

# WEISMANNISM.\*

## A SCIENTIFIC THEORY OF HEREDITY.

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We may classify Weismann as one of the men who have made epochs not only because his ideas made more talk than those of any other man save Darwin, but because these ideas are already having their effect upon all sound considerations of social welfare and progress, and will probably have a more far reaching influence upon social and political history than that of all the soldiers and statesmen of the world put together.

Weismann, like Darwin, was seeking to solve the mystery of organic evolution. He had no notion of the vast social and political importance hidden away in his fascinating theory, just as Darwin had no notion that his "struggle for life" would be expanded into a "struggle for existence" as wide as the universe itself and operating in the world of so-called dead as well as of living matter. Weismann not only cut away one-half of the complicated machinery which Darwin had constructed to account for evolution, but he inadvertently opened up a view of man and society which forces us to reconsider all the old convictions we have had concerning the possibilities that may lie in the savage and in civilized man, and the parts they are to play in the future of human affairs.

Weismann sums up his entire theory and its corollaries in the phrase, "The continuity of the Germ-Plasm." These suggestive and alluring terms can be understood by a brief examination of the simpler details of the reproduction of the lowest forms of plant and animal life as they are revealed by the microscope. It was the observation of these facts that first suggested to Weismann the basis of his remarkable theory which is an application to man and other higher organisms of the established fact that the individuals of the lowest forms of life are immortal. Man's body itself is not immortal, but a part of his body is immortal, and this part—what Weismann calls the germ-plasm—is handed down immortal and continuous, from generation to generation, unbroken and unchanged—except in certain circumstances—by the adventures of the body itself in the surroundings, or environment, in which it lives. How true this immortality is will be seen in the method by which the simplest forms of life reproduce themselves.

it shoots out from the substance of its body, crawls about the weeds in ponds, and feeds on various kinds of nutritious substances. It grows large, and when it reaches a certain size the capsule bursts and the animal escapes. The nucleus then divides, and each

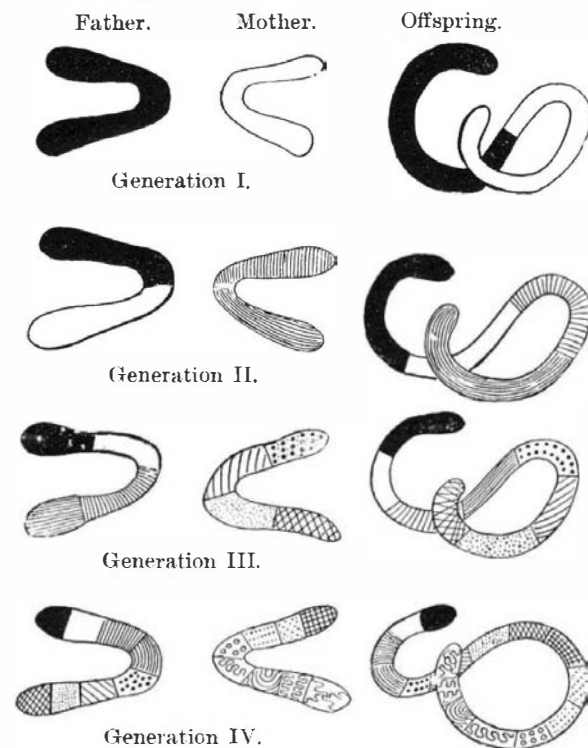


FIG. 4.

Diagram showing how the units of the heredity-substance, the germ-plasm, grow more complex with succeeding generations. (From Weismann's Essays.)

half withdraws to opposite poles of the cell. The cell body itself constricts in the middle and is cut in two. There are now two cells instead of one, two amœbæ instead of one. But each new amœba is actually a part of the parent—one-half of the parent. The parent does not beget two children, and then

