"ON HEREDITY."

by

DAVID WILLIAM HORN PATERSON.

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The recognition of the Principle of Heredity extends back to the early Greeks and Romans. Plato and Lucretius both compare the succession of lives to the racers with torches in the games of the Athenian festival to Vulcan: thus Plato, "Handing on life to one another as a lamp (or torch)", and Lucretius, "And in a short space the generation of living beings are changed and like runners hand on the torch of life." Osborn in his book "From the Greeks to Darwin", MacMillan & Co., 1894, p.27, says "The notion of hereditary transmission of characters was extremely ancient, and was naturally founded upon the early observed likeness of offspring to parents. Aristotle also commented upon the principles of the prepotency of the characteristics of one parent over the other, as well as of Atavism." He says:- i.e. Aristotle "Children resemble their parents not only in congenital characters, but in these acquired later in life. For cases are known where parents have been marked by scars, and children have shewn traces of these scars at the same points; a case is also reported from Chalcedon in which a father had been branded with a letter, and the same letter somewhat blurred and not sharply defined appeared upon the arm of his child."

It is of great interest to note that the system of Lycurgus established by him nearly 800 years B.C. did /

did not omit regulations regarding marriage and children, "whose welfare was even before their birth a concern to the republic", Gillies History of Ancient Greece, Vol.I, p.141. Lycurgus argued that the physical qualities of children depend largely on the constitution of their parents, while likewise the "generous and brave produce the brave and good." The Spartan women were not degraded, as in some other countries of Greece to drudgery, as Lycurgus believed that women so degraded were incapable of bearing good sons to the state, but were expected to take as their chief employment the performance of offices of domestic economy and to prepare food and clothes for themselves and families. Marriage although regarded as a duty could only be contracted in the full vigour of age, and it is stated that those regulations produced a beneficial effect in the physical condition of the Spartans. Lycurgus lived in the infancy of society, regarding which state Gillies says "men are occupied with the business of the present hour, forgetful of the past, and careless of the future." The system instituted by this famous legislater of Sparta was, however, superior in many respects to some customs with which we are not unfamiliar to-day. In this connection the words of Darwin may well be quoted "Man scans with scrupulous care the characters and pedigree of his horses, cattle and dogs, before he mates them. But when he comes to/

to his own marriage, he rarely or never takes any such care. He is impelled by nearly the same motives as the lower animals when they are left to their own free choice, though he is so far superior to them that he highly values mental charms and virtues. On the other hand, he is stronly attracted by mere wealth or rank. Yet he might by selection do something not only for the bodily constitution and frame of his offspring but for their intellectual and moral qualities. Both sexes ought to refrain from marriage if they are in any marked degree inferior in body or mind, p.617 Descent of Man. Haeckel, in his "Evolution of Man", p.103, referring to the same subject, at a later period than Darwin, says "In this respect many of the higher animals exercise a better taste and a more impartial judgment than does man. But even among men, sexual selection has given rise to a noble form of family life which is the chief foundation in which civilisation and social states have been built. The human race certainly, owes its origin in great measure to the perfected sexual selection which our ancestors exercised in the choice of wives."

Heredity and Evolution are principles which are closely allied in their respective operations. A brief view of the history of the theory of Evolution, beginning with Buffon may not be out of place here.

The treatise of Dr Henry Fairfield Osborn, "From the Greeks to Darwin" gives an admirable outline of the "development of the Evolution idea" and many of the statements made in the following paragraphs are derived from this work. Buffon believed that all animals sprang from a common source" which, in the succession of time, has produced by perfecting itself and by degeneration, all the races of other animals.

"Mais non, il est certain, par la révélation, que tous les animaux ait également particepé à la grâce de la creation: que les deux premiers de chaque espèce, et de toutes les espèces, sont sortis tout formes des mains du Créateur; et l'on doit croite qu'ils étaient tets a peu près qu'ils nous sont aujourd'hui represéntes par leur descendants."

The main feature in the theory of Buffon is the role to which he ascribes the direct action of environment viz. Environment modifying the structure of plants and animals and heredity transmitting these modifications/

modifications.

The doctrine of the mutability of species maintained that species were not immutable, but that one species might give rise to two or more new ones. This was clearly recognised by Goethe in 1796.

"Thus much, then, we have gained, that we may assert, without hesitation, that all the more perfect organic natures, such as fishes, amphibious animals, birds, mammals, and man at the head of the list, were all formed upon one original type, which varies only more or less in parts which are none the less permanent, and which still daily changes and modifies its form by propagation."

The greatest advocates of the doctrine of the mutability of species were Lamarch and St. Hiliare and the greatest openent Cuvrir. In 1795 Erasmus Darwin in Zoonomia announced the theory of a common ancestry for man and all other vertebrata, believing that species were the results of modifications arising from the requirements of the animals themselves. "Dr Darwin's theory of the causes of Evolution" says Osborn " was not similar to Buffons for he nowhere lays stress upon the modifications induced by the direct action of Environment; on the other hand, he believed that modifications spring from within by the reactions of the organisms."

In a note to the Historical sketch of the Progress/

gress of Opinion on the Origin of Species, Charles Darwin says "It is curious how largely my grandfather, Dr Erasmus Darwin, anticipated the views and erroneous grounds of opinion of Lamarch in his Zoonomia, Vol.I. p.500-510, published in 1794. Osborn has searched the writings of Erasmus Darwin and finds "striking confirmation" of the above sentences, as for example in the following paragraph, "Fifthly, all animals undergo transformations which are in part produced by their own exertions, in response to pleasures and pains, and many of these acquired forms or propensities are transmitted to their posterity." "This"says Osborn "is the first clear and definite statement of the theory of the transmission of acquired characters considered as one of the factors of Evolution."

Lamarck expresses his personal conclusion thus, "Nature in producing successively all the species of animals, and commencing by the most imperfect or the most simple to conclude its labour in the most perfect, has gradually completed their organisation; and of these animals, while spreading generally in all the habitable regions of the globe, each species has received, under the influence of environment which it has encountered, the habits which we recognise and the modifications in its parts which observation reveals in it."

He//

He postulated several laws, one of which is known as the "inheritance of acquired characters."

Geoffrey St. Hiliare in 1795 says "species vary with their environment, and existing species have descended by modification from earlier and somewhat simpler species."

In 1851 Mr Patrick Matthew published his work on Naval Timber and Arboriculture. In his remarks on this, Mr Darwin says "He saw clearly the full force of the principle of natural selection." Matthew's statement is as follows, and in view of Mr Darwin's criticism is well worthy of attention.

"As nature in all her modifications of life has a power of increase far beyond what is needed to supply the place of what falls by Time's decay, these individuals who possess not the requisite strength, swiftness, hardihood or cunning fall prematurely without reproducing - either a prey to their natural devourers, or sinking under disease generally induced by want of nourishment, their place being occupied by the more perfect of their own kind who are pressing on the means of existence is limited and preoccupied, it is only the hardier, more robust, better-suited-to-circumstance individuals who are able to struggle forward to maturity..... the weaker and less circumstance-suited being premately destroyed.

"This principle is in constant action; it regulates/

regulates the colour, the figure, the capacities and instincts; those individuals in each species whose colour and covering are best suited to concealment or protection from enemies or defence from inclemencies and vicissitudes of climate, whose figure is best accomodated to health, strength, defence and support."

In 1852 Mr Herbert Spencer in the Westminster Review says, "In families and races whom this increasing difficulty of getting a living which excess of fertility entails, does not stimulate to improvements in production ..... are on the high road to extinction, and must ultimately be supplanted by those whom the pressure does so stimulate ..... and here indeed, without further illustration, it will be seen that premature death under all its forms and from all its causes cannot fail to work in the same direction. For as those prematurely carried off must in the average of cases be those in whom the powers of self-preservation is least, it unavoidably follows that those left behind to continue the race must be those in whom the power of self-preservation is the greatest, must be the select of /

of their generation."

The theory of Evolution was at this stage when Darwin published his "Origin of Species." A few quotations from that epoch making work will perhaps illustrate the trend of thought which he followed in arriving at his conclusions.

"In considering the Origin of Species, it is quite conceivable that a naturalist reflecting on the mutual affinities of organic beings, on their embryological relations, their geographical distribution, geological succession, and other such facts might come to the conclusion that species had not been independently created, but had descended like varieties from other species. Nevertheless, such a conclusion even if well founded would be unsatisfactory, until it could be shown how the innumerable species inhabiting this world have been modified so as to acquire that perfection of structure and co-adaptation which justly excites our admiration. Naturalists continually refer to external conditions, such as climate, food etc. as the only possible cause of variation. In one limited sense this may be true, but it is preposterous to attribute to mere external conditions the structure for instance, of the wood-pecker with its feet, tail, beak and tongue so admirably adapted to catch insects under the bark of trees."

"Origin of Species." Introduction.

"But the mere existence of individual variability and of some few well marked varieties, though necessary for the foundation of the work helps us but little how species arise in nature." "All these results follow from the struggle of life. Owing to this struggle, variations however slight and from whatever cause proceeding, if they be in any degree profitable to the individuals of a species, in their infinitely complex relations to other organic beings and to their physical conditions of life, will tend to the preservation of such individuals, and will generally be inherited by the offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation , if useful, is preserved, by the term "Natural Selection", in order to mark its relation to man's power of selection. But the expression often used by Mr Herbert Spencer of the Survival of the Fittest is more accurate, and is sometimes equally convenient."

Thus is borne out the statement that evolution and heredity are closely allied. Haeckel states that "the type of Evolution is the mechanical result of Heredity." "For" says Alfred Russel Wallace in "Darwinism/

"Darwinism" "if in each generation of a given animal or plant the fittest survive to continue the breed, then whatever may be the special peculiarity that causes "fitness" in the particular case, that peculiarity will go on increasing and strengthening so long as it is useful for the species. But the moment it has reached its maximum of usefulness and some other quality or modification would help in the struggle, then the individuals which vary in the new direction will survive, and thus a species may be gradually modified , first in one direction, then in another, till it differs from the original parent form as much as the greyhound differs from any wild dog, or the cauliflower from any wild plant." And again in the Fortnightly Review, April 1893, the same authority says, "Modifications have been effected by the selection of the capacities or qualities resulting from the infinitely varied combination of variations that are always occuring (not as Mr Herbert Spencer assumes by the selection of improvements in any special bone or muscle or limb.") Likewise Weismann in the Romanes Lecture Effects of External Influence upon Development p.15. "It is not the particular adaptive structures themselves that are transmitted but only the quality of the material from which intra-selection forms these structures anew in every individual life."

Here/

Here it may be remarked that a difference of opinion exists between Darwin and Wallace regarding the powers of Natural Selection. In 1859, Darwin wrote to Lyell "I believe Natural Selection will account for the production of every vertebrate animal", while in the Origin of Species he said, "I am convinced that Natural Selection has been the main, but not the exclusive means of modification."

Wallace has always believed that Natural Selection has been the sole means of modification excepting in case of man, and Weismann also believes that Natural Selection is the sole cause of adaptive modification.

Darwinians who believe that acquired characteristics are inherited give"adaptation" a place as a factor in Evolution. "Adaptation and variation are simultaneous: they are fundamentally the same."

Those who believe with Weismann that acquired characters are not inherited "question the principle of adaptation and substitute " variation coupled with "Natural Selection" (Haeckel " Last Link). According to this view, adaptation is not the cause but the result of the formation of the species.

How is it that Darwin saw so clearly what others failed to perceive? It has been said that he owed much to the workers in the past, quite true, so did others of his day who did not formulate any theory

or/

or who did not accept his theory when laid before them.

Darwin himself said "I worked on true Bacinian principles and without any theory collected facts on a wholesale scale, more especially with respect to domesticated products, by printed inquiries, by conversation with skilful breeders, and gardners, and by extensive reading." "This" says Osborn "is the most deliberate and rigid instance of the application of the inductive method which we have met with in our whole study of the contributors to the Evolution theory."

Sir David Brewster in his life of Sir Isaac Newton says "Sir Isaac Newton is represented as having owed all his discoveries to the application of the principles of that distinguished writer"(Lord Bacon). He shows that neither Newton nor Boyle nor any other distinguished scientist ever mentioned the name of Bacon or his system when referring to their discoveries.

"When we are told therefore" he continues "that Newton owed all his discoveries to the method of Bacon, nothing more can be meant than that he proceeded in that path of observation and experiment which had been so warmly recommended in the Novum Organum, but it ought to have been added that the same method was practised by his predecessors - that Newton possessed/

possessed no secret that was not used by Galileo and Copernicus - and that he would have enriched science with the same splendid discoveries if the name and the writings of Bacon had never been heard of."

Haeckel has said that Darwin had inherited the genius of his grandfather Dr Erasmus Darwin, that this is really an example of reversion, and Wallace believes that the genius of Erasmus was of as high an order as that of Charles Darwin himself. None will deny that Charles Darwin had genius such as has been bestowed upon few, and that that genius was of such a kind as fitted him for work among the problems of Natural History, for genius has many forms in which it may show itself in the possessor. Without that genius the magnificient fabric which the Natural Sciences present to-day on their solid and enduring basis would instead be a poor and incomplete structure. We must, I think, admit that the explanation which Newton gave of his brilliant researches and which curtained much truth also applies to Darwin.

Newton declared that"any service he had done to the public was not owing to any extraordinary sagacity but solely to industry and patient thought."

Bishop Berkley in his introduction to "The Principles of Human Knowledge" says "However difficult and discouraging soever this attempt to make a strict enquiry concerning the First Principles of Human Knowledge, to sift and examine them on all sides may seem,

seem/

seem , when I consider what a number of very great and extraordinary men have gone before me in the like designs, yet I am not without some hopes - upon the consideration that the largest views are not always the clearest, and that he who is short-sighted will be obliged to draw the object nearer and may perhaps by a close and narrow survey discern that which had escaped far better eyes."

Few observers have had a greater share of genius and ability than Darwin had, many of them have followed the methods of the Baconian philosophy, but the question arises how many have had the Patience of Philosophy. To the lack of this attribute Brewster ascribes the failures of many of Newton's predecessors, and when we think of the long years of patient labour and research by which Darwin drew the object closer to eyes which were of clear and unprejudiced vision we may conclude that this humble and earnest scientist possessed the Patience of Philosophy as well as her methods, and to these facts we must give due consideration in summing up our debt to Darwin.

One very potent reason why the study of Heredity especially interests a medical man is the fact that the public take a great interest in the question. My experience has chiefly been among the working class population in districts in England, Wales and Scotland/

Scotland, and I find that this class as a whole take a considerable interest in the subject of Heredity. The reason of this is not very far to seek. Their observation has shown them like the ancient Greeks, that children resemble their parents, their own ailments and those of their parents and relatives are often of absorbing interest to them and the question is frequently asked of the medical adviser whether the illness runs in the family. They have a great belief in the Heredity of Phthisis, they sometimes consult a medical man regarding marriage with a member of a family in which there is a phthisical taint: they are in many cases cognisant of the heredity of cancer and have a dread that any growth in a family with a cancerous history is of this nature. It is true, I am afraid, that the medical man is the only individual who is aware of the interest which is taken by this class in this particular branch of Science, true also that their views upon the subject are extremely vague and based upon observation, in fact their knowledge is empirical, and they turn to the doctor and in this question they believe he knows all about it. It must also be remembered that in stating a view to the ordinary run of working man, it is useless to tell him what may be, he expects a definite answer and consequently it is well for the practitioner ~~like~~ to be well versed/

versed in all the definite facts known about Heredity and to be able to expound them to his patients. Theories and possibilities have no interest for the great majority of them.

And it is from the Medical Profession that any enlightenment upon this subject as far as these people are concerned must come. This is easily seen when endeavouring to get a faithful record of the family history in cases where it is absolutely necessary, as for instance in insanity. The public require to be educated up to a certain standard upon the subject of Heredity, and it is a question upon which they are willing to listen to instruction, being interested as I have endeavoured to show in the more patent manifestations of the principle and likewise in some of the more obscure problems thereof as witness the interest which the exhibition of the Zebra Hybrids excited among the populace.

It is very commonly believed that Genius is hereditary. Mercier's statement that all the qualities of the parents tend to be inherited in the offspring applies here and enables us to see if we accept that statement that it is quite possible that Genius may be inherited. Galton in his book "Hereditary Genius" has gone thoroughly into the subject and gives many instances of genius being inherited in the children of men distinguished in Arts, Literature/

ature and Science.

Strachan thinks that both parents require to be of high intellectual order before Genius can be inherited by the offspring and this tends to confirm Galton's view of filial regression, viz, that children as a rule tend to fall back to the average of the race, tall people do not necessarily beget the tall, the children of clever people are not necessarily distinguished for intellectual capacity, but they tend to strike an average.

In the case of genius, the "transmutation in transmission" is very marked, perhaps because it has been more noticed in the case of distinguished people; the cases being put on record. The offspring of brilliant men may be likewise brilliant but the genius may take a perverted form in the offspring and may unhappily develope into conditions undesirable and unfortunate. So, too, genius even if of the same type may take different expressions in the offspring. In "The Military Life of John, Duke of Marlborough" (Archibald Alison) the military genius of Wellington, Eugene, Napoleon and Marlborough are compared with one another and differences are discovered, the same type of genius exhibiting different forms, symbolical, I think, of what often occurs in hereditary genius.

When it is borne in mind that many men of genius have/

have risen from the common people it is pertinent to note that the medical adviser may be the first to observe these traits of latent genius in a child which may under careful nurture assume a proper bias. Boy- Tessier in his article on Old Age XX Century Practise p.475 defined Heredity as a "biological phenomena of transmission to the descendants, of some characteristic of the generators" and he therefore argues that Heredity is only of secondary importance transmitting only the conditions of development of old age and thus giving to the individual a portion of the vital characteristics of the ancestors.

I will now turn for a moment to the question of Heredity of Crime, and upon this as upon many other points opinions differ. Lombroso (Criminal Anthropology Twentieth Century Practise p.406.) states that Virgitio found a criminal parentage in the proportion of 26·80% chiefly on the paternal side, while the estimated 6% of indirect heredity. A certain number of the relatives of criminals he shows are afflicted with mental aberration, while alcoholism in the parents favour crime in the children. Lombroso states that according to officials statistics out of 2,800 criminals under age in 1871 and 1872 7·4% were of drunken parentage, the fathers were in the proportion of 5·3%, the mothers 1·7% and both together 0·4%. The father appears to exercise a greater /

greater influence than the mother both in criminal and drunken parentage. It will be remembered that Esquirol expressed the opinion that insanity is more frequently transmitted through the mother than the father. "These figures" says Lombroso " are sufficient to show how great is the influence of heredity in c crime." He cites the gynealogy of the Juke family to prove the relations to mental disease and to prostitution. Of the descendants of the robber and libertine Max Juke , 77 were criminals, 128 prostitutes, 131 impotents, idiots or syphilitics, 142 were vagabonds, 18 brothel keepers, 91 parents of illegitimate children and 40 sterile, and he says that the statement of an eminent statistician "Prostitution is to women what crime is to men" is proved by the gynaelogy of the Jukes as worked out by Dugdale. In view In view of the enormous number of children both legitimate and illegitimate of this notorious Max Juke it is surely patent that even if he had not been a criminal his children and their descendants could well enough shew such a record as they did, badly fed and educated as they must have been they would take the course most easily accessible to them and this discounts to some extent the value of the Juke's gynealogy; while we would expect to find in such an enormous number of descendents many who were either sterile, impotents or idiots. A study of criminal anthropology shows clearly that there are many other cases/

causes than heredity acting so as to produce criminals and it is fair to note the conclusion of Frances Kepler in the Arena, May 1900, on "Criminality among Women." It is there shown that the penitentiary classes (felonies) come from better homes than do the workhouse classes (misdemeanour). These last come from districts possessing the worst sanitary and social surroundings and are more uniformly from these same districts.

The above statements tend to show some facts regarding criminal women that are more dependent upon social and economic influences than upon hereditary ones, says Miss Kepler.

While Huxley gives his opinion thus, "In a large proportion of cases crime and pauperism have nothing to do with heredity but are the consequences partly of circumstances and partly of the possession of qualities which under different conditions of life might have excited esteem and admiration."

And again Lloyd Morgan in the Monist April 1900 says "The squalor and vice of our city slums is to a large degree the product rather of a vitiated and disturbing environment than of a debased and vicious hereditary nature."

In the sphere of Literature we come across some very interesting problems bearing upon hereditary.

"If" says Matthew Arnold in his book "Celtic Literature/

Literature" "I were asked where English poetry got those three things, its turn for style, its turn for melancholy and its turn for natural magic for catching and rendering the charm of Nature in a wonderfully clear and vivid way - I should answer with some doubt that it got much of its turn for style from a Celtic source; with less doubt that it got much of its melancholy from a Celtic source, with no doubt at all that from a Celtic source it got nearly all its natural magic."

It has been pointed out that nearly all our great literary men have had some Celtic blood in their veins, or to put it in a more scientific way have had some units of Celtic origin in their particulate inheritance. Shakespeare was excepted from this statement, he being claimed by the Anglo-Saxon as being purely of that type, but recently, I believe, it has been shown that Shakespeare's grandmother on his maternal side was a Griffiths of Welsh birth and training. If this be true the exception no longer exists.

In the Spectator, August 12th, 1871 the following paragraph of interest occurs:-

"Lord Houghton , in a well-turned speech at the centenary in honour of Miss Hope Scott, the sole survivor of the line, mentioned the kind of loneliness in which the names of all the great littérateurs stand. They have rarely left descendants. We have no Shakespeare, no Milton, no Bacon, no Newton, no Pope/

Pope, no Byron. Italy has no Dante, no Petrarch, no Ariosto, no Alfieri. Germany has no Goëthe, no Schiller, no Heine. France has no Montaigne, no Descartes, no Voltaire, no Lamartine. There is no descendant known of Luther, Calvin or John Knox. The fact is remarkable, and not favourable to the theory of an indefinite progress of humanity. The race of the very great does not multiply, while the race of the very little - sat any Irish hodman - is as the sands of the sea."

Every modern authority is agreed that the physical basis of Heredity is to be sought for in the cell. As Oscar Hertwing has said "a Theory of Heredity must be reconciled with the cell Theory."

Professor Sir William Turner in "The Cell Theory Past and Present" Nov.1st 1889, has given a resume of the history of the Cell Theory. The more salient features may be mentioned here, and others will be referred to as occasion occurs.

The vegetable cell was discovered by Schlieden Professor of Botany at Jena in 1838, and next year Schwann found the animal cell, and is regarded as the founder of the cell theory "That there is one universal principle of development for the elementary part of organisms however different and that this principle is the formation of cells." Goodsir 1842 says that "the nucleus is the reproductive organ/

organ of the cell that it is from it as from a germinal spot that new cells are formed."

Dr Martin Barry in 1841 says "that young cells originate through division of the nucleus of the parent cell."

The human ovum was discovered in 1827, by Carl Earnst Van Baer , and in 1833 Coste described the germical vesicle in the mammal's ovum.

In 1627 Hamm, a student in Leyden in the microscopic examination of semen saw briskly moving bodies and Leewen Hoeck after a more minute examination published the discovery, stating that these filaments were the pre-existing germs of animals, maintaining that at fertilisation they penetrated the ovum and grew up in it. Thus arise the School of Animalculists (Dr Hertring Embryology of Man and Mammals p.26.).

Barry in 1843 discovered the actual entrance of spermatozoa within the Zona of the mammiferous ovum.

Virchow maintained in his lectures on cellular Pathology that in "Pathological structures there was no instance of development de novo; but that where a cell existed there one must have been before. He called it the law of continuous development which could be formulated in the expression ominis cellula e cellula .

A short review of the chief facts regarding the animal /

animal cell as contained in the treatises of Hertwing and Wilson will assist materially in the elucidation of many points regarding the various theories of Heredity and also will explain some of the Phenomena of Heredity.

The Animal Cell is composed of two morphological elements which are always present, and a third present in most cells. The two former are Nucleoplasm (Strasbruger) or Karyoplasm (Flemming) - the substance of the Nucleus; and Cytoplasm - the substance of the cell-body. The Centrosome is the third element.

Chemically the nucleoplasm contains a substance rich in Phospoorus, called Nuclein - the cytoplasm contains no nuclein being rich in Proteids and other related substances, containing a low average of Phosphorus.

Hoppe-Seyler's classification of nucleins is
1. Nucleins like those in Spermatazoa which contain no proteid but consist only of Nucleic Acid.
2. The true nucleins, these found in cell nuclei, they yield proteid, Zanthine, or alloxuric basis (hypozanthine, Zanthine, guanine, adenine) and phosphonic acid. Those richest in nucleic acid occur in the chromatic fibres of the nucleus.
3. Paranucleins or Pseudo-nucleins.

Nuclei in their resting stage may be divided into (a)/

(a) The nuclear membrane.

(b) The nuclear reticulum - an irregular branching network composed of (a) chromatin (Flemming) the nuclear substance par excellence (b) Linin (Schwarz) a transparent substance visible only after staining by reagents surrounds and supports the chromatin forming the basis of the nuclear network, is probably composed of plastin a substance similar to nuclein but containing a lower percentage of Phosphorus.

Nucleoli - may be absent or there may be more than one. In some cases the Centrosome lies within the nuclear mambrane in the linin network; in exceptional cases the nucleus contains the centrosome.

Chromatin is probably identical with nuclein; in certain cases (nuclei of Spermatozoa and probably also the chromosomes at the time of mitosis) chromatin may be composed of nearly pure nucleic acid.

Ray Lankrester observes (article Protozoa Encyclopaedia Britannica) that even in higher animals the nuclei do not always conform in all respects to the typical description such as above, nor do they invariably exhibit in division the usual Karyokinetic changes, while in some of the highest Protozoa the nucleus may be diffused throughout the cytoplasm in the form of fine particles of chromatin substance, stainable by Carmine but invisible during life.

In all the higher and in many of the lower forms of life/

life indirect division or mitosis is the typical mode of cell-division. It is by mitotic division that the germ-cells arise and are prepared for their union during the process of maturation and by mitotic division the oösperm segments and gives rise to the tissue cells.

Mitosis; (Flemming 1882,) Karyokinesis (Schleider 1878,) or Indirect Nuclear Division typically involves

(a) The formation of an amphiaster,

(b) Conversion of the chromatin into a thread

(c) Segmentation of the thread into chromosomes, the nuclear capsule disappearing and the chromosomes lie naked in the cell.

(d) Longditudinal splitting of the chromosomes, into exactly similar halves, which are after-wards transported to opposite poles of the spindle and give rise to the daughter nuclei .

This splitting of the chromosomes is of primary importance and is one of the main objects of mitosis. The process was discovered by Flemming in 1880, and Roux pointed out that by this means each daughter nucleus receives exactly equivalent parts of chromatin from the parent nucleus.

Every species of plant or animal has a fixed and characteristic number of chromosomes which regularly recurs in the division of all its cells, and in all forms arising by sexual reproduction the number is even.

The/

The chromosomes are derived directly from the chromatic network of the resting nucleus.

It is the object of Mitosis to divide every part of the chromatin of the mother-cell equally between the daughter nuclei , all the other processes being preparatory to this. Therefore, we may regard the mitotic figure as essentially an apparatus for the distribution of the hereditary substance and in this sense as the essential instrument of inheritance. "Whatever be the properties of the chromosomes of the mother cell they are distributed equally between the nuclei of the two daughter cells." An exception to this important phenomenon of splitting of the chromosomes is afforded in the process of "Maturation."

"The Centrosome represents the dynamical centre of the cell" Boveri. The appelation "sphere of attraction" is justified in the case of the centrisome for owing to the influence which that body possesses over the vital particles of the cell we have formed the astral system from the extra-nuclear reticulum. Wilson believes that some of those fibres are contractible and drag the daughter chromosomes asunder to either end of the spindle, while Weismann affirms that the splitting of the chromosomes is due to some inherent power acting within the rods themselves.

The/

The cytroplasm of the cell undergoes a mass division in contradistinction to the division of the nucleus as described above.

Both ova and spermatozoa arise from the germ epithelium of the genital ridge situated on the mesial side of each Wolfian body. These primordial germ-cells would seem at first to be sexually indifferent, until some external stimulus transforms them either into ova or spermatozoa. Maupa's experiments on the fresh water rotifer Hydatina Senta lead him to believe that the determining influence here was temperature - a high temperature tending to produce males, a low temperature females. In the case of Lepidoptera, Mrs Yeats has shown that nutrition produces the differentiation, and Yung's experiments on tedpoles gave the same result; highly fed individuals producing a great preponderance of females, while those that are underfed give rise to a majority of males.

Davenport in an article in the Intercolonial Medical Journal October 1899, comes to the conclusion that the sex of the child is determined at the moment of conception and is the opposite to whichever parent is at that moment in relatively the more vigorous health. A series of experiments on dogs seem to favour this view. First keeping the male in confinement and on a limited diet, while the female had exercise and a bountiful diet. Result after two weeks treatment, a litter of five male pups. Conditions reversed in the following year, females the result.

Boveri/

Boveri has shown in Ascaris Megalocephala Univalens, that only the germ-cells receive the sum total of the egg-chromatin handed down from the parent. All of the somatic cells contain only a portion of the original nuclear material.

In the embryo which is to develope into a male, the Primordial Germ-cells give rise by mitotic division to spermatogonia which for a time undergo further division with the usual or somatic number of chromosomes and ceasing for a time to divide, enlarge considerably to form spermatocytes, lastly each spermatocyte divides twice in rapid succession to form four spermatids, which ultimately develope into spermatozoa. The history of the chromatin in these two divisions is exactly parallel to that in the formation of the polar bodies. Each spermatocyte is morphologically equivalent to an unripe ovarian ovum or oöcyte and the group of four spermatozoa to which it gives rise is equivalent to the ripe egg together with the three polar bodies.

Hertwig asserts that while in immature spermatozoa protoplasm is present in the form of drops of various sizes, they eventually disappear and in typically developed spermatozoa he doubts if protoplasm is present at all; while the nucleus is metamorphosed into the head of the seminal filament forming a homogeneous mass of chromatin.

The chief chemical constituent of the spermatozoa /

ozoa is nuclein. Meischer also prepared a base which he called Protamine.

The heads of the Spermatozoa contain,

60·73% of Nucleic Acid, and

19·78% of Protamine

The tails contain,

Proteid 41·9%

Lecithin 31·73%

Fat and Cholesterin 26·27%

(TextBook of Physiology E.A. Schafer Vol.1. p.931)

The ova arise by mitotic division of the primordial germ-cells; each cell giving rise to a number of descendants known as oögonia - which are the immediate predecessors of the ovarian egg - at a certain period they cease to divide, each of them growing to form an ovum - its nucleus enlarging to form the germinal veside - its cytoplasm becomes more or less laden with food matter - the ovum is now known as the oöcyte (Boveri) or ovarian egg.

In this condition the egg-cell remains until near the time offertilisation when the process of maturation proper i.e. the formation of the polar bodies takes place. Although the formation of the polar bodies was shown to be a process of true cell-division, or rather as Oscar Hertwing has insisted of cell-budding (the two products being of very unequal size) - the process as observed by Boveri in the ova/

ova of Adcaris differ in some important particulars from the mitotic process of tissue cells.

As a preparatory stage the chromatin of the germinal vesicle is grouped into a number of masses, each of which splits up into a group of four bodies thus forming a quadruple group (tetrad), the number of Tetrads being always one-half the usual number of chromosomes, then each of the tetrads is halved to form two double groups (dyads) one remains in the ovum the other passes into the polar body; the second polar body is formed by each dyad splitting to form two single chromosomes, one passing into the ovum, the other into the polar body.

The nucleus of the mature egg has been designated by Oscar Hertwig as Egg-nucleus, by Van Beneden as Female Pronucleus, which is not to be confounded with the germinative vesicle of the unfertilised ovum. The germinative vesicle is of considerable size, being about the fourth part of the diameter of the ovum, in the human ovum the size is about $\frac{1}{500}$ th part of an inch in diameter; the egg-nucleus is remarkably small and attains a diameter of about 13M. The former possesses a nuclear network, and a nucleolus , while a well-defined nuclear membrane separates it from the cytoplasm; the latter appears almost hemogeneous and is without a nuclear membrane . (Oscar Hertwig Embryology of Man and Mammals p.33).

Weismann/

Weismann is of the opinion that the process of reduction is very obviously a phenomenon to hold constant the number of chromosomes characteristic of the species, for if it did not occur the number would be doubled in each succeeding generation through union of the germ-cells.

Hertwig favours Boveri's view that the polar bodies are abortive eggs, "That the polar bodies are abortive eggs which are formed by a final process of division from the egg-mother-cell (oöcyte) in the same manner as the spermatozoa are formed from the sperm-mother-cell (spermatocyte). But while in the llatter case the products of the division are all used as functional spermatozoa, in the former case one of the products of the egg-mother-cell becomes the egg, appropriating to itself the entire mass of the yolk at the cost of the others which persist in rudimentary form as the polar bodies." Wilson on the cell.

In 1885 Weismann discovered that a single polar body is expelled from the parthogenetic summer egg of Polyphemus Oculus, therefore he concludes that the significance of the first polar body is different from that of the second. The extrusion of the first polar body, he believes, signifies the removal of ovagenetic nucleoplasm from the egg, while the second is a reduction of the germ-plasm itself/

itself to half its original amount. Thus Weismann distinguishes in the germinative vesicle, ovogenetic and germinal plasm, and he states that "The quantity of nuclear substance decides whether the egg is capable of undergoing embryonic development. This quantity is twice as large in Parthenogenetic as in the Sexual egg. In the Parthenogenetic the nuclear substance is only reduced to one-half by a single division, in the sexual to one fourth by two divisions. In the sexual egg the removal of the germ-plasm must be replaced by fertilisation before development occurs." (Weismann. Essays on Heredity, Vol.I Chapter VI.).

The act of Fecundation consists in the union of a sperm - nucleus from the male, and an egg - nucleus from the female to form the cleavage nucleus of the fertilised egg; the nucleus of the fertilised egg being designated cleavage - nucleus by Oscar Hertwig 1875. At one time Oscar Hertwig believed that the egg nucleus descended from the germinative vesicle and in fact from the nucleolus of the vesicle.

Auerbach in 1874 showed that in the egg of Ascaris two nuclei may be seen shortly after the spermatozoa reach the egg and that these two nuclei fuse. In 1875 Oscar Hertwig stated from observation on eggs of Echini that one of the nuclei seen by/

by Auerbach is the head of the spermatozoon, the other is part of the nucleus or germinal vesicle of the egg. In 1875 Van Beneden saw the fusion of two nuclei or pronuclei, as he named them, in the ovum of the rabbit as a result of fertilisation, one of these pronuclei he found arose from the egg - nucleus- not from the nucleolus as Hertrig supposed, - the other or male pronucleus, Van Beneden recognised as in some way connected with the spermatozoon, though he failed to trace it directly to the head as Hertwig did in the Sea-urchins.

Experiments have shown that the spermatozoon exercises an influence upon the ovum as it approaches (action à distance), the latter shows upon the surface of its superficial hyaline layer a small protuberance(cone d'attraction) is in the direction of the advancing spermatozoon which is withdrawn after contact.

This phenomenon Hertwig calls Sexual affinity and defines it as the reciprocal influences which are exercised by cells of related species requiring fertilisation upon each other. The explanation which he suggests, in lieu of Nagelies one of electrical forces, is that the phenomena in general are due to the reciprocal action of two somewhat differently organised protoplasmic bodies; because he states "nature has brought the principle of division of /

of labour to bear upon the act of fertilisation. The male cell has been made active and fertilising capable of searching out the large mon-motile, female cell which while developing in the ovary has stored up yolk material."

Fertilisation being a fusion of equivalent nuclear substances derived from two cells, but it is not a combination of sexual opposites for the differences depend solely upon structures of subsidiary importance (Hertwig on the Cell).

Weismann (Germ-plasm p.232.) understands by fertilisation an arrangement which renders possible the intermingling of two different hereditary tendencies - the two germ-plasms fusing and as a rule accompanied with the fusion of two cell bodies and this process he calls Amphimixis which in all multicellular organisms is always connected with reproduction. "The process of fertilisation therefore, consists in the union of the nuclei of the two sexual cells within the maternal germ-cell, and also of the bodies of the cells, together with their apparatus for division."

After the extrusion of the polar bodies the egg - centrosome disappears and the ovum thus loses the power of division. During fertilisation the spermatozoon introduces a new centrosome, and the power of division is thus restored to the ovum.

In/

In the parthenogenetic ovum the egg-centrosome persists and the egg has the property of dividing without fertilisation. Wilson argues that the disappearance of the egg-centrosome would seem to be in some manner a provision to necessitate fertilisation and thus to guard against parthenogenesis. The segmentation nucleus contains chromatin fibres derived from the male and female and it is therefore, a composite or hermaphrodite nucleus. (Professor Sir William Turner, Cell Theory Past and Present.)

By segmentation there is produced in higher animals the germinal membrane or blastoderm (protembryo of lower forms) and by further developmental process, epiblast, hypoblast and mesoblast are ultimately formed, from which three layers all the organs and tissues of the body are developed.

Van Beneden and Boveri proved that the paternal and maternal nuclear substances are equally distributed to each of the first two cells and more recent investigation would tend to show that they are equally distributed in the subsequent divisions, therefore it is possible that every cell of the body contains in its nucleus chromatin derived from both parents which would convey properties as well as structure (Professor Sir W. Turner, Cell Theory Past and Present.)

"There can now" says Weismann, Germ-plasm, p.23, "be/

"be no longer any doubt that the view which has been held for years by Strasburger and myself is the correct one, according to which the nuclei of the male and those of the female germ-cells are essentially similar i.e. in any given species they contain the same specific hereditary substance."

The two germ nuclei which by their union give rise to that of the fertilised ovum were shown by Van Beneden to be of exactly the same morphological nature since each gives rise to chromosomes of the same number, form and size. While Roux pointed out that the object of Mitosis seems to be to secure the accurate division of the nuclear material in all its parts, while division of the cytoplasm is a mass division, while lastly, the researches as to maturation show that elaborate processes prepare the germ nuclei for their approaching union by making them equivalent, the cytoplasm becoming different in the two germ cells. The inference therefore, is clear that the part of the nucleus which more especially is concerned with heredity is the "chromosomes" which fibres splitting longditudinally into similar halves are distributed equally to the daughter cells - "so that whatever be the properties of the chromosomesof the mother-cell they are distributed almost equally between the nuclei of the two daughter cells." (Professor Sir W. Turner, Cell Theory Past and Present.).

Weismann/

Weismann therefore, infers that the hereditary substance consists of different "qualities" and that the division is a qualitative as well as a quantitative one.

Hertwig gives the following reasons for regarding the nucleus as the transmitter of hereditary qualities.

1. The equivalence of the male and female hereditary masses.

2. The equal distribution of the multiplying hereditary mass among the cells derived from the fertilised ovum.

3. The prevention of the summation of the hereditary masses. This he believes to be a most important point. For in consequence of the nature of nuclear division each cell receives the same quantity of nuclear substance as the fertilised ovum. A, therefore when germ cells of the third generation conjugate, the product ought to contain four times as much as A, the nuclear mass thus increasing by geometrical progression. He does not accept Nageles view that summation is prevented by the strands of idioplasm becoming fused together in a peculiar manner so that the result remains as before, nor does he believe with Weismann that the summation is prevented by a process of reduction, it being halved before each act of fertilisation.

Hertring/

Hertring assumes that the nuclear mass is identical with the hereditary mass, and further that the idioblasts of paternal and maternal origin unite together in some manner to form a compound elemental germ and not a complicated piece of mosaic, composed of innumerable units "the ancestral plasms" which are indivisible, and he sees no difficulty in assuming the divisibility of the hereditary mass as a whole, even although it be composed of a number of idioblasts representing past ancestors. Consequently, he says "it is self-evident that a reduction of mass without the essential nature of the idioplasm being altered is possible in the same manner as has been observed in the maturation of the sexual products and therefore any further complicated hypothesis are unnecessary and in this theory of Hertwig's he explains the phenomena of reversion to an ancestral type by assuming that the elemental germs may themselves remain latent.

Weismann (Foundation of a Theory of Heredity. Essays on Heredity Vol.I.) believes that the nucleoplasm in the fertilised ovum contains the nucleoplasm of all past generations - the nucleoplasm of father or mother constitute one half the nucleus of a fertilised ovum, that of a grandparent $\frac{1}{4}$th and that of the tenth generation backward $\frac{1}{1024}$ th.

Oscar Hertwig's last reason is the isotropism of/

of the egg. From the results of his own and his brother's experiments he puts forward the fundamental proposition that the egg-nucleus which may be enclosed in any part of the yolk is able to produce a complete organism.

The Dual Nature of Inheritance is therefore abundantly proved and Professor E. B. Wilson in his book "The Cell in Development and Inheritance" p.170 says"From the mother comes in the main the cytoplasm of the embryonic body which is the principal substratum of growth and differentiation. From both parents comes the hereditary basis or chromatin by which these processes are controlled and from which they receive the specific stamp of the race. From the father comes the centrosome to organise the machinery of mitotic division and by which each of these elements receive its quota of the common parentage of chromatin." The observation of Huxley in Encyclopaedia Brittanica, Art.I."Evolution" made in 1878 has thus been confirmed. "It is conceivable and indeed probable, that every part of the adult contains molecules derived both from the male and from the female parent; and that regarded as a mass of molecules, the entire organism may be compared to a web of which the warp is derived from the female and the woof from the male." "What has since been gained" Professor Wilson says "is the/

the knowledge that this web is to be sought in the chromatic substance of the nuclei; and that the centrosome is the weaver at the loom."

Professor J. Arthur Thompson in a Lecture on "The Facts of Inheritance" Royal Institution of Great Britain, 30th March 1900, remarks that "If Loëb is able to induce artificial parthenogenesis in sea-urchins' eggs exposed for a couple of hours to sea-water to which some magnesium chloride has been added; if Edelage is able to fertilise and to rear normal larvae from non-nucleated ovum fragments of sea-urchin, worm and molluse, we should be chary in committing ourselves definitely to the conclusion that the nuclei are the exclusive bearers of the hereditary qualities, or that both must be present in all cases. Furthermore, the fact that an ovum without any sperm - nucleus can develop into a normal larva, points to the otherwise probable conclusion that each germ-cell, whether ovum or spermatozoa, bears a complete equipment of hereditary qualities."

Galton's law of Ancestral Heredity recognises the part influence of the grandparents as well as the parents.

According to this law "the two parents between them contribute <u>on the average</u> one-half of each inherited faculty, each of them contributing one-

quarter of it. The four grandparents contribute between them one-quarter or each of them one sixteenth, and go on, the sum of the series $\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+$ etc; being equal to 1, as it should be.

It is a property of this infinite series that each term is equal to the sum of all those that follow; thus $\frac{1}{2} = \frac{1}{4} + \frac{1}{8} + \frac{1}{16} +$ etc; $\frac{1}{4} = \frac{1}{8} + \frac{1}{16} +$ etc. and so on. The prepotencies or subpotencies of particular ancestors, in any given pedigree are eliminated by a law that deals only with <u>average</u> contributions, and the varying prepotencies of sex in respect to different qualities are also presumably eliminated." (Natural Inheritance,) Professor Ewart, Page XXII, General Introduction.) Penycuik Experiments Penycuik's Experiments referring to this law observes

"It is however, conceivable that owing to what for want of a better name may be called "Antagonism" between the protoplasmic units during fertilisation and development the grand-parents or even the great grand-parents might contribute more than the immediate parents and that when the "antagonism" is still more pronounced the comparatively remote ancestors might become the main contributors."

Roux's theory of intra-cellular selection in which he argues that natural selection applies also to every unit within the body supports the views of/

of Professor Ewart.

This question is of considerable interest to the clinician and Dr Clouston in the Neuroses of Development puts the views which seem to be sound both in theory and fact in a very clear manner.

"The philosophic and protoplasmic views of the individual as being organically one in structure and functions with his ancestry and his posterity must always be kept in mind. They are not even links in a chain; links are separate from each other and may have been forged from different pieces of iron, they are only one in function, whereas a man is just as much a part of his ancestry and his posterity of him as the root and stem are parts of one tree."

Haekel states (Evolution of Man P.155.) that Ontogeny or the Evolution of the Individual Man is the blending and co-operation of the following organic functions:

1. Growth,
2. Nutrition,
3. Adaptation,
4. Reproduction,
5. Heredity,
6. Division of labour or specialisation,
7. Atavism,
8. Coalescence.

Heredity/

Heredity, therefore, is linked with several other organic processes especially with Reproduction of which Haeckel says it is a necessary phenomenon. Division of labour, simple in the lower animals has necessarily become extremely complex in the higher forms. Hertwig, in his embryology of Man and Mammals, p.83 remarks -

"In the lowest multicellular organisms each of the individual parts discharges in the same manner as the others the ennumerated functions necessary for organic life; but the more highly an organism is developed the more do we see that its individual cells differentiate themselves for the duties of life - that some assume the function of nutrition, others that of sensibility and still others that of reproduction- and that with this division of labour is likewise joined a greater degree of completeness in the execution of the individual functions. The development of a specialised duty likewise leads invariably to an altered appearance of the cell, with the physiological division of labour there always goes hand-in-hand a morphological or histological differentration."

Haeckel observes that "This differentration of the cells originally arose in tribal history afterwards it appears in the germ history and by that time it has been made over to Heredity, and is merely repeated/

repeated in accordance with the fundamental law of Biogeny. While in the Evolution of Species under t the influence of the Struggle for Existence, Heredity and Adaptation enter into most intimate reciprocal relations and there thus necessarily arise new forms or variations which are of advantage to the organism. Heredity is responsible for the internal correspondence from ancestral forms, Adaptation producing External dissimilarity."

Darwin in the "Origin of Species" Chapter I, states that "The laws governing inheritance are for the most part unknown." But he goes on to state some rules one of which will have to be noticed here. I will give his own words, "A much more important rule, which I think may be trusted, is that, at whatever period of life a peculiarity first appears, it tends to reappear in the offspring at a corresponding age, though sometimes earlier. In many cases this could not be otherwise; thus the inherited peculiarities in the horns of cattle could appear only in the offspring when nearly mature; peculiarities in the silk-worm are known to appear at the corresponding caterpillar or cocoon stage. But hereditary diseases and some other facts make me believe that the rule has a wider eextension, and that when there is no apparent reason why a peculiarity should appear at a particular age, yet that/

that it does ~~not~~ tend to appear in the offspring at the same period at which it first appeared in the parent. I believe this rule to be of the highest importance in explaining the laws of embryology."

Van Baer showed that dividing the animal kingdom into four groups viz Vertebtata, Arthropoda, Mollusca, Lower animals, each group had a different course of Evolution, identical in every animal of the same type, but different in those of different types.

Van Baer's law is founded on this fact, and is as follows,

"The Evolution of an individual of a certain animal form is determined by two conditions: firstly, a continuous perfection of the animal body by means of an increasing histological and morphological differentrations, or an increasing number and diversity of tissues and organic forms, secondly, and at the same time, by the continual transition from a more general form of the type to one more specific."

Haeckel's fundamental Biogenic law to which reference has been made in a quotation above, is based upon a study of Embryology, Morphology and Palaeontology , and is briefly, "The ontogenesis of any given living organism is a short, condensed recapitulation of its ancestral history or of its phylogenesis." This is also known as the recapitulation/

tulation Hypothesis and is stated thus by Marshall Address on "Modern Study of Zoology" 1879-1880, Owens College, "the development of the individual is an epitome of the development of the species, that is the actual changes through which an animal passes in its development from the egg to the adult represent in a condensed form its genealogical history or pedigree."

Haeckel in his Lecture "The East Link" traces the ancestral chain of man on this principle from the Monera or a simple granule of protoplasm not yet a cell, but a cytode or cell without a nucleus, through many forms till he reaches the highest.

Professor Ray Lankester, in an article on Degeneration (The Advancement of Science, Occasional Essays and Addresses, 1890) remarks "There is very strong reason to believe that it is a general law of transmission or inheritance that structural characteristics appear in the growth of a young organism in the order in which these characteristics have been acquired by its ancestors.

"Accordingly the phases of development or growth of the young are a brief recpaitulation of the phases of forms through which the ancestors of the young creature have passed. In some animals this recapitulation is more in others it is less complete. Sometimes the changes are hurried through and disguised/

disguised, but we find here and there in these histories of growth from the egg most valuable assistance in the attempt to reconstruct the genealogical tree."

Fritz-Muller was the first to draw attention to this latter observation, viz. that the ontogeny of an animal is not always a simple, abreviated record of its phylogeny, but that it is altered and thus obscured by two tendencies, firstly, the tendency to shorten the processes of development and thus omit stages which may be of great historical significance, and secondly, the tendency of the struggle for existence to modify the ontogenetic history, as it modifies the history of the adult. "Modern study of Zoology.", Marshall.

Professor Ewart says "There is in fact in the seven weeks embryo (horse) not a little in favour of the view that all individuals climb their own ancestral tree - that there is a more or less accurate recapitulation by each individual of the entire ancestral tree. That there is not an exact, or anything approaching an exact, recapitulation, a glance at the seven weeks embryo will at once show. The remote ancestors had five complete digits, but even in the seven weeks' horse there is no external indication of more than a single digit for each foot. At or about the end of the seventh week the remote Marserpial ancestors of the horse were, in all probability/

ability, in the habit of leaving the uterus for the shelter of the pouch or marsupium, already capable of imbibing uterine milk from teats, instead of absorbing uterine milk by means of a yolk sac. The seven weeks embryo horse, which is nearly half an inch larger than the six weeks one, is at a most interesting stage in its development. Had it been an opossum, it would have already been glued to a teat in the marsupium - not yet able to suck, but sufficiently advanced to admit of milk being pumped from the mammary glands into its gullet. The open mouth and well formed lips and tongue seem to indicate that it is quite ready (should a hugh reversion or throw-back take place) to receive and hold on to a teat. There is no doubt the remote ancestors of the horse were born ere this stage was reached. If the rate of progress was the same in the remote past as it is now, the birth would originally occur on the forty-seventh or forty-eighth day. The head is less flexed than at six weeks, and the nose, eyes and ears are better formed and that it is beyond doubt a mammalian embryo is proved by the presence of rudiments of hair on the snout and eyelids. But any embryologist would not only at once place this embryo in the mammal group, he would have no hesitation in asserting it belonged to the horse-"family". "A critical period in the Development of the Horse" p.14.

In the President's address to the Biological Section/

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Section of British Association, Leeds 1890, Professor Milne Marshall makes the following observations,

"Natural selection explains the preservation of useful variations, but will not account for the formation and perpetuation of useless organs; and rudiments would be unintelligible but for recapitulation, which solves the problem at once, showing that these organs though now useless must have been of functional value to the ancestors of their present possessors, and that their appearance, in the ontogeny of existing forms, is due to repetition of ancestral characters. Such rudimentary organs, as Darwin pointed out, are of larger relative size in the embryo than in the adult because the embryo represents the stage in the pedigree in which they were functionally active. Man himself affords numerous and excellent examples of rudiments unintelligible but for their past history as are the the gill clefts, functional in fishes and tadpoles - and are present though useless in embryos of all higher vertrebrates which in their early stages, the hare and the tortoise alike possess and which are shared with them by cats and kings."

Haeckel observes that not only progressive but retrograde changes take place in consequence of Division of labour. During the evolution of the human and other embryos, fatty degeneration destroys whole/

whole organs and structures which were of importance in the ancestors. Rudimentary organs are arrested although traces of them remain in various stages of development.

Darwin (Origin of Species, Chap.I) and in "The variation of Animals and Plants under Domestication" Vol.II, p.280. ~~XXXXIX~~ endeavours to show that such results might be produced by the inherited effects of use and disuse, changed habits producing an inherited effect.

Romanes ("Darwin and after Darwin") believes that the same results would be brought about by the cessation of selection (which is the same thing as the Panmixia of Weismann) in the case of our domesticated animals, combined with an active reversion of selection in the case of Natural species.

The theory of Panmixia (Weismann), Cessation of Selection (Romanes), Regression to Mediocrity (Galton) has thus been put forward in place of the theory of use-inheritance. Romanes gives his views thus, "If cessation of selection alone is capable of reducing an organ through ten or twelve per cent of its original size nearly all the direct evidence on which Darwin relied in favour of use-inheritance is destroyed. On the other hand, if reduction through five per cent be deemed a "very liberal estimate" of what this principle can accomplish the whole body of/

of Darwin's direct evidence remains as he left it. I have now given my reasons for rejecting this lower estimate on the one hand, and what seems to me the extravagant estimate of Weismann on the other. But my own intermediate estimate is enough to destroy the apparent proof of use-inheritance that was given by Darwin."

These and the following observations modify or augment Darwin's work although the fundamental postulates remain practically the same. Thus Romanes believes with Darwin that natural selection has been the main but not the exclusive means of modification. He maintains that "without isolation in the prevention of free intercrossing organic Evolution is in no case possible. Therefore it is Isolation that has been the exclusive means of Modification, or more correctly the universal condition to it. "Therefore" he says "Heredity and Variability being given the whole theory of Organic Evolution becomes a theory of the causes and conditions which lead to Isolatin." By Isolation he means exactly what Mr Gallick does by Segregation and approximately what Professor Weismann does by "Amixia" that is the prevention of Intercrossing.

Professor Ewart believes that Prepotency has been a means of Modification. He says, p.XLIII General Introduction "Penicuik Experiments" I believe interbreeding/

interbreeding is common among wild animals and that by inducing Prepotency, it plays an important part in the Origin of Species. Hitherto the explanation of one variety persisting while others equally fit in every way vanished has sometimes been that the members of the more fortunate variety while fertile with each other were sterile, or at least less fertile, with other varieties and with the parent species. It is, of course, conceivable that some sports are sterile except amongst themselves, just as some sports are prepotent but satisfactory evidence of this is still wanting. The explanation which prepotency affords does away with the need of sterility and it does away with the need of rigid Isolation, with natural barriers or fences, because the prepotent forms have so much "character" that however mated some of the offspring inherit their own structural and other peculiarities."

"Any animal, male or female, which strongly impresses its own peculiarities of form, colour, dispositions, etc. on its offspring is prepotent, while animals that are the offspring of more or less intimately related parents are interbred ..... Prepotency when associated with useful characters is highly beneficial, while inbreeding is often a doubtful heritage.

"It may be taken for granted that interbreeding

(1)/

(1) induces prepotency by fixing the characters of the particular variety selected; (2) in as far as it prevents or at least limits intercrossing it diminishes the chance of reversion on the one hand and restricts the range of variation on the other, thus tending to maintain undiluted the distinctive characters of the type. But it must be added in-breeding while keeping the "blood" pure tends to weaken it by diminishing the vitality of the breed. Prepotency on the other hand, however, acquired alike in nature, on the farm, or in the dovecote, tends to arrest or neutralise the swamping effects of intercrossing. Some breeders say that they can produce a horse so prepotent, so fixed by inter-breeding (inbreeding) that it will produce its like however mated."

Prepotency refers to the fact that in the development of a character, the paternal or the maternal qualities may predominate, as in unequal blending where there is relative prepotency or in exclusive inheritance where the prepotency in respect to a given character is absolute. What we have to do with is the fact that in respect to certain characters the paternal inheritance seems more potent than the maternal or <u>vice versa</u>.

Karl Pearson "Variation in Man and Women" says that "The Statistics of Structure seem to shew that both sons and daughters take sensibly more after their fathers/

fathers than after their mothers, but that daughters inherit less from their parents than sons, on the other hand, mediocre fathers have more frequently sons, and exceptional fathers, daughters; a result making the ultimate variability of the two sexes very nearly the same."

"As inbreeding may be frequent in nature especially among gregarious and isolated groups and as it tends to develop prepotency, we are able to understand better how new variations may have been fixed in the course of evolution. And we can better understand the position maintained by Reibmayer that the evolution of a human race implies alternating periods of dominant breeding and dorminant cross-breeding.

The inbreeding gives fixity to character, the cross-breeding arrests degeneracy and stimulates new variations which form the raw material of progress." "Facts of Inheritance, Professor J . A. Thompson.

Professor Karl Pearson endeavours to prove "That the true measure of heredity is the numerical correlation between some characteristic or organ as it occurs respectively in parent and offspring."

"If" he says "there be any sensible correlation between fertility and the size of any organ or intensity of any characteristic in male or female - that is/

is, if deviations in excess(or defect) from the mean of this organ correspond to a greater fertility than deviations in defect (or excess) - then under the action of heredity we have a vera causa of progressive evolution in this organ, for an increasing number of individuals will be born with the organ in excess (or defect), and consequently the mean, and most probably the variation about the mean, of the general population will be progressively modified." He states that the result is somewhat similar to that due to artificial selection in domestic animals and this factor he calls, Reproductive Selection. "Chances of Death", Vol.I, p.66.

His statistics lead him to the opposite conclusion to that of Darwin, the latter believing that male animals are more variable than females, the former maintains that there is a slight preponderating variation in the female and that this is mainly due to a relatively less severe struggle for existence. "Chances of Death", Vol.I. p.374.

Max Schultze attributes the principle of division of labour amongst cells to the formative activity of the cell, that is the power of the protoplasmic body to create different structures from the raw material brought to it, and it is by this power that the animal body attains its degree of perfection.

Häckel has shown the cause of cell division among/

among Protozoa. The cell increases in size, the superficial portion now being too small for the internal growth and so it either divides or ceases to grow. "Häckel" says Weismann "was probably the first to describe reproduction as an overgrowth of the individual, and he attempted to explain heredity as a simple continuity of growth" "Essays upon Heredity and Kindred Biological Subjects", authorised translation, Oxford 1889. Weismann thinks that a proper conception of this principle will lead to an explanation of heredity. It is easy to understand heredity in uni-cellular organisms, he says, but in multi-cellular organisms where the whole body of the parent does not pass into the offspring, the power of reproduction is connected with certain cells - germ cells which have no significance for the preservation of the life of the body but they alone possess the power of preserving the species.

Boy-Teissier in a very suggestive article "Old Age", Vol.XII, Twentieth Century Practice p.433, attributes to the pouvoir d'amorce a very important role in the explanation of vital phenomena.

The essential character of living matter, he argues is instability. "The presence of some particle of living matter is necessary to stimulate the formation of new matter; and it is the resultant of the actions excited by this particle on the surrounding/

rounding medium which alone has determined the process of integration of the elements contained in this medium in order to form a new particle of living matter. This role of attraction of surrounding elements which the particle of living matterplays is according to Sabatier a most important one in the existence of living matter, and he says that protoplasm plays it of necessity. This is to endow protoplasm with an intrinsic property which is "the characteristic of living matter since in the absence of this action protoplasm could not find for its growth or repair a ready - formed protoplasm which it would only be necessary to appropriate."

He applies this principle to explain many normal phases of existence from conception to the process of senile decay.

In the metazoa the cells which are differentiated very markedly and from the various tissues die; the explanation being that they have diminished power of attraction, the vital energies being at their maximum; but little by little differentiation becomes manifest and consequently there is diminished functional activities, a part of the embryo being already specialised in the blasto-dermic layers. This specialisation, he says, is definitive, since each layer presides over the constitution of certain parts of the body. This, therefore, would be the first step towards senesence, because as soon as a differentiation and specialisation has been effected there/

there is produced a diminution of the power of attraction ; however, the vital activities are still very great, but as soon as cells have developed which have restricted functions, nerve cells, muscle cells, etc, then the power of attraction is limited so that it cannot produce the reconstruction of the cell - if any injury happens to such a cell it becomes destroyed and cannot restore itself , connective tissue being formed in its place.

Quite independently of the above observer, Professor Adami has elaborated a theory somewhat similar. "On growth and overgrowth and on the relationship between Cells Differentiation and Proliferative Capacity; its Bearing upon the Regeneration of Tissues and the Development of Tumors." I.G.Adami, M.D. F.R.S.E, "Jacobi Festschrift."

He insists that there is a very broad biological law underlying the process of the growth of tissues, and that this law may be applied to pathological processes.

The various tissues of the fully formed adult are derived from a single undifferentiated cell, the fertilised ovum, the resultant of two component parts, ovum and spermatozum, each of which again have been derived from undifferentiated cells.

From a very early period in the process of development of the embryo, certain cells alone appear to be/

be actively dividing and proliferative, while other cells, the products of these, take on characteristic appearances and do not divide. So that very early in the embryo the existence of "mother cells„ can be recognised, that is cells which themselves remaining embryonic in type give rise to other cells which assume more highly differentiated characters.

In the fully formed individual, the specific cells of the tissues, that is the highly differentiated and characteristic cells of those tissues, do not give rise to other specific cells, but in each tissue the mother cells have the power of proliferating and the daughter cells assume specific properties - if in some instances the active cells of certain not very highly differentiated tissues themselves proliferate, they only do this after a preliminary reversion to a mother cell, or more embryonic type. After giving examples illustrative of the above argument, he proceeds,

"Thus from a study of the process of regeneration as seen in the different tissues in man and vertebrates generally, it is possible to lay down the following laws:

1. The fully differentiated cells of a tissue proper never arise from cells that are themselves fully differentiated.

2. Under the normal conditions of growth and during/

during physiological regeneration, the fully differentiated cells would seem in nearly every case to be developed from "mother cells" - undifferentiated or but partially differentiated cells, which themselves throughout the term of life of the individual never attain to the full differentiation peculiar to the tissue to which they belong, and which indeed they produce. For these mother cells by division give origin to the daughter cells xxxxx)and it is the daughter cells which attain full differentiation and form the specific cells of the tissue. More rarely the functional cells themselves, by reversion to a more embryonic type, take on the properties of mother cells.

3. Under abnormal conditions, the fully differentiated functioning cells of certain tissues are capable of proliferation and giving rise to cells of like nature, but this is only after a preliminary reversion to a simpler, more embryonic type. The fully differentiated cell as such is incapable of proliferation.

4. Or otherwise, the energy stored up in the cell may be expended in one of two directions, but not in both - either in functional activity or in preparation for proliferation and the structure of a cell being the expression of the activity of that cell, the expenditure of energy in either direction is attended by corresponding morphological or structural/

structural differences in the cell.

5. The more highly differentiated a cell, the more highly elaborated its structure, the less ease with which it resists and the less the liability to reversion to a simpler reproductive form; the simplier the cell, the greater the ease and the greater the liability to such reversion. It is thus possible to conceive at the one extreme, cells so simple in function and in structure that functional or reproductive activity may be called into play indifferently without recognisable preliminary structural alteration and at the other cells so highly differentiated that the capacity for proliferation has become entirely lost."

Professor Adami still further elaborates his argument so as to apply to tumour growth. If the above principle be true the converse, he holds, will likewise be correct, that is - "that the more the daughter cells in a given tissue retain the characteristics of the mother-cells in a given tissue the greater their proliferative capacity" or " if through any cause the daughter cells in a tissue do not attain full specific differentiation then, they are peculiarly liable to proliferate and function not as specific cells but as mother-cells, and further as Bizzozero has pointed out, tissues in which the cellular elements exhibit frequent mitosis are/

are those which more especially are liable to be the seat of excessive growth and tumour formation."

This, he urges, is an important principle in the formation of the blastomata, not forgetting, of course, that some stimuli, either temporarily or permanently are in action leading to neoplastic growth. These stimuli Adami does not consider in his article but by his theory "at least we gain a comprehension of why in the first place histoid tumors (in which one or other tissue is more or less faithfully reproduced) are essentially benign; and, in the second place, why malignancy and excessive cell proliferation (which is the essence of malignancy) go hand-in-hand with tumor formation of a pronounced embryonic type."

In Lectures on Surgical Pathology, James Paget, F.R.S., 1870, p.791, we find the following remarks.

"First it is evident that a disposition to cancer may be derived by inheritance; that something may be transmitted from the parent to the offspring which shall ultimately produce both the cancerous condition of the blood, and in some instances the locality apt for the cancerous growth.

In 322 cancerous patients there were seventy eight or very nearly one fourth who were aware of cancer in other members of their families.

But the influence of inheritance in the production/

tion of cancer must be much greater than it will appear in many tables. Many cases of cancer of internal organs are overlooked, many are forgotten after a generation; many persons in whom cancer would be manifested late in life die before its appearance, but not before transmitting the tendency to their offspring. Every year's experience in practice among persons whose family histories are known makes me more sure that inheritance is the great power in the production of all diseases that are not of distinctly external origin and among these are cancer.

Our expression then may be that in the impregnated germ from a cancerous parent one or more of the materials normal as they may seem are already so far from the perfectly normal state, that after the lapse of years, by their development or degeneration they will engender or constitute the cancerous material in the blood, and it may be the locality apt for a cancerous growth.

But now let it be observed, the tendency to cancerous disease is most commonly derived from a parent who is not yet manifestly cancerous, for most commonly the children are born and sometimes even become cancerous and die before cancer is evident in the parent; so that as we may say that which is still future to the parent, is transmitted potentially to the offspring, may more; the tendency

which/

which exists in the parent may never become in him or her effective although it may become effective in th the offspring, for there are cases in which a grandparent has been cancerous and although his other children have not been so, the grandchildren have been."

Heredity is thus a determining ingluence not only of the cancerous growth but in some instances of the locality and may be regarded as one of the stimuli of a permanent character which Adami says we know lead to neoplastic growth.

Sexual affinity has already been referred to and Oscar Hertring states that the degree of relationship between the two cells may vary considerably, and may be ranged under three heads, viz,

1. Inbreeding.
2. Normal Fertilisation.
3. Hybridisation.

He believes that when a relationship of the reproductive cells is either too near or too distant sexual affinity is either lessened or entirely done away with, therefore we may state, he says, as a general rule that a moderate degree of relationship which is more or less distant according to the species is the one most likely to render fertilisation possible.

In/

In "Penycuik Experiments", p.p. 128-129, we find Professor Ewart's views. "We often use the phrase "like produces like" but we often fail to realise that to give the offspring a chance of being like the parents, the parents or their grandparents must be like each other. It seems to me that as a rule progress in any given direction, that is progressive development will only be possible when the parents closely agree with each other in their physical and mental peculiarities. They are, of course, likely to agree when closely related by birth if their ancestors have been interbred for several generations: but they may also agree in all essential points when distantly related, or when belonging to quite different strains.

The opposite of mating closely related forms is the crossing of distinct breeds (intercrossing).

Intercrossing tends to arrest development in any given direction, to prevent the formation of new types or varieties and hence unlike imbreeding it may be considered retrogressive in its tendency and at the same time uncertain in its results.

If the intercrossing of varieties in the same area arrests the formation of new species, is non-progressive, if not actually retrogressive, the crossing of distinct species from, it may be widely separated areas will a prioir not only arrest progressive/

gressive development - abruptly put an end to the progress the respective species were making in various directions - but actually lead to retrogressive changes, in other words to reversion. If two inbred fantails which present almost identical characters are mated, the offspring will in all probability agree closely with the parents, they may even show some advance in the direction desired by the fancier - in, say, the characteristic attitude, or in the number of feathers in the tail. If, however, one of these fantails is afterwards mated with, say, a blue povter, the young, instead of being intermediate between a fantail and a povter may closely resemble the wild rock-pigeon, may in fact, have reverted towards the remote ancestor. This would simply be an exaggerated example of the swamping effects of intercrossing. If, therefore, the result of crossing extreme forms is under ordinary circumstances accompanied with retrogressive changes, I fail to see how the difference in the marking of Romulus from those of his sire could be considered as due to abrupt or discontinuous variation."
And in the General Introduction, p.XLIV.

"Nature only tolerates imbreeding up to a certain point for while it may assist in perpetuating useful characters by inducing prepotency, it often does this at the expense of vitality - it may be of fertility as well. It is conceivable that imbreeding has played/

played an important part in the extinction of species - it has undoubted ly been the means of deteriorating if not actually destroying many of the breeds and varieties artificially produced."

Consanguine marriages even among the healthy have been alleged to be the cause of disease among the offsprings, the degree of relationship being responsible. Trousseau believed that such marriages were a frequent cause of deafness among the children.

In Deaf-Mutism, Dr I.K. Love, and W.H. Addison, 1896, state that "amongst consanguineous unions congenital deafness is from two to three times commoner than when parents are not related."

Other diseases have been traced to consanguinity such as idiocy, epilepsy and imbecility.

The percentage of children born idiotic or imbecile by marriages among first cousins has been given as

4·38 per cent (Langdon Down), 2 per cent (Grabham), 3·4 per cent (Ireland).

"Others again assert that, though the marriage of blood relations may intensify hereditary tendency, it does not create it in a healthy pair." Mental Affections of Children, W.W. Ireland M.D. 1898.

Mr Alfred Huth in Medical Press and Circular, February 27, 1889, insists that reliable facts disprove/

disprove the prevalent belief as to the infecundity and physical degeneration produced by such unions, and refers to the enforced consanguinity in marriage in isolated districts, where no physical degeneration is manifested.

The results of the investigations of the Committee appointed by the New York State Medical Society and published in the American Journal of Insanity 1869-70 show that if the family be free from degeneracy marriage among its members in noway diminishes the chances of healthy offspring.

M. de Quatrefages Rapport sur les Progrèsde l' Anthropologic p.461 states that if the parents be sound consanguinity will tend to preserve perfect health in the offspring; but if the balance be disturbed among such closely related families the chances are that the disturbance will be similar in both father and mother, therefore the offspring of such a marriage will be degenerate. The two views are thus reconciled.

This is Mercier's Second Law of Heredity - the Law of Sanguinity, and he states it thus -

"There are certain limits, on the one hand of similarity, and on the other of dissimilarity, between two individuals, between which limits only can the union of these individuals be fertile; and in proportion as these limits are approached, the offspring/

offspring deteriorates."

"When the imbreeding is pushed sufficiently far, the deterioration of the offspring is certain, and the ultimate extinction of the race inevitable." Sanity and Insanity, Charles Mercier M.B., Chap.VI.

Darwin, "Origin of Species", Chap.IV. says, "I have collected so large a body of facts and made so many experiments, showing, in accordance with the almost universal belief of breeders, that with animals and plants a cross between different varieties, or between individuals of the same variety, but of another strain, gives vigour and fertility to the offspring; and on the other hand, that close interbreeding diminishes vigour and fertility; that these facts alone incline me to believe that it is a general law of nature that no organic being fertilises itself for a perpetuity of generations; but that a cross with another individual is occasionally- perhaps at long intervals of time - indispensible."

In the guide to Zebra Hybrids 1900, Professor Ewart summarises some of the results he has obtained thus; "Many take for granted that in their characters offspring are intermediate between their parents, while others, following Mr Galton, assume that the offspring take about equally after their immediate and remote ancestors - the further removed ancestors counting/

counting the least. Since Darwin recognised that the crossing of distinct breeds led or appeared to lead to reversion, i.e. to the reappearance in the offspring of ancestral traits, it has been assumed by many that intercrossing is invariably accompanied by reversion or atavism, while others have sought to maintain that there is no such thing as reversion.

I find, as the result of many experiments, that in animals, as in plants, the offspring can rarely be said to be intermediate between their parents, or to unite in equal proportions the characters of their immediate and less immediate ancestors, and further, that the crossing of perfectly distinct strains, varieties or breeds, is not necessarily followed by reversion.

The offspring or some of them, may (1) down to the smallest details resemble one of the parents - sometimes the male, sometimes the female; or (2) that they may reproduce both the mental and physical peculiarities of one of the grandparents, or of even a fairly remote ancestor; or (3), they may consist of an unequal mixture of two or more breeds, and well deserve to be designated mongrels; or (4) they may combine the more striking characters of two breeds; or (5) they may present quite new characters: when this happens they are often termed "sports." p.p.25-26, Cases of Reversion may be classified into three groups, Descent of Man, p.38-40.

1./

1. Rudimentary Organs: e.g. the human uterus when malformed owing to an arrest of development "appear to reproduce the analogous organs of lower classes of animals; for instance, the double uterus resembles in some degree the tubular oviduct of birds: it opens by two ora uteri into the vagina, or both the uteri and vaginae may be distinct.

The uterus bicollis exhibits two bodies with but one os uteri, and resembles the organ of some rodentia and carnivora.

Again, the junction of the cornua may take place higher up, constituting the uterus bicorporous; here the lowest part of the body of the uterus is single, and the upper double.

In the uterus biangularis the body of the womb is tolerably well-formed and terminating in cornua, as in the monkey tribes." Theory and Practice of Midwifery, Fleetwood Churchill M.D., 1855.

Darwin maintains that these results are produced by the Principle of Reversion by which a long lost structure is called back into existence.

These malformations are really due to persistent stages of arrested development, (D, Berry Hart, p.63, System of Gynaecology, Albutt and Playfair.)

W. Balls-Headly ibid p.113 observes that such abnormalities of the uterus are produced by defective heredity. The influence of this hereditary sexual feebleness/

feebleness is he affirms probably not immediate, "but it is a gradual declension, generally on the maternal side, tending by continuous degeneration to induce in the progeny feebler sexual formation, frequently in the uterus. Thus the first stage may be found in a woman of deficient sexual appetite, having a uterus of moderate development, but contracted at its opening, which may be lacerated in her first confinement, so perhaps as to prevent further conception: the child, cold-mannered, unsympathetic and egoistic, with a feebly developed uterus and disgust at marital rites, becomes pregnant only by chance - it may be long after marriage or after successful operation: or, with a congenitally contracted, though permeable upper vagina, closed hymen, or a tendency to the infantile pelvis with absence of sexual appetite, she becomes the mother of one child, who has a yet feebler unimpregnable uterus and atrophic ovaries, with deficient Catamenial discharge, and a premature menopause; a more marked abnormality may occur, and the woman be sterile. In the father hypospadias may exist, or some other state of deficient congenital urogenital formation. Such unions are often attributable to the inducements of money or position in marriage; in a simplier state of society they would be prevented by the competitive success of those physically more robust. This heredity/

dity may be rectified in the children if the feebly sexual woman become pregnant by a partner of exceptionally vigorous type, whereby the tendency to sexual deterioration may be neutralised."

2. Some parts which are rudimentary in men as the os coccyx in both sexes, and the mammae in the male, are always present. Supernumerary developments as of nipples are multiplications due to recurrence to an anterior type.

These supernumerary developments occur in three forms,

1. An additional nipple or nipples without a breast.

2. A breast without a nipple.

3. A more or less complete additional organ.

Diseases of Breast, W. Watson Cheyne, F.R.S. F.R.C.S. Treves System of Surgery, Vol.II.

The next common form is an accessory nipple without a breast, only in a few cases are complete accessory organs present.

Darwin thought that mammae eraticae occurring on the back, in the armpit, and on the thigh seriously weaken the probability that the additional mammae are due to reversion. On further consideration he came to the conclusion that mammae eraticae are atavistic because they usually occur symetrically on the breast.

Messrs/

Messrs Parker & Shaltock and later Bland Sutton have shown that in congenital talipes Equino-varus there is a reversion to the Simian type, the articular surfaces of the astragalus and the fibular malleolus retaining the characters normal in the ape.

3. Others such as the supracondyloid foramen only occasionally appear.

In the Lancet, 1873, Professor John Struthers records a case of hereditary Supra-condyloid Process in Man: the process could be felt in the arm of the father and of four of his seven children. In father in left arm distinctly felt, not felt in right arm; the children are five sons and two daughters. In eldest son, process very distinct in left arm, no trace on right; second son slightly marked on left, no trace on right arm; next three (first daughter, third son, and second daughter) no trace felt on either. Fourth son, process well developed on both arms, most in left. In youngest son (aet.15) process pretty well marked on left, no trace felt in right arm. Thus transmitted to four of the children, in three on same side as in the father, and more developed in same side (left) in the son in whom process present in both arms. No reason, says Professor Struthers, to doubt that supracondyloid process hereditary, like other varieties.

This is a return to a very ancient state of things/

things, says Darwin, because in the higher Quadrumana it is absent.

Congenital Cervical fistulae are more common, being remnants of organs highly developed in certain past ancestors. The former are equivalent to the gills or branchiae of Cartilaginous fishes, and the latter to the gill-cover or operculum - growing like the normal pinna from the edge of a branchial cleft and contain a portion of cartilage derived from the branchial bar. In man and mammals it is only the mandibular, hyoid and thyro-hyoid viseral arches in which cartilaginous bars are found, the fourth bar giving rise merely to soft tissues of the neck. The fistulae result from incomplete closure of branchial clefts, two, three and four which normally should completely disappear in the amniota at a period corresponding to the sixth or seventh week in the human embryo. When present they frequently communicate with the upper part of the oesophagus or lower part of the pharynx and are much drawn out by the cervical elongation.

"These fistulae and auricles usually affect many members of a family, the mother may possess cervical auricles, one child have a cervical fistula, whilst a third may have fistulae and auricles combined." Bland Sutton, Evolution and Disease.

Fistulae/

Fistulae of the neck may run through several generations, Bernard Pitts, Treves System of Surgery, Vol.VII,p.368.

Häckel, History of Creation, Vol.I. p.203 comprises the phenomena of Reversion under the law of "Interrupted or Latent Transmission by Inheritance", which he says might also be termed "Alternating transmission." This law occurs chiefly among lower plants and animals, the grandchildren being like the grandparents but quite unlike the parents. It occurs frequently, but in a less degree in human families. Thus alternation of generations - metagenesis - corresponds to this law, which is in a certain measure opposed to the first law mentioned by Häckel viz, the "Law of Uninterrupted or Continuous Transmission," or as it is sometimes expressed "Like tends to produce like." The descendants of any organism are never absolutely equal in all points but only similar in a greater or less degree.

"Differences exist among men not only superficially but also in the internal structure of the body" "Hence in the development of each individual a morphological specialisation occurs both in internal structure and external form by which distinctive characters are conferred, so that each man's structural individuality is an expression of the sum of the individual variations of all the constituent parts/

parts of his frame." Professor Sir Wm. Turner, address to the Anthropological Section of the British Association 1889.

Professor Ewart Penycuik Experiments, p.113 asks the question, "Have our horses descended from striped Ancestors?" and comes to the conclusion that they have, and that the stripes in those ancestors were arranged more after the plan in the common than in that of the Burchell Zebra.

In answering the question, does Reversion occur in the Equidae? Professor Ewart says "when due allowance is made for imbreeding in the respective dams, the conclusion seems inevitable that the remarkable differences between the hybrids and their immediate ancestors are due to reversion, either towards the less remote ancestors of the Zebras or horses, or towards the common ancestors of the recent Equidae" p.133.

Instances of Regression in Professor Ewart's experiments are

(1) In the case of the last Iceland foal which is an exact reproduction of the mother - this, says Professor Ewart, might be considered an example of prepotency, or regression to the mother's ancestors.

(2) In the Angora Rabbit, which is a restoration of the grandmother.

(3) In the Collie Dalmatian pups which are apparently/

apparently a reappearance of family remote ancestors.

(4). In the fantail-owl-archangel pigeon in which we have an almost complete reversion to the common ancestor of all the pigeons. (Columba livia - the wild blue rock pigeon.)

General Introduction, p. XLI, Professor Ewart remarks, "I think it must be admitted the pigeon and rabbit experiments go a long way towards proving the fact of reversion, and the more I comtemplate my Zebra hybrids, the more convinced I am that they are neither new creations in the strict sense of the term, nor yet intermediate forms; and if they are neither the one or the other, they must be more or less accurate restorations of their remote ancestors."

"In Sir John we have probably the nearest approach to the primeval horse that has ever been seen" while Aura represents the medieval horse, and Circus Girl has no Zebra taint about her, but is as far as colour goes a good representative of the ideal modern horse.

Note on Zebras and Equine Hybrids, 1900, p.p.10-11

"All such relapses" says Häckel "are to be brought under the law of interrupted or latent transmission, although the number of intervening generations may be enormous."

William Aitken, M.D. F.R.S., in his "Outlines of the Science and Practice of Medicine" makes some observations/

observations in Atavism and Disease which are worthy of attention.

"The transmission of the tendency to certain diseases from parent to children, is only part of the general fact of the influence of constitutional or anatomical peculiarities of parents on their offspring."

"Atavism is the name given to the occurrence of hereditary disease when it passes over one generation in a family history, without affecting any of its members, and then appears in the next generation."

"The tendency thus failing to appear in one generation, may lie dormant, and at last burst forth "in some collateral branch of the family tree"; thus proving that tendencies not obviously expressed by the parents may nevertheless be transmitted by him. A person therefore, cannot be considered free from the inheritance of constitutional maladies simply because his parents may not have suffered from any of them; and now it is admitted that, under three generations, the investigation of hereditary tendency is uncertain."

Gout is one of the diseases he states which "in some families attacks only alternate generations following the"law of Atavism."

Blandford (Insanity and its treatment; Lectures on/

on the Treatment, Medical and Legal, of Insane Patients, 1872)in Lecture VI. "Causes of Insanity" referring to Atavism states that although some one or more of the children may escape, yet others will show signs of insanity or other neuroses, and that if the descendants of these healthy children are affected, we may call it Atavism, but the disorder cannot be truly said to have missed a generation if uncles and aunts were affected.

"One expression of the atavic influence is seen in families saturated with insanity where the tendency is either to extinction, or to modify or throw off the taint by the admission into it of healthy blood. This latter process may take a long time owing the phenomena of reversion. A patient who has suffered from insanity or some other neurotic disorder may transmit this to his children, or some of them may escape but if they mate with wives who are not themselves of a stable nature, their children will in all probability show some form of nervous defect." (Mercier in Tukes Psychological Dictionary, p.588.)

Kiernan on the other hand, has shown that atavism at times tends to preserve the type and offsets the influence of degeneracy. This element of atavism underlies not merely the production of the sound scions of degenerate stock, but also those in whom/

whom the degeneracy affects the earlier and not the later acquirements of the race. Degeneracy, Its causes, signs and results, Eugene S. Talbot, M.D. 1898.

In Penycuik Experiments, General Introduction, p.XXIX, we find the following, "That highly bred, not very fertile, delicately nurtured parents, with weak constitutions, should sometimes give rise to vigorous, prolific, hardy offspring, may seem impossible, and yet a great many facts may be marshalled in support of this assumption. Reversion, in fact, seems to lead to a form of rejuvenescence due presumably to the ancestral units overcoming and controlling the more recently evolved and less stable units, which, if allowed to have their way, would give rise to offspring bearing all the marks of decadence that characterised the immediate ancestors."

Haemophilia is transmitted in nearly every instance by the non-bleeder members of the family, and almost exclusively by the females. Treves, Vol.I. System of Surgery, p.376. This is well illustrated by the gynealogy of the Family Manepel recorded by Dr Lorsen and quoted by Sir William Turner.

Mercier "Sanity and Insanity" p.152, assumes that atavism is the cause of the children of bleeders escaping the malady, but it is to be remembered that a mild form of haemophilia is seen amongst the women of/

of bleeder families. T. Weckham Legg. Dictionary of Medicine. Quain, p.568.

Professor Hamilton , Debate on Heredity in Disease, Scottish Medical and Surgical Journal, April 1900, thinks that haemophilia is a manifestation of a monthly constitutional disturbance of the general functions in the male. The fact that the disease does not appear to exist in Italy, Greece, Turkey, Spain or Portugal(Treves) militates I think, against this view.

A brief notice of the Stigmata of Degeneration may be pertinent here. Professor Ray Lankester "The Advancement of Science", p.24 observes that "It is clearly enough possible for a set of forces such as we sum up under the head "Natural Selection" to so act on the structure of an organism as to produce one of three results, namely these; to keep it in statu quo; to increase the complexity of its structure; or, lastly, to diminish the complexity of its structure; we have as probabilities either B Balance, or Elaboration, or Degeneration."

Those degeneracies appear at varying periods because the struggle for existence among the different organs and tissues of the body are most intense during the periods of body evolution and involution viz. during foetal life, first and second dentition, puberty and adolescence, climacteric during which period/

period extending from forty to sixty years of age, uterine involution occurs in woman and perstatic involution in man. "During all these periods, Degeneracy may be shown by mental and physical defect, a congenital tendency to which has remained latent until the period of stress" Talbot, "Degeneracy."

"These marks are of much importance in relation to the different forms of nervous disease in children, especially epilepsy, idiocy, and insanity. They are of great value in determining existing nervous disease, or as showing latent neuropathic tendencies."

The "Law of Transmutation in Transmission" signifies that the defect reproduced is not always exactly the same as that in the predecessor. Thus one child may have a superfluous digit and one other of the same family merely a deformed and overgrown one. What is hereditary is clearly a liability to disturbance in the development of a certain portion of protoplasm but falls short of the necessary production of identity of result.

This law is probably applicable under conditions in which it is not so easy to prove its influence. In the case of various forms of skin disease, it may be conjectured that a liability to defective formation of the skin is general in the antecedent rather than a definite proclivity to the single type of malady. Thus an inheritance from a parent who has suffered/

suffered from Psoriasis may possibly be transmitted as Ichthyiasis or some form of chronic Ecxema or Lichen." Jonathan Hutchinson, Vol.I., Clifford Albutt's System of Medicine.

" In families where there is a strong disposition to insanity" says Maudsley "one member may sometimes suffer from one form of nervous disease, another from another form, one perhaps has epilepsy, another severe neuralgia, or hysteria, a third may commit suicide, a fourth may become maniacal or melancholic, and it sometimes happens that the fifth evinces remarkable artistic talent."

"Metamorphosis of heredity has principally been studied in connection with disease, but observation so far as it has gone, points unmistakeably to the existence, as in other branches of Science, of the great principle that "nothing is lost" - that peculiarities of body or mind when they are not transmitted directly become transformed in passing from one generation to another", I. F. Nisbet, Marriage and Heredity. A view of Psychological Evolution. London Ward, Lock and Droney 1889."

"To look in each new generation for a return of the identical phenomena observed in the preceding one" observes Moreau "would be to misunderstand the law of heredity ..... The family of a man who dies insane or epileptic do not necessarily suffer from/

from the same malady; they may be idiotic, paralytic or scrofulous. What the parent transmits is not his insanity, but a constitutional defect which may manifest itself under different forms."

Julés Comby in Twentieth Century Practice, Vol. XII. p.545, in his description of Arthritism, says that this is recognised in France as a pathological disposition, which is transmitted from one generation to another, in a form characterised by a profound and permanent disturbance of nutrition, which is according to Bouchard, a slowing of the nutritive processes. Arthritism assumes different forms and degrees in the child in whom it exists only as a germ which may develop into obesity, asthma, migraine, (which are found both in the neurotic and arthritic branch of the common neuroarthritic stock) or Diabetes Mèllitus, some forms of Ecxema, gout, gravel.

In all neuroses he states that we find a similar and a dissimilar heredity, according to whether the parents had the same disease as the children or some other neuropathