Mr. Gales refers to this question of "sinking effort" at great length.

Owing to the bridge being designed to carry only a single track, the form of well adopted was of the double octagonal type, the curbs being 33 feet 6 inches long by 19 feet wide. The sinking plant comprised steam hoists so disposed as to be capable of serving two wells, so that merely by slewing round the sinking of one well could be carried out while the other was being built on. Taken on the whole, sinking was completed rapidly; but in one or two cases, owing to substrata of hard clay and conglomerate being encountered where only sand was believed to exist, these operations were somewhat delayed, since it was found that the dredges could not make any effect upon certain material which had to be removed by blasting. The wells were sunk until they became stanched in the clay, which was found to be extremely hard, efforts to drive the wells more than a few feet into the strata proving unavailing, even when artificially loaded with iron rails, pig iron, sand, etc., to the extent of 1,000 tons or so, as shown in the engraving. The wells were for the most part built of brick, and were carried up to within two feet of the lowest water level recorded, when the construction of the piers was commenced. The piers are of masonry, two kinds of native stone being used, one for the external walls and the other for the hearting. The wells themselves were filled with sand, ballast, and concrete as follows: The bottom of the well to the top of the cantplate of the curb with sand, followed by 9 feet of cement concrete. Upon this was pure sand for a depth of 41.25 feet, followed by a layer of sand and brick ballast rammed down for another 40 feet (the sand filling the spaces between the ballast), and crowned by 10 feet of rammed concrete. The piers themselves are stepped, so that a slight batter is secured. The bottom layer of masonry is 35 feet in length by 20.5 feet wide, while that carrying the cornice is 29 feet long by 14.5 feet. The height of the masonry piers in each case, with the exception of the shore and training-bund abutments respectively, is 60 feet. The piers are carried up a sufficient height to give a clearance of 31 feet between the normal level of flood and the under side of the girders. Even should the waterway again attain its highest recorded rise of 41 feet, which was registered in 1875, this will still give a headway of 21 feet.

The girders are of the single triangulation N type, having nine bays each of 25.75 feet length center to center, representing 200 feet in clear span, while they are 25.75 feet in height. The total amount of steel work in each span, including the flooring of the public roadway on the top deck, is 320 tons, aggregating 4,800 tons for the whole bridge.

The top deck carrying the public roadway has a clear inside width of 23 feet 2 inches, and is carried at a height of approximately 60 feet above ordinary high flood level of the river. There is a metaled roadway 15 feet in width, flanked on either side by a timber sidewalk 49 inches wide. Access to the top deck is obtained from the approach banks at either end of the bridge over steel viaducts.

The time occupied in carrying out the whole undertaking, from the commencement of the preliminary operations to the running of the first train over the bridge, was exactly three working seasons, and its rapid completion testifies to the energy with which the whole task was carried out. By narrowing the course of the river through the construction of the heavy training-bund, and thereby shortening the length of the bridgework, a saving of over $500,000 was effected. Despite the departure from general practice in the design of the training-bund, the initiative of the designer is evidently completely justified, since no signs of the defects which have characterized previous works of this type have yet developed, though it has been subjected to exacting tests by high floods.

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Sven Hedin's Return.

Sven Andera Hedin, the explorer, who started in 1906 from Chinese Turkestan on a journey through Tibet, and concerning whose whereabouts there was great anxiety for many months, has arrived at Simla.

He traveled 4,000 miles or more, mainly in western Tibet, and did not see a white face until he reached the province of Pobo. Dr. Hedin states that he made valuable discoveries, but that there still was ample room in Tibet for future explorers.

Summarizing the remarkable achievement of Sven Hedin, the New York Sun thus comments editorially:

When Sven Hedin reached Gartok in the southwestern part of Tibet, late last year, he gave out that he was going to Ladakh in Cashmere, and in the spring he would travel either to India or to Peking. The event shows that he had in view another long journey in the unexplored part of Tibet. He went north to Leh, the chief town in Ladakh, ostensibly to spend the winter but actually to outfit and push again into northwestern Tibet in order to make another route through the vast unmapped region to the west of his route in 1906.

This secrecy was necessary because the Tibetans were determined to prevent him from renewing his travels in Tibet. He did not even impart his plans to his family, and they were anxious for his safety when they failed to hear from him last spring. But he has reached civilization again and is now going home after experiencing last winter the acutest phase of his privations and losses during his migratory tent life in the bitter cold of the Tibetan winter two miles and a half or more above the sea.

The work of Sven Hedin in these three years, 1906-1908, will rank among the great achievements of exploration. The results obtained are enormous in spite of the active opposition of the Indian and Tibetan officials, who did their best to prevent the explorer from getting into the country at all.

The work, spread over three years, is embraced in three journeys, each distinct from the others. In 1906 Hedin entered the northwestern part of Tibet at Aksai Chin (White Desert), crossed the vast unexplored region of western Tibet from northwest to southeast, traveled 840 miles without touching the routes of any earlier explorers excepting where he crossed the tracks of Bower and Littledale, and discovered mountain ranges, new lakes and rivers and gold fields.

The second journey, which filled most of 1907, was west from Shigatse through the southern part of the unknown area, about 1,000 miles to the southwestern corner of Tibet. On this eventful expedition Hedin discovered the sources of the Brahmaputra, Indus, and Sutlej rivers, and found that the Nin Chen Tangla Mountains, well known south of Lake Tengri, are simply part of a chain extending, he believes, clear across Tibet east and west and at least 2,000 miles long.

The third journey, just completed, carried Sven Hedin again from north to south across unknown expanses he had not seen on his route of 1906. He found everywhere repeated the mountains and valleys interspersed with fresh and salt water lakes that he had discovered two years before. He has proved that the great white expanse on the maps is practically filled with these features, for no part of it has been found to be an extensive and comparatively level plain.

In this last journey Hedin crossed the Nin Chen Tangla three times—he had crossed it five times on his first and second journeys—and he now reports complete proof that the mighty range is continuous to the western border of Tibet. Although the absolute height of all these Tibetan mountains is very great, they are not remarkably impressive as seen rising from plateau surfaces that are 16,000 to 18,000 feet above the sea.

Sven Hedin reports that he has saved his scientific material. No other pioneer explorer has ever produced better surveys for map purposes, and it is certain that his map sheets will fill with accurate details a large part of the regions both in northern and southern Tibet that were marked "unexplored" on the Royal Geographical Society map of Tibet prepared three years ago.

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Coming Aeronautic Contests.

The recently-formed Aeronautic Society, mention of which has already been made in these pages, has leased the Morris Park race track in Westchester, and moved its headquarters to the club house adjoining. This fine oval course is 120 feet wide with a 1½-mile circuit, while a ⅞-mile straight track runs diagonally across it. The fences have been removed, thus making the place an ideal one for aeronautic experiments. Altogether, there is a field of 325 acres over which flights may be made. There are ample sheds for the storage of flying machines, and a machine shop will soon be ready. All members may take advantage of the exceptional facilities thus provided for aeronautical experimentation. In addition to these, Mr. W. R. Kimball will loan members the 50-horse-power 150-pound motor (which at present he has mounted upon his helicopter) for the purpose of trying out flying machines which they may have constructed but for which they have no motor. A tower with dropping weight (like that used by the Wrights) has been built for the purpose of launching gliders, and on October 17 it is proposed to hold contests for man-carrying and model gliders, self-propelled model and full-sized aeroplanes, a kite-flying competition, etc. While the Aeronautic Society intends to experiment in all branches of aeronautics, its members are chiefly interested in heavier-than-air machines. Several of these, including the Kimball helicopter, are now being experimented with at the race track. The society welcomes all inventors who are striving to advance the art and science of aeronautics and every facility will be given them to try out thoroughly their machines. For full particulars regarding the contests, address the Aeronautic Society, Morris Park Race Track, Westchester, N. Y.

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Energy Consumed for Light.

In a lecture delivered by Sir James Dewar on "Flame" before the Royal Institution in London he showed the large amount of energy expended in the production of a small amount of light. The following figures show how inefficient the various lighting devices now employed are from a scientific point of view: Candle: Percentage of light, 2; non-luminous energy, 98. Oil: Percentage of light, 2; non-luminous energy, 98. Coal gas: Percentage of light, 2; non-luminous energy, 98. Incandescent lamp: Percentage of light, 3; non-luminous energy, 97. Arc lamp: Percentage of light, 10; non-luminous energy, 90. Magnesium lamp: Percentage of light, 15; non-luminous energy, 85. Incandescent lamp: Percentage of light, 99; non-luminous energy, 1.

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Fire and Water-proof Cement.—Mix 10 parts of finely sifted unoxidized iron filings and 5 parts of perfectly dry, pulverized clay, with vinegar spirit, by thorough kneading, until the whole is a uniform plastic mass. If the cement thus made is used at once, it will harden rapidly and withstands fire and water.—Werkstatt.

Are Growth and Evolution Forms of Memory and Habit?*

BY FRANCIS DARWIN, M.A., LL.D., F.R.S.

Sleeping plants are those in which the leaves assume at night a position markedly different from that shown by day. Thus the leaflets of the scarlet-runner (*Phaseolus*) are more or less horizontal by day and sink down at night. This change of position is known to be produced by the alternation of day and night. But this statement by no means exhausts the interest of the phenomenon. A sensitive photographic plate behaves differently in light and darkness; and so does a radiometer, which spins by day and rests at night.

If a sleeping-plant is placed in a dark room after it has gone to sleep at night, it will be found next morning in the light-position, and will again assume the nocturnal position as evening comes on. We have, in fact, what seems to be a habit built by the alternation of day and night. The plant normally drops its leaves at the stimulus of darkness and raises them at the stimulus of light. But here we see the leaves rising and falling in the absence of the accustomed stimulation. Since this change of position is not due to external conditions it must be the result of the internal conditions which habitually accompany the movement. This is the characteristic *par excellence* of habit—namely, a capacity, acquired by repetition, of reacting to a fraction of the original environment. We may express it in simpler language. When a series of actions are compelled to follow each other by applying a series of stimuli they become organically tied together, or *associated*, and follow each other automatically, even when the whole series of stimuli are not acting. Thus in the formation of habit *post hoc* comes to be equivalent to *propter hoc*. Action B automatically follows action A, because it has repeatedly been compelled to follow it.

Let us take a human habit, for instance that of a man who goes a walk every day and turns back at a given mile-post. This becomes habitual, so that he reverses his walk automatically when the limit is reached. It is no explanation of the fact that the stimulus which makes him start from home includes his return—that he has a mental return-ticket. Such explanation does not account for the point at which he turns, which as a matter of fact is the result of association. In the same way a man who goes to sleep will ultimately wake; but the fact that he wakes at four in the morning depends on a habit built up by his being compelled to rise daily at that time. Even those who will deny that anything like association can occur in plants cannot deny that in the continuance of the nyctitropic rhythm in constant conditions we have, in plants, something which has general character of habit, i. e., a rhythmic action depending on a rhythmic stimulus that has ceased to exist.

On the other hand, many will object that even the simplest form of association implies a nervous system. With regard to this objection it must be remembered that plants have two at least of the qualities characteristic of animals—namely, extreme sensitiveness to certain agencies and the power of transmitting stimuli from one part to another of the plant body. It is true that there is no central nervous system, nothing but a complex system of nuclei; but these have some of the qualities of nerve cells, while intercommunicating protoplasmic threads may play the part of nerves. Spencer bases the power of association on the fact that every discharge conveyed by a nerve "leaves it in a state for conveying a subsequent like discharge with less resistance." Is it not possible that the same thing may be as true of plants as it apparently is of infusoria? We have seen reasons to suppose that the "internal conditions" or "physiological states" in plants are of the nature of engrams, or residual effects of external stimuli, and such engrams may become associated in the same way.

There is likely to be another objection to my assumption that a simple form of associated action occurs in plants—namely, that association implies consciousness. It is impossible to know whether or not plants are conscious; but it is consistent with the doctrine of continuity that in all living things there is something psychic, and if we accept this point of view we must believe that in plants there exists a faint copy of what we know as consciousness in ourselves.

The development of the individual from the germ-cell takes place by a series of stages of cell-division and growth, each stage apparently serving as a stimulus to the next, each unit following its predecessor like the movements linked together in an habitual action performed by an animal.

My view is that the rhythm of ontogeny is actually and literally a habit. It undoubtedly has the feature which I have described as pre-eminently characteristic of habit, viz., an automatic quality which is seen in the performance of a series of actions in the absence of the complete series of stimuli to which they (the stages of ontogeny) were originally due. This is the chief point on which I wish to insist—I mean that the resemblance between ontogeny and habit is not merely superficial, but deeply seated. It cannot be denied that the ontogenetic rhythm has the two qualities observable in habit—namely, a certain degree of fixity or automaticity, and also a certain variability. A habit is not irrevocably fixed, but may be altered in various ways. Parts of it may be forgotten or new links may be added to it. In ontogeny the fixity is especially observable in the earlier, the variability in the later, stages. Take the case of a man who, from his youth up, has daily repeated a certain form of words. If in middle life an addition is made to the formula, he will find the recently acquired part more liable to vary than the rest.

Again, there is the wonderful fact that, as the egg develops into the perfect organism, it passes through a series of changes which are believed to represent the successive forms through which its ancestors passed in the process of evolution. This is precisely paralleled by our own experience of memory, for it often happens that we cannot reproduce the last learned verse of a poem without repeating the earlier part; each verse is suggested by the previous one and acts as a stimulus for the next. The blurred and imperfect character of the ontogenetic version of the phylogenetic series may at least remind us of the tendency to abbreviate by omission what we have learned by heart.

Enough has been said to show that there is a resemblance between the two rhythms of development and of memory; and that there is at least a *prima facie* case for believing them to be essentially similar. Hering says that "between the *me* of to-day and the *me* of yesterday lie night and sleep, abysses of unconsciousness; nor is there any bridge but memory with which to span them." And in the same way he claims that the abyss between two generations is bridged by the unconscious memory that resides in the germ cells. I prefer to limit myself to asserting the identity of ontogeny and habit, or, more generally, to the assertion in Semon's phraseology, that ontogeny is a mnemic phenomenon.

Evolution, in its modern sense, depends on a change in the ontogenetic rhythm. This is obvious, since if this rhythm is absolutely fixed, a species can never give rise to varieties. This being so, we have to ask *in what ways* the ontogenetic rhythm can be altered. An habitual action, for instance, a trick learned by a dog, may be altered by adding new accomplishments; at first the animal will persist in finishing his performance at the old place, but at last the extended trick will be bonded into a rhythm of actions as fixed as was the original simpler performance. May we not believe that this is what has occurred in evolution?

We know from experiment that a plant may be altered in form by causes acting on it during the progress of development. Thus a beech tree may be made to develop different forms of leaves by exposing it to sunshine or to shade. The ontogeny is different in the two cases, and what is of special interest is, that there exist shade-loving plants in which a structure similar to that of the shaded beech-leaf is apparently typical of the species, but on this point it is necessary to speak with caution. In the same way Goebel points out that in some orchids the assimilating roots take on a flattened form when exposed to sunlight, but in others this morphological change has become automatic, and occurs even in darkness.

Such cases suggest at least the possibility of varieties arising as changes in or additions to the later stages of ontogeny. This is, briefly given, the epigenetic point of view.

But how can a new species originate according to an epigenetic theory? How can a change in the latter stages of ontogeny produce a permanent alteration in the germ-cells? Our answer to this question will depend on our views of the structure of the germ-cells. According to the mnemic theory they have the quality which is found in the highest perfection in nerve-cells, but is at the same time a character of all living matter—namely, the power of retaining the residual effects of former stimuli and of giving forth or reproducing under certain conditions an echo of the original stimulus. In Semon's phraseology germ-cells must, like nerve-cells, contain engrams, and these engrams must be (like nerve-engrams) bonded together by association, so that they come into action one after another in a certain order automatically, i. e., in the absence of the original stimuli.

This seems to me the strength of the mnemic theory—namely, that it accounts for the preformed character of germ-cells by the building up in them of an organized series of engrams. But if this view has its strength, it has also its weakness. Routine can only be built up by repetition, but each stage in ontogeny occurs only once in a lifetime. Therefore if ontogeny is a routine each generation must be mnemically connected with the next. This can be possible only if the germ-cells are, as it were, in telegraphic communication with the whole body of the organism; so that as ontogeny is changed by the addition of new characters, new engrams are added to the germ-cell.

Thus, in fact, the mnemic theory of development depends on the possibility of what is known as somatic inheritance or the inheritance of acquired characters. This is obvious to all those familiar with the subject, but to others it may not be so clear. Somatic inheritance is popularly interesting in relation to the possible inherited effects of education, or of mutilations, or of the effects of use and disuse. It is forgotten that it may be, as I have tried to show, an integral part of all evolutionary development.

It may be objected that the inheritance of anything so complex as an instinct is difficult to conceive on the mnemic theory. Yet it is impossible to avoid suspecting that at least some instincts originate in individual acquirements, since they are continuous with habits gained in the lifetime of the organism. Thus the tendency to peck at any small object is undoubtedly inherited; the power of distinguishing suitable from unsuitable objects is gained by experience. It may be said that the engrams concerned in the pecking instinct cannot conceivably be transferred from the central nervous system to the nucleus of the germ-cells. To this I might answer that this is not more inconceivable than Weismann's assumption that the germ-cell chances to be so altered that the young chicken pecks instinctively. Let us consider another case of what appears to be an hereditary movement. Take, for instance, the case of a young dog, who in fighting bites his own lips. The pain thus produced will induce him to tuck up his lips out of harm's way. This protective movement will become firmly associated with not only the act of fighting but with the remembrance of it, and will show itself in the familiar snarl of the angry dog. This movement is now, I presume, hereditary in dogs, and is so strongly inherited by ourselves (from simian ancestors) that a lifting of the corner of the upper lip is a recognized signal of adverse feeling. Is it really conceivable that the original snarl is due to that unspecialized stimulus we call pain, whereas the inherited snarl is due to fortuitous upsets of the determinants in the germ cell?

I am well aware that many other objections may be advanced against the views I advocate. To take a single instance, there are many cases where we should expect somatic inheritance, but where we look in vain for it. This difficulty, and others equally important, must for the present be passed over. Nor shall I say anything more as to the possible means of communication between the soma and the germ-cells. To me it seems conceivable that some such telegraphy is possible. But I shall hardly wonder if a majority of my readers decide that the available evidence in its favor is both weak and fantastic. Nor can I wonder that, apart from the problem of mechanism, the existence of somatic inheritance is denied for want of evidence. But I must once more insist that according to the mnemic hypothesis, somatic inheritance lies at the root of all evolution. Life is a gigantic experiment which the opposing schools interpret in opposite ways. I hope that in this dispute both sides will seek out and welcome decisive results. My own conviction in favor of somatic inheritance rests primarily on the automatic element in ontogeny. It seems to me certain that in development we have an actual instance of habit. If this is so, somatic inheritance must be a *vera causa*. Nor does it seem impossible that memory should rule the plasmic link which connects successive generations—the true miracle of the camel passing through the eye of a needle—since, as I have tried to show, the reactions of living things to their surroundings exhibit in the plainest way the universal presence of a mnemic factor.

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* Abstracted from the Presidential address delivered to the British Association for the Advancement of Science. The full text of the paper appears in the current number of the Scientific American Supplement.

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Death of Gardiner D. Hiscox.

The readers of this journal will learn with regret that Gardiner D. Hiscox, whose name is well known to them as a former contributor of articles on mechanical subjects to these columns and as the author of several well-known books on mechanics, died in the eighty-sixth year of his age at East Orange, N. J. Mr. Hiscox, although not a college-trained man, had a broad knowledge of mechanical, ventilating, and hydraulic engineering, gained in the hard school of experience and which eminently qualified him to practise his chosen profession of consulting engineer. In his youth he was a school teacher, but from teaching he gradually drifted into engineering and science. In his death the engineering profession has lost an able and sturdy member.

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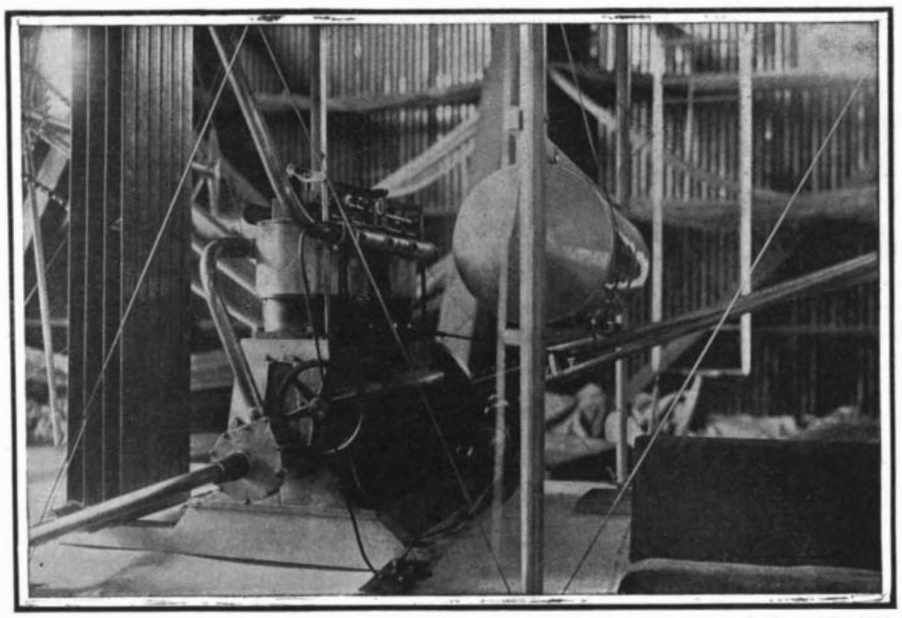
Manganese steel is now generally recognized as being the only suitable material for street railway track work where any large amount of traffic is to be dealt with, and, as is well known by street railway engineers, this material cannot be dealt with by the ordinary cutting tools, i. e., chisels, saws, files, etc., owing to the extreme hardness of the material.



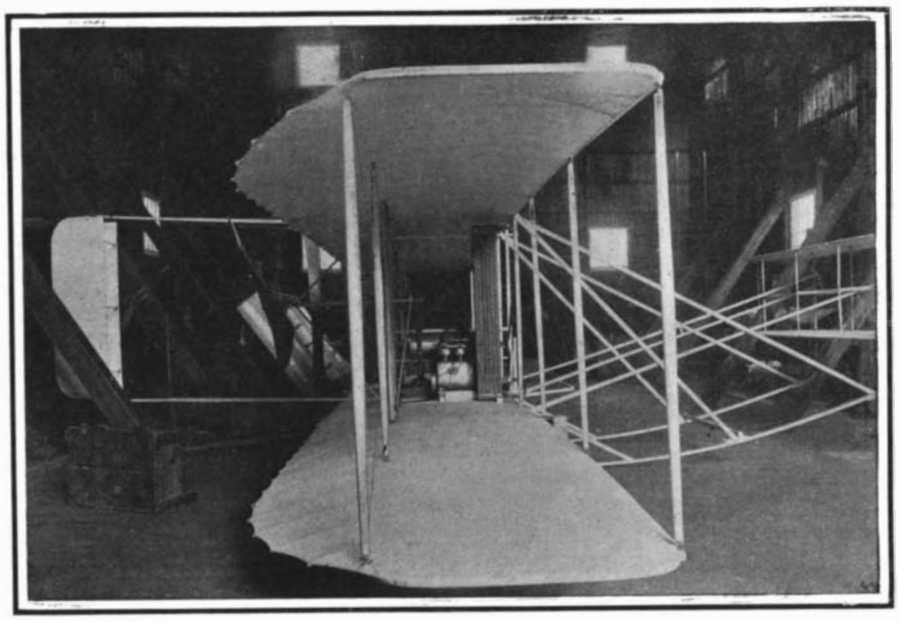


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Fig. 1.—Detail Front View of Center of Aeroplane, Showing the Motor, Radiator, Gasoline Tank, and Seat.

The driving chain and sprocket of one propeller are visible at upper left-hand corner, and the crossed tubes carrying the other propeller chain can be seen on the right. The twin vertical rudder is also seen on the right at the rear.

Fig. 2.—End View of the Aeroplane, Showing the Vertical and Horizontal Rudders, Propellers, Gasoline Tank, Motor, and Radiator.

This photograph gives a good idea of the slight curve of the planes as well as of their construction.

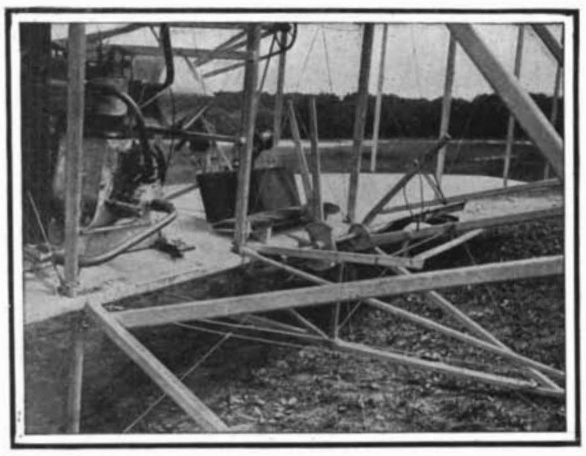

Fig. 5.—Front View of Lower Plane.

The radiator, motor, fuel tank, seat, and levers are visible. The aviator sits farthest from the motor and holds the horizontal-rudder lever in his left hand and the vertical-rudder and wing-warping levers in his right. Note foot-rest in front of levers.

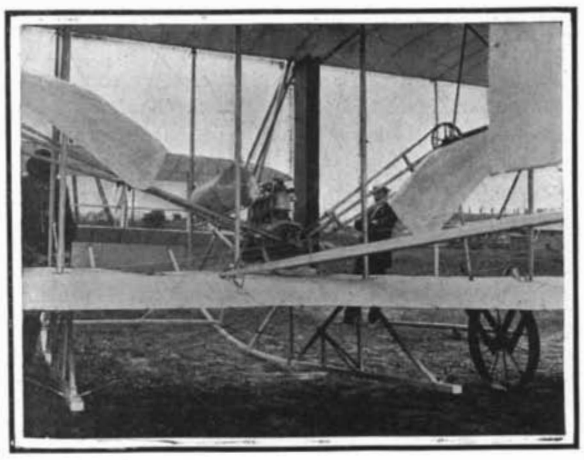

Fig. 7.—Rear View, Showing Motor, Propellers, and Driving Chains.

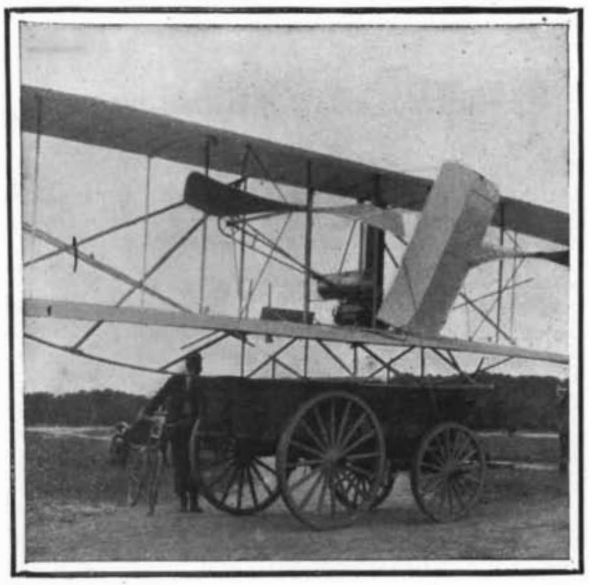

Fig. 8.—The Aeroplane on an Army Wagon.

The runners are folded back against the front edges of the planes and the rudder is placed against their rear edges.

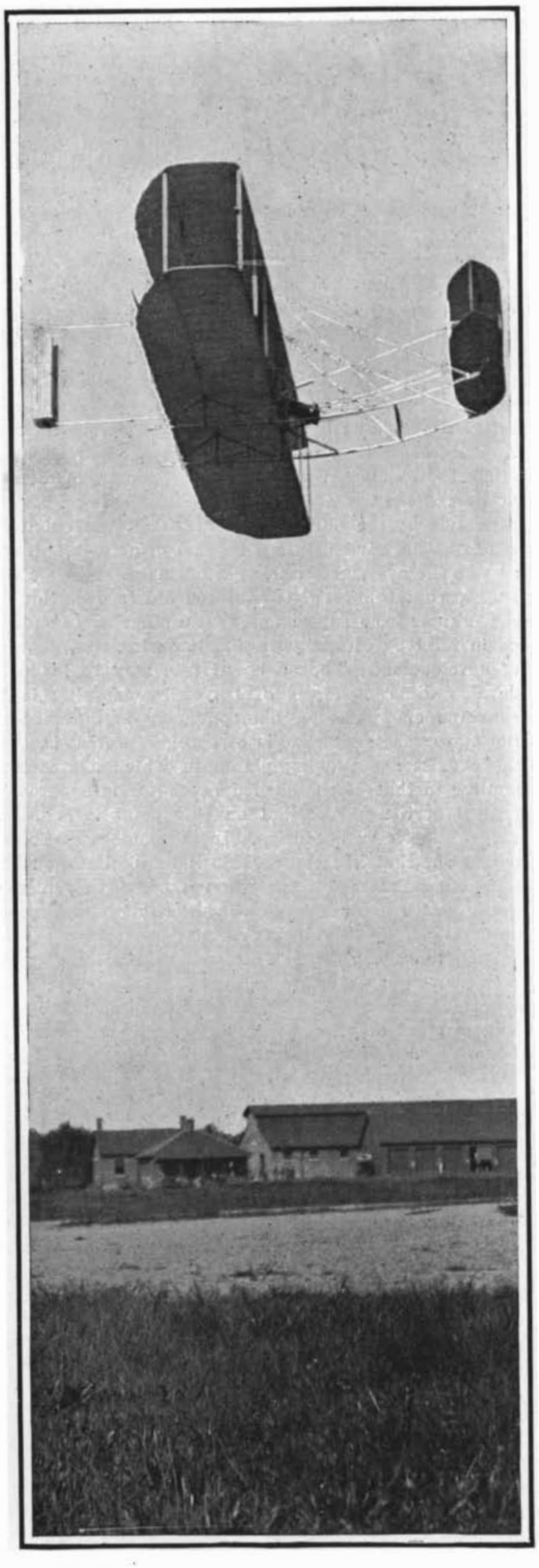

Fig. 9.—The Aeroplane Flying at a Great Height.

In some of its flights the machine is estimated to have reached an elevation of 200 feet.

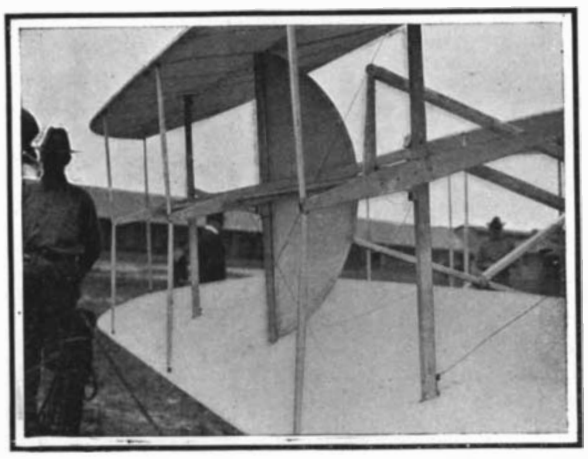

Fig. 6.—Detail View of Front Horizontal Rudder.

In this photograph the rudder is shown tipped downward. The operating lever and wood rod connecting to lever on aeroplane are visible. Also note semi-circular vertical surface which is loosely mounted at the center.

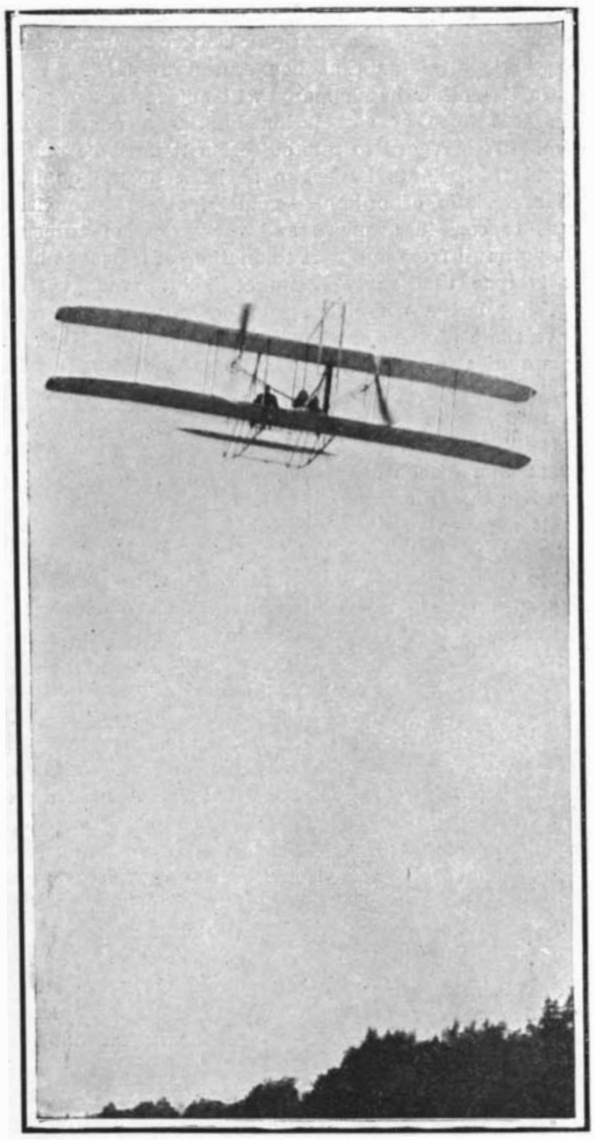

Fig. 10.—Rear View of the Aeroplane Making a Turn.

The machine can make a much sharper turn than this, and in so doing dips downward much more.

THE CONSTRUCTION OF THE WRIGHT AEROPLANE.