It will be seen from what I have stated that chromatin exists, and in the fertilization of the germ cells undergoes a remarkable series of changes; prior to fertilization there is a remarkable reduction in the nuclear substance. In indirect cell division a somewhat parallel series of changes are to be made out. All these are known facts which can be followed and readily observed; but biophores, ids, and idants have never been recognized; they are creatures of the imagination, and what is more, recent researches have shown that they cannot account for the facts of heredity.

From what I have stated it will be seen that this theory requires for the upbuilding of the organism that a special set of these biophores becomes distributed to each of the early blastomeres, so that eventually sundry of these find their way into the mother cells of each separate tissue. As a general rule in bilaterally symmetrical animals it has been determined that the first segmentation of the ovum leads to the formation of two blastomeres, one on either side of the median plane, which correspond and give rise to the future right and left halves of the body. Thus, according to Weismann, a set of biophores which will lead to the development of the organs of the right side passes into one blastomere, a set for the organs of the left side into the other. But now the observations of Driesch, confirmed and expanded as they have been, more especially by Morgan of Bryn Mawr, by E. B. Wilson of Columbia, by Zoja and others, show that in the two-, four-, eight-, and even sixteen-cell stage of the segmenting ovum of quite a number of animals, the blastomeres can be shaken apart and each separate cell may show itself capable of developing into a complete, if dwarfed larva. Again, as Roux, of Breslau, showed years ago, if a given blastomere of the frog's ovum be destroyed, that is to say one holding a definite position in regard to the rest, the individual is liable to develop minus one special portion of the body—one side of the head for example, one hind limb or quadrant. This, while it would seem at first to point in favor of Weismann's view, is nevertheless no proof that individual blastomeres contain special germ plasms, for as Driesch and others have shown, if the segmented ovum in the morula stage be submitted to pressure and the blastomeres be forced into abnormal relationships, upon removing the pressure the individual blastomeres do not continue to segment and produce those organs and parts which they would have done in normal conditions, but, according to their newly acquired position and relationship toward the rest so do they now proceed to develop; there is, in short, an exchange of properties. So that to a very large extent the prospective development of given cells is, as Driesch has laid down, a function of their relative position. It certainly is not determined by primary qualitative modifications of the nuclear chromatin.

Yet clearly this is not all. Mere relative position of the segmenting cells of the ovum does not determine the eventual structure of the adult. The eggs of a vast number of species are curiously alike, and what is more, under like environment, the earlier segmentations are along the same lines, and yet these eggs give rise to individuals absolutely dissimilar and belonging to wholly different species. There is, I need scarce say, a something in the nature and composition of the ovum—nay more, we can go further and say—of its nuclear constituents, which determines the eventual structure of the individual and this something is conveyed by the parental germ plasm. Thus while denying as wholly inadequate Weismann's theory of "determinants" and also being unable to explain heredity and variation by any conception of fixed morphological gemmules, pangenes, biophores, etc., we nevertheless have to attribute directive properties to the germ plasm and its contained idioplasm. Is it possible to conceive the idioplasm of the fertilized germ cell as being of such a nature that with the progressive growth and segmentation of the embryonic cells, set up by its agency, it undergoes progressive modification according to the forces acting upon it in the different cells of the embryo to which it is distributed? Let me indicate the lines along which we may develop such a theory:

The Chemico-Physical Theory of Inheritance.

The primary property of living matter, whereby it is distinguished from non-living matter, is the capacity of growth—is the capacity manifested by that living matter to assimilate non-living matter of certain orders, to absorb it and, in so doing, convert it into matter like unto itself, in doing which work is performed. As I have pointed out elsewhere, looking upon living matter in this light and recognizing that its other properties are but secondary manifestations and outcomes of this capacity for growth, we see that multiplication of the cells composing the individual, and multiplication of the individual (whether by simple fission as in certain unicellular organisms or by the development and emission of germ cells as in multicellular organisms) are in essence means whereby it is insured that the living matter of the individual continues to absorb and assimilate new material, means whereby to insure its continued existence and activity. Reproduction thus, as it occurs in man, is but a form of interrupted growth and a means of carrying on and carrying downward the living human substance.

When we come to inquire what is the nature of growth we see, as above indicated, that it is essentially a process of conversion—a chemical process. Certain substances through the agency of this living matter undergo chemical change and are united with and converted into the living substance. The living cell unit is thus to be regarded as composed of at least two substances—the *idioplasm* or essential and directive living matter, and the *cytoplasm* or, better, *paraplasm* consisting of substances absorbed but not yet converted, of the remains of substances, portions of which have been assimilated, and of various formed elements developed and controlled by the idioplasm. Accepting this as the chemical basis of life and of growth, can we go further and picture to ourselves the manner in which the molecules of living matter undergo the process of accretion and multiplication? The modern working conception of the structure of complex molecules is that these are composed of a central radicle or series of radicles which are united relatively firmly in the form of a ring. This method of attachment does not necessarily result in the attachments of all the combining atoms and radicles being brought into play and "saturated" and the ring thus becoming closed. The atom of carbon, for example, is quadrivalent; capable, that is, of uniting with four atoms of hydrogen. If in such a ring it is united with an atom of hydrogen on either side, this still leaves two attachments free, and to these two surfaces there may be lateral attachments of other atoms or radicles.

Our conception, therefore, of the molecule of idioplasm is that it consists of such a central ring with attached side

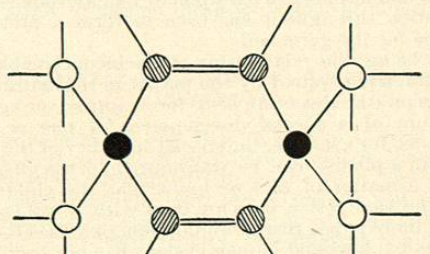

Fig. 2620.

chains formed of various radicles and combinations of atoms. Judging from the results of analysis of cell substance, the molecules of living matter are extraordinarily complex; the figure here given is, I need scarcely say, but diagrammatic and illustrative of the structure of these molecular rings; in it the composing atoms or radicles are supposed each to be capable of gaining four attachments.

Assimilation then must be regarded as a process in which certain unsaturated surfaces of constituents of the side chains become saturated, and we can conceive growth, that is, multiplication of the molecules of idioplasm, as being brought about by a process of progressive

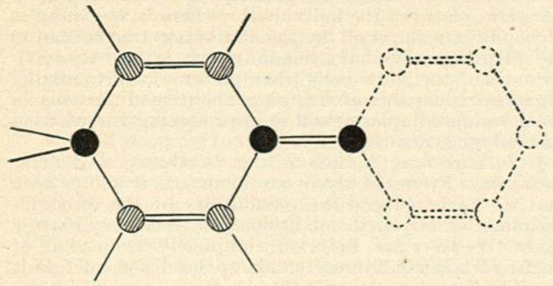

Fig. 2621.

building up of new rings with their attached side chains in intimate connection with pre-existing rings, the new molecule when completed breaking apart (*vide* Fig. 2621).

If now we take this as our fundamental conception and postulate further that sundry side chains may be added or removed without destroying the cardinal properties of the molecule, as also that the longer a side chain remains in relation to the central ring (or it may be the more multiple the attachments it gains to that central ring), the more fixed it becomes as an integral portion of the molecular constitution,* we then gain the basis for a physico-chemical theory of inherited variation.

Let us take the simplest example that offers, that, namely, of the bacteria. We know that, preserved in the same environment, these retain the same characteristics for a long series of generations. In other words, the same food-stuff being presented for assimilation, the idioplasm enters into combination with a certain definite number of the constituents of the same; when the increase of this idioplasm has reached a certain point fission or division occurs and the substance of the individual divides into two like parts, each containing idioplasm of the same composition. Hence tnese two members of the second generation are identical in characters and carry on the particular and distinguishing properties of the species. We know also that, grown on different media the same strain of bacteria exhibits fine points of difference in size, rate of growth, pathogenicity, etc. In other words, a different food-stuff being presented for assimilation the idioplasm combines with somewhat different substances and so forms somewhat different side chains. If this growth on different media is not continued for too long, return to the original medium leads to complete return to the original characters.

But we know also from several examples that growth under widely different conditions for a short period, or subjection to less widely different conditions for a long period, is capable of impressing such alterations upon bacteria that these modifications persist, it may be for years after return to previous environment, *i.e.*, the change in the constitution of the idioplasm has become *relatively* fixed. Thus Roux with the action of minute quantities of carbolic acid added to the medium of growth has developed an asporogenic variety of the anthrax bacillus; by growth at higher temperatures several observers have produced more or less permanent colorless races of pigment-producing bacteria, while Vincent has succeeded in making non-virulent bacteria, like the B. Megatherium, intensely virulent for the animals of the laboratory.

* I have discussed the grounds upon which we may make these assumptions in the article already referred to.

Without discussing at length the modifications introduced by multicellular organization and by descent following upon conjugation of germ cells emanating from different individuals, following these lines of reasoning it will, I think, be evident that we can conceive heredity in higher animals as being brought about by the transmission from generation to generation of idioplasm of a certain chemical composition, which idioplasm, present in one form in the germ cell, becomes inevitably modified in one or other direction as the ovum segments and the cells of different areas of the embryo and developing tissues of the body become subjected to different chemical and physical activities according to their relationship one to the other and to the exterior; so that the eventual structure of the different tissues is the manifestation of the different modifications which this controlling idioplasm has undergone in the course of embryonic and fœtal life. Or, otherwise, a given idioplasm in a given normal environment must follow a particular line of growth and differentiation, so that under like conditions successive generations inevitably resemble each other (*heredity*). With conjugation, however, and the fusion of distinct idioplasms *variation* is induced. The result of the conjugation is an idioplasm having properties not absolutely identical with those of either parental idioplasm. The resulting individual, while resembling, varies from either parent.

We now are in a position to discuss how and to what extent conditions acquired by either parent are capable of being inherited, either directly—the offspring showing the same morbid state as did the parent, or indirectly—disease of the parent having an influence upon the organism of the offspring, but this of a different order from that manifested in the parental organism.

1. *Mutilation.* Gross lesions of the body tissues can at most, according to this theory, only affect the offspring indirectly. They cannot be directly reproduced in the offspring; only in certain cases, by bringing about a poorer state of nutrition of the parental organism in general, and so of the germ cells, may they lead from the offspring not attaining full development.

The only well-authenticated example frequently quoted as an instance of the inheritance of gross lesions—viz., Brown-Séquard's experiments in which by sections of nerves, etc., in guinea-pigs, he produced epilepsy which manifested itself in the offspring—is not, it may be noted, an example of the inheritance of gross lesions, but is an example of the inheritance of a constitutional state set up in the parents by such a lesion. What is more, repeated attempts to confirm these experiments have failed. We do not doubt that Brown-Séquard obtained the results recorded by him, but under the circumstances the only valid explanation is, that he experimented with animals of lowered vitality, this showing itself especially in the direction of nervous instability, and that the nutritional changes following upon his operations led to the offspring being of still poorer constitution and still more unstable. (*Vide* paragraph 3 A, following.)

2. *Acquired Overdevelopment and Relative Excessive Function in One or Other Direction.* Similar considerations show that these cannot be directly transmitted to the offspring. At most, full and harmonious exercise of sundry functions of the body by leading to increased nutrition may tend toward a healthy sound state of the system, and by insuring general good nutrition may insure good nutrition and assimilation on the part of the germ cells, and so tend toward a sound condition and good development of the offspring.

3. *Intoxications (Including Infections); Indirect Effects.* Inasmuch as we cannot regard the germ cells as lying absolutely inactive and inert within the parental reproductive organs, and must from every consideration regard them as undergoing metabolism—assimilating food-stuffs from the surrounding lymph and discharging the products of their metabolism, so does it follow that the diffusible toxic substances capable of acting upon the cells of the body generally, when circulating through the tissues, must be liable to be absorbed by the germ cells and

so *may* alter the constitution of their idioplasm.* Nor do we lack clear evidence that this actually occurs. Thus Mairet and Combemale have subjected male dogs to chronic or acute alcoholic intoxication and found that the young exhibited various arrests of development and were predisposed to epileptoid seizures. The only explanation is that the alcohol had caused deterioration of the spermatozoa so that these conjugating with a healthy ovum nevertheless gave origin to impaired individuals. Nor are clear cases wanting of similar degenerations occurring in the progeny of alcoholic fathers and healthy mothers in man. The most clear example, however, of this order was afforded years ago by Constantin Paul in connection with the effects of lead poisoning. Studying a series of cases in which the father alone in the course of his work became the subject of plumbism, he was able to obtain the history of 32 pregnancies. Of these 12 resulted in the death of the fœtus before term; 20 children were born alive, of which 8 died during the first year, 4 died during the second year, 5 died during the third year, and 1 died later. Two alone were found to be alive, one of these aged twenty.

The only conclusion from these observations is that substances which lead to intoxication in the parental system tend also to act deleteriously upon the germ cells. It will be seen that the individual offspring itself is in one respect the direct victim of the intoxication; inherited plumbism is lead poisoning acting initially upon one or both of the conjugating germ cells, but it must be clearly understood that the mental and other disturbances showing themselves after birth are not the results of the action of lead salts still circulating in the system and that thus the lesions of inherited plumbism are of a totally different order from those of acquired plumbism. These are one and all lesions of incomplete development.

3 A. *Neuropathies.* The effects of parental intoxications are peculiarly liable to show themselves in the form of conditions of imperfect organization of the nervous system. This is in accordance with the principle or law, the action of which we repeatedly see in evidence: the law, namely, that characters which are the last to be acquired by the individual, the race, or the species are those which are the first to be lost. Thus in the evolution of man, one of the last acquirements—that acquirement whereby man is distinguished from all other animals—has been that of the higher mental organization. Another has been the development of relative insusceptibility to sundry infectious diseases. Thus the individual whose full development is arrested is particularly liable to manifest a greater or less degree of mental instability, the development of the higher nervous centres being incomplete; or again to manifest a peculiar susceptibility to the infections liable to attack human beings. Thus nervous instability of various orders may be regarded as an evidence of familial degeneration and as due to a condition acquired by one or other parent or to inheritance from previous ancestors, and noticeably may be accompanied by other stigmata of incomplete development and degeneration, liability to contract infectious disease, etc.

3 B. *Increased Susceptibility toward Infectious Diseases.* What I have stated regarding neuropathies may be stated *mutatis mutandis* with regard to infections. That is, the toxins of one or other infection circulating through the system, becoming absorbed by the germ cells and acting chemically upon the idioplasm, may result in the weakening of that idioplasm. As a matter of fact Gheorghiu has pointed out the frequency with which one notes the history of parental infection in cases of various monstrous developments.

It may be and it has been urged that here we are not dealing with the inheritance of conditions acquired by the parent, that the toxic substances produced these results not by their action on the body cells, but by direct action on the germ cells, and that so the inheritance is blastogenic, not somatogenic. We are quite prepared to grant that these inheritances are of blastogenic origin, nevertheless they are of individual acquirement. The individual consists of body plasm and germ plasm, and whether the defect tell primarily or secondarily upon the germ plasm of the individual we here have examples of conditions acquired by the individual transmitted to the offspring. We have to admit, that is, that the environment of the germ cells when present in the parental organism is capable of bringing about modifications in the germinal idioplasm, and so of producing variations in succeeding generations.

4. *Intoxications, Infections, and Diatheses; Direct Inheritance.* From the above considerations it will be seen that we have reduced the possibilities of the direct inheritance of acquired conditions to a relatively narrow field. We have not, however, completely removed all of them; certain conditions remain to be discussed. Is it possible, for example, that these various parental intoxications, telling as they do in one or other direction upon the parental constitution, tell also in a differential manner upon the germ cells, so that alcoholic inheritance differs from inherited plumbism, and these again from the indirect inheritances of syphilis and tuberculosis? *A priori* if these toxic substances, circulating in the parental system and gaining entrance into the germ cells, forming different combinations with the idioplasmic molecules, combine with, that is, or alter different side chains, we must conclude that it is possible. As a matter of fact, children of syphilitic parentage not the victims of intra-uterine syphilis, tend to show parasyphilitic lesions which are of a somewhat different order from the paratuberculous lesions of the progeny of tuberculous parentage. Here, however, it has to be admitted that fuller statistics are necessary regarding the lesions of those whose fathers and mothers respectively have suffered intoxication; for in maternal intoxication of any order, placental absorption of the circulating toxic substance must tell upon the fœtal existence. Nevertheless, taking the germ cells as, from their potentialities, apparently representative of the body cells in general, the abundant studies upon immunity made during recent years give us the strongest grounds for believing that the different toxins act specifically and affect the idioplasm in one particular direction. At this point it will be seen that our theory falls into line with Ehrlich's side-chain theory of immunity.

In short, the facts gained from the study of immunity point to three possibilities:

(*a*) Where through disease or through introduction of toxins the cells of the body become immunized to one special infection, those cells are so modified that they now produce substances antagonizing the toxins of that infection. We might therefore expect specific parental immunity to be accompanied by specific immunity of the germ cells and a condition of relative immunity of the offspring.

(*b*) When through disease immunity is not attained, but on the contrary the parental tissues—as in progressive tuberculosis—become progressively weakened and susceptible to the deleterious action of the toxin, the germinal idioplasm may also be weakened and an offspring be developed more susceptible to the particular infection.

(*c*) The idioplasm of the germ cells, being relatively undifferentiated while within the reproductive glands, might not in this state possess side chains capable of being acted upon by the circulating toxins; so that while the parental organism in general is affected thereby in one or other direction, the germ cells may be uninfluenced, and the offspring in consequence may present neither increased susceptibility nor increased powers of resistance to the specific disease.

Here it will be seen that we are in a region of hypothesis pure and simple; indeed, our researches into the in-

* I say *may* because it has to be remembered, as pointed out by Meyer, that the cellular absorption of toxic substances is of two orders: (I.), absorption into the cell without resulting chemical combination (as in the case of the alkaloids), the absorbed substance interfering with metabolic processes, and (II.) absorption with chemical combination, the toxic substance becoming fixed, *e. g.*, tetanus toxin in the cells of nerve tissue.

heritance of specific morbid constitutional states have not been sufficient to indicate positively which, if any, of these possibilities accords with the ascertained facts. Even granting that the first of these possibilities is correct, it has to be noted that according to the principle already mentioned—that conditions last acquired are those soonest lost,—we should expect that acquired immunity of the germ cells, if obtained, would tend to be of slight duration, not strongly impressed. Hence for the development of acquired immunity as of acquired susceptibility, not a single act of immunization of the parent but repeated immunizations through several generations might be requisite before any marked and permanent influence showed itself. As a matter of fact, the various attempts to confer immunity by immunizing the male parent have in the main given negative results. Gley and Charrin alone have detected such; Ehrlich strenuously denies that it is obtainable.

Nevertheless I think it is useful to call attention to these possibilities in order that more exact studies be made which shall prove or disprove them. Thus far the importance of determining the part played by acquired disease, more especially in the father, in the development of morbid constitutional states of the offspring has not been sufficiently recognized. It has not been grasped by our profession that in the study of these states we have a more subtle means of determining this question of the inheritance of acquired states than can possibly present itself to the morphologists, dependent as they are upon the more extensive gross anatomical changes before they can determine whether any alteration has been impressed upon the offspring.

We have, as I have pointed out, definite evidence that constitutional disturbance in the parent affects the germ plasm, and having this, it is for us sedulously to collect all the evidence which presents itself in order that we may determine the limitations of this affection of the germinal idioplasm within the parental organism.*

The views here enunciated are, I know, contrary to the generally expressed opinions of morphologists. It is well to point out once again that the conception of the existence of micelli, ids, gemmules, etc., can only lead to the view that acquired characters, not being able to tell on these ancestral bodies, cannot possibly be inherited. Save in the matter of spontaneous variation I do not suggest that visible anatomical changes can be expected in the course of one generation; but this physico-chemical theory, by realizing the possibility of progressive modification in the constitution of the idioplasm while within the parental organism, is fitted to explain not only what we observe in connection with the effects of disease, but also the development of familial and racial characters, and to aid materially our comprehension of the nature of evolution in general. *J. George Adami.*

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* More especially I would call attention to the valuable material in the possession of the great American insurance companies and the possibility of gaining information as to the effects of acquired disease of the parent upon the offspring by employing the mathematical methods elaborated by Carl Pearson (*vide* article on *Evolution*); if they can give mathematical expression to the influence of, say, acquired parental tuberculosis, upon the life period of the offspring, we shall make a most material advance.

HERMOPHENOL, mercury phenol-disulphonate of sodium, is a white, amorphous powder soluble in five to seven parts of water. It is said to contain forty per cent. of mercury, and to be strongly bactericidal without caustic effect on the tissues. It can stand a heat of 120° C. without decomposition. Bérard uses it as a disinfectant for the hands, and in three-per-cent. solution for ophthalmia neonatorum, and Reynes injects 4 c.c. (ʒ i.) of a half-per-cent. solution, every two or three days, for syphilis.

W. A. Bastedo.

HERNIA.—This term, derived from the Greek ἕρνος (a spout), is employed for denoting the protrusion of a viscus from the cavity in which it is normally contained. Although it may be used to denote the escape of organs from other cavities, yet when unqualified it signifies, as does the vulgar term "rupture," a protrusion from the abdominal cavity. As usually employed it implies a pouching of the containing wall forming a continuous sac for the displaced contents. An escape of the viscera through a wound in the wall is better termed a "protrusion." The term "internal hernia" is employed to denote either the protrusion of the abdominal contents into the thoracic cavity—*i.e.*, *diaphragmatic hernia*—or the introsusception of the intestine into one of the peritoneal fossæ. The latter condition is, however, more properly classified as one of the forms of intestinal obstruction.

A hernia may occur at one of the openings of the abdominal wall normally present in fœtal life, which has not become closed at the time of birth, and is then termed a *congenital* hernia; *i.e.*, a congenital inguinal hernia is one in which the abdominal contents push their way into the unobliterated processus vaginalis. All herniæ developed subsequently to birth are termed *acquired.* They occur at the points where the abdominal wall is relatively weak. Hence arises the anatomical classification of herniæ: inguinal, femoral, umbilical, lumbar, diaphragmatic, obturator, etc. The parts constituting a hernia are, first, the sac and, second, the contents. The sac consists of peritoneum continuous with the parietal peritoneum of the abdominal cavity. The coverings of the sac vary with the anatomical variety of the hernia, and are as a rule fascial with the exception of the skin. The shape of the sac depends upon the nature of the opening in the abdominal wall and the degree of restraint afforded by the fascial coverings. If the opening be circular with more or less sharp margins the sac as a rule is globular, as in umbilical and femoral herniæ.

In inguinal hernia the sac is elongated, owing to the fact that the fascial coverings are tubular. If the hernia is incomplete the sac is sausage-shaped. On the other hand, it is pyriform in shape when the hernia becomes scrotal. Bands of the investing fasciæ may constrict the sac in such a manner as to produce hour-glass forms; or from the same cause diverticula may result, the pressure being unequally exerted. The parts of a sac are termed the mouth, the neck, and the fundus or body. The contents of the sac usually consist of small intestine or omentum, or both; more rarely they consist of the colon, cæcum, or appendix, sigmoid flexure, bladder, or uterine adnexa. When the contents consist of intestine alone the hernia is called an enterocele; when of omentum alone an epiplocele; when of both, an entero-epiplocele. Fluid may be found in the sac either free or encysted by adhesions—*hydrocele of the hernial sac.*

ETIOLOGY.—Causes predisposing to hernia are:

1st. *Heredity.*—Weaknesses in the abdominal wall predisposing to hernia are undoubtedly inherited.