Let us fancy now that when a cell divides, the daughter cells do not separate and go on living as independent individuals, as amœbæ do, but that they remain stuck together by a kind of cement, or other substance, manufactured by themselves; that the division of the cells takes place innumerable times; the new cells being held together—and that the cells, as they multiply by the billion, are changed in their form, so that in this growing organism one group of cells is built up into one organ or tissue, another group into another, until ultimately this single cell has grown into a great cosmos of cells—why then, we would have a *multicellular* animal such as a frog or a man; or, if the cell were a plant-cell, a multicellular plant, such as an orange tree or a rose bush. That such is really the case with all animals and plants can easily be proved by making a very thin slice of any animal or plant tissue and examining it in a compound microscope. Such a slice, or section, is shown in Fig. 2, which is an excellent picture of the sight one sees when one examines an extremely thin section cut from the tip of a growing onion root. Here we see the cells bound together, each with its nucleus and germ-speck (sometimes two germ-specks), the drawing representing, of course, not entire cells, but very thin sections of cells. And when one considers that this drawing presents but the merest invisible fragment of the tip of the onion root, one can form an idea of the incalculable number of cells in the whole plant. Here and there in the drawing is seen a cell in which the nucleus is replaced by odd-looking black, curved rods, or loops, which seem strung upon a spindle-shaped structure made up of thin threads. These little threads are the mechanism by which the nucleus and cell are divided, and these cells are in process of division. We can see here, by means of the special technique used, what takes place in the cell when it divides like the amœba in Fig. 1.

To understand Weismann's views of inheritance it is necessary to state a few more of the simpler details of cell division which is at the bottom not only of the mysterious facts of inheritance, but which is also the fundamental fact of organic evolution, and for the

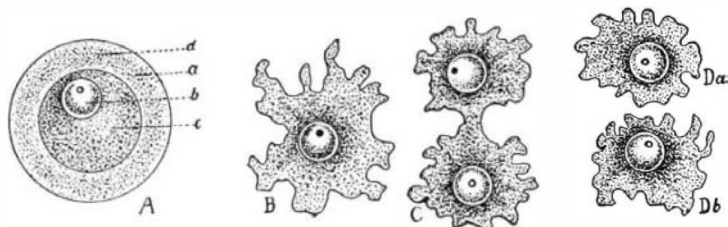


FIG. 1.—REPRODUCTION OF A CELL, AMŒBA.

Highly magnified. (Haeckel.) A. The cell in its capsule *d*. The cell-body *c* encloses the nucleus *b* and this encloses the nucleolus, or germ-speck *a*. B. The cell has burst through its capsule. C. The nucleus has divided into two nuclei and the cell body is pinched in the middle. D. The division is completed by the cell body falling into two equal halves, making two new cells *Da* and *Db*.

The lowest form of life—man being considered the highest—is found in races of microscopic animals and plants which consist of a single cell. Fig. 1 shows an animal, a species of amœba, highly magnified, in the different stages of its reproduction. The animal consists of a tiny lump of jelly-like, semi-fluid matter, which, in a state of rest, is spherical. It is surrounded by a capsule and inclosed within it is another spherical body, the nucleus, and within this still another little body called the germ-speck, or nucleolus. The animal, by means of finger-like processes which

die. It becomes itself two—multiplies itself by two, and so on without end.

What causes the little nucleus to divide and then, later, the cell body itself? There must be some mechanism for this remarkably equal and orderly division of the cell. Then, too, it is clear, that in this perfectly equal division each daughter cell is obviously like the parent, if the parent was divided into two perfectly similar parts. The begetting of like by like is here an obvious necessity. How could it be otherwise—if the halves are just alike? Inheritance here, in this little cell, is not precisely a question of *transmission*, but of *division*.

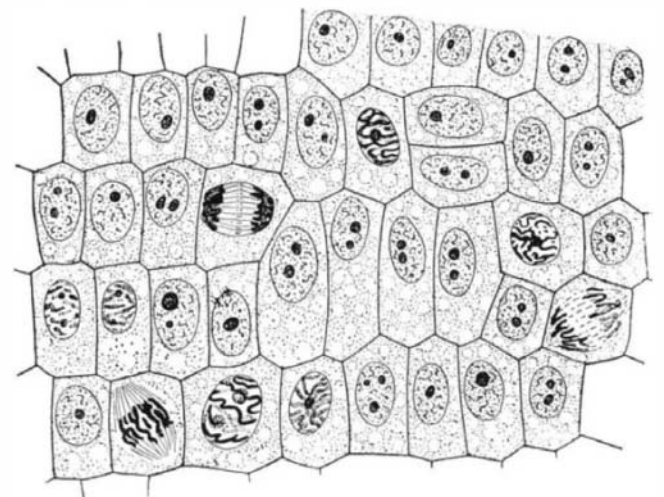


FIG. 2.—VERY THIN SECTION FROM THE TIP OF A GROWING ONION ROOT, SHOWING HOW THE CELLS OF MULTICELLULAR ORGANISM ARE BOUND TOGETHER.

Highly magnified. Several of these cells are in process of self-division. (From Wilson's "The Cell.")

most part of vital growth itself. The nucleus of every cell is made up of a delicate network called *chromatin*, because it is quickly and permanently colored by certain ordinary dye-colors which do not stain the rest of the cell. The conduct of this net-

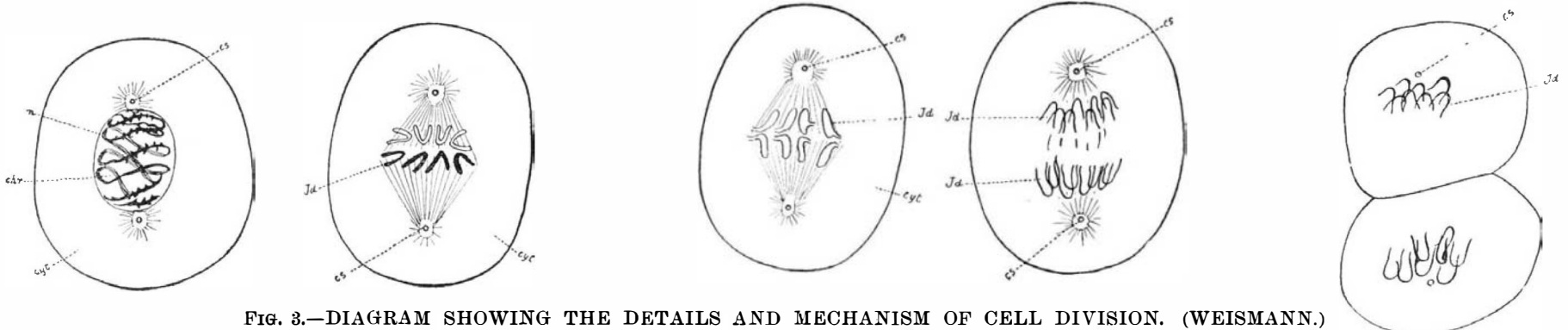


FIG. 3.—DIAGRAM SHOWING THE DETAILS AND MECHANISM OF CELL DIVISION. (WEISMANN.)

A. The cell with the nucleus *n*, the chromatin *chr* loosened and formed into a spiral. The centrosomes *cs* have appeared in the cell-body *cyt*. B. The nuclear membrane has disappeared. Delicate threads radiate from the centrosomes and have laid hold of the loops, or rods, or chromosomes *Jd* into which the chromatin has broken up. C. The rods have split longitudinally and the threads are about to pull them apart. (Only eight of the sixteen new rods are shown for the sake of clearness.) D. The daughter rods are being pulled to opposite ends of the cell. E. The cell has divided and each new cell contains half of the new rods into which the chromatin split.

\* Abstracted from Uncle Remus's Magazine.

work of chromatin is very curious during the division of the cell, so much so that it gives us clear evidence of the existence of a special and highly complex mechanism by which the cell is pulled in two, as one pulls a piece of soft candy into two equal parts.

When the cell is ready to divide there appears at either side of the nucleus a small body surrounded by thread-like radiations, called the *centrosome*. The network in the nucleus becomes thickened and loosened. This is shown in diagram *A* of Fig. 3. The next step is shown in diagram *B* of the same figure. The network has broken up into eight horse-shoe-shaped rods, and the threads from the centrosomes have approached the rods so as to form a kind of spindle. In diagram *C* the rods have split longitudinally and are about to be drawn apart by the threads of the spindle. In *D* each centrosome, by means of the threads, has drawn eight of the sixteen new rods toward itself to opposite ends of the cell. In diagram *E* the cell is shown divided in the middle, each new cell having half of the split rods of chromatin in its center. The nucleus in each new cell is now reformed as in diagram *A*, acquires a membrane, and the division is complete.

All cells normally divide in this manner, and all higher animals are formed by the repeated division and differentiation of cells which come originally from the division, in a similar manner, of the egg, which is itself a simple cell the size of which is made more or less large by the accumulation of yolk or food-stuffs in the cell body around the nucleus. The egg-cell by dividing into two, four, eight, sixteen, thirty-two, sixty-four and so on, doubling the number with each quick division, soon becomes a vast colony of cells, thus building up the body with all its various tissues which are themselves composed of cells and their products. The new animal, thus produced, in its turn produces eggs which again, by multiplication, grow into new animals just like their parents. This has been demonstrated again and again by the observation of the developing eggs of numerous animals, principally the hen, while the principal facts of cell division have been demonstrated again and again by careful observation and experiment upon the eggs and other cells of various animals and plants.

These facts warrant the conclusion that the chromatin in the nucleus of the egg-cell is the basis of inheritance, that the destiny of the organism depends upon the nature of and the laws governing these minute, microscopic bodies, and that all the inherited characters of the full grown animal—be it man or other—are potentially contained within these little rods which may measure no more than say one-fifty-thousandth of an inch in length.

These facts and these assumptions were still in the making when Weismann announced his theory in 1885, and it is noteworthy that some of his predictions, one may call them, have been verified by microscopic observation. Granting that the chromatin of the nucleus is the basis of heredity, Weismann assumes that these little rods, small as they are, are very composite bodies, made up of units which are themselves made up of units still smaller, and that these units of the second order are composed of yet smaller units of a third order while these again are composed of units of a fourth order—which he calls *biophors*, or life-bearers. These inconceivably small units—the life-bearers—are capable of growth and multiplication, as are also the units of each succeeding order, up to the chromatin rods themselves. And Weismann further holds that in the dividing egg the halves of the split rods, while equal in number, are *unlike in kind*. This makes it possible for successive generations of cells to vary more and more in form until, at maturity of the animal, the countless descendants of the original egg-cell are all highly different from their common ancestor, with the exception of certain cells which are destined in the future to reproduce new germ-cells which will contain the original stuff—the germ plasm—unchanged. These germ-cells contain the potent matter which, in this inconceivably minute form, carry down the immortal life-bearers from generation to generation as an inviolable legacy which all parents hold in trust for their children, but which they cannot take from or add to by any conceivable conduct of their own. The individual is thus made up of two kinds of cells—the cells of which its body is composed—a great race which lives for a season and dies—and the cells which contain the potent heredity-stuff, the legacy that the

individual holds in trust and passes down, unaffected by the individual, to his offspring—the immortal part of life. This conception, vast and magnificent as it is, is Weismann's contribution to science. His chief merit is that of having anticipated a number of epoch-making discoveries in the reproductive physiology of the cell; of having stimulated the researches which led to those discoveries, and of having united upon a common basis the great development theory of Darwin and the marvelous cell theory of Theodor Schwann. He has made evolution intelligible by the light of the cell, and the cell intelligible by the light of evolution. For by this theory we can rid the conception of organic evolution of the entire cumbersome machinery of the transmission of acquired characters, the whole stress being confined to natural selection and to variation produced by the mixing of germ-plasms of different individuals—what Weismann calls *amphimixis*. Weismann has constructed a most ingenious diagram to show how generation after generation can develop new characters until an individual is produced as different from its ancestors as a man differs from an ape or a reptile. This diagram is reproduced in Fig. 4. The drawings, of course, do not represent a real animal, but only go to show how successive mixtures of the constituent bodies of two different germ-plasms would produce a germ-plasm in four generations immeasurably more complex than that of the first generation. In the first generation the mixture of the black and white naturally produces a black and white germ-plasm. In the second generation this two-fold germ plasm, uniting with another and a different two-fold germ-plasm, produces a four-fold offspring, and so on, so that the last offspring has sixteen times as many units of the third order as either the father or the mother in the first generation. This multiplication of characters in succeeding generations is not due to the transmission to offspring of characters acquired by the parents, but is due to the simple mixing of the different units possessed by different individuals and passed down by them to their offspring. Organisms having characters favorable for survival continue to live and propagate while those not so favored are eliminated and disappear from the list of living races.

# ACETYLENE.\*

## ITS PRESENT COMMERCIAL STATUS.

BY A. CRESSY MORRISON.

ACETYLENE is so largely used throughout the world that it is generally recognized as one of the common illuminants. Any illuminant which candle power for candle power and cost for cost compares favorably with city gas at a dollar a thousand cubic feet, and which can be generated by an inexpensive individual apparatus, commands serious consideration. When it can be said in addition that it is the nearest approach to sunlight yet attained, then C.H. is destined by inherent merit to win and hold a conspicuous place.

In March, 1836, Edmund Davey, professor of chemistry to the Royal Dublin Society, described the properties of a new gas,  $C_2H_2$ , and followed this in the autumn of the same year by a more extended paper to the British Association, closing the report with the following remarkable statement: "From the brilliancy with which the new gas burns in contact with the atmosphere, it is, in the opinion of the author, admirably adapted for the purpose of artificial light, if it can be produced at a cheap rate." Scarcely a year passed without some step being taken which elucidated the physical and chemical properties, and a list of those who contributed to our knowledge of the subject would embrace many of the greatest names in chemistry and physics. An unusual condition surrounds the birth of this interesting gas, in that, long before its production on a commercial scale seemed possible, its properties were thoroughly understood, its place in nature had been ascertained, and its field of utility anticipated.

With the extraordinary progress of electrical science, came the development of the electrical furnace, by the use of which, in the spring of 1892, Thomas L. Willson produced calcium carbide by the combination of lime and carbon in the terrific temperature of the electric arc. On September 16, 1892, Willson sent specimens of his carbide to Lord Kelvin. Later, Moissan, working in France, also produced calcium carbide.

Calcium carbide is a substance resembling dark granite, running in various sizes (according to the use to which it is to be put) from egg size coal to the

size usually known as pea. The component parts are lime and carbon. Coke, as a typical carbon, is largely used in the production of calcium carbide. The lime must be pure and practically free from some of the usual constituents of lime. The lime and carbon are crushed very fine, mixed in proper proportions, and, in a specially constructed furnace, subjected to the heat of an electric arc. The amount of electric horse-power required for the production of calcium carbide varies, but it has been stated that it takes a horse-power year to produce a ton. Under the best conditions, a horse-power year will produce somewhat in excess of this quantity.

When the lime and coke are subjected to enormous temperature, said to be above 5,000 deg. F., they combine and are removed from the furnace either by tapping, when the molten material runs into molds, or in a species of rotary furnace the calcium carbide, still hot, is removed in pigs weighing a thousand pounds or more. These are broken by sledge hammers, run through crushers, packed in sheet steel drums, and, for domestic use, distributed one hundred pounds to the drum.

When calcium carbide is placed in water, the affinity of the calcium manifests itself, and the carbon is set free. The carbon immediately forms a combination with the hydrogen of the water, in the form of  $C_2H_2$ , which is acetylene.

Theoretically, one pound of calcium carbide will liberate somewhat over five cubic feet of acetylene; in practice the yield is about five cubic feet to the pound.

With the birth of calcium carbide as a commercial product, there arose a series of scientific investigations that the best practical methods of utilizing the new illuminant might be found. The process of generating acetylene being so simple, the field opened was a very promising one. While the physical characteristics of acetylene had early been studied, its use for domestic or industrial purposes brought into play conditions hitherto unconsidered.

Acetylene when compressed to liquefaction, occupies but one-four-hundredth of its bulk at atmospheric pressure. The most obvious course of procedure was,

therefore, the compression of acetylene into cylinders, and its release under pressure regulators, to be utilized at the burner as required. It was found, however, that acetylene when compressed gradually changed its nature, and under heavy pressure became a very dangerous substance. Explosions followed the experiments, and as a result compressed liquefied acetylene is no longer utilized.

Some years were to elapse before a means could be devised for the utilization of acetylene in compressed cylinders with safety. It was subsequently found, however, that acetone, a liquid related to alcohol, would at atmospheric pressure absorb about twenty-five times its bulk of acetylene, and for each additional atmosphere would take up an equal quantity. It was also found by filling the cylinders with asbestos, in the form of disks, that while the entire space was apparently occupied, as a matter of fact eighty per cent of the space still remained. It is a well-known property of gases that they will not explode through apertures of varying sizes, and in the case of acetylene no explosion will transmit itself through a minute aperture.

By exhausting the air from the asbestos in the cylinder and filling the vacuum thus caused with a certain percentage of acetone, it was discovered that an enormous quantity of acetylene could be stored in these cylinders at pressures not exceeding ten atmospheres, and that such cylinders could be subjected to all ordinary and some extraordinary tests with no danger whatever.

This system has been so developed that acetylene is rapidly replacing other illuminants upon railroads and in yacht lighting, and a conspicuous illustration of the utilization of acetylene on this principle is in the headlights of locomotives and automobiles, a field in which acetylene is rapidly extending.

While these uses of acetylene are interesting, its real use throughout the world is in domestic and business illumination, either by means of individual generators or by means of central town plants. There are domestic plants in operation in the United States exceeding one hundred thousand individual units. The number of towns lighted by central acetylene

\* Abstracted from a paper read before the Illuminating Engineering Society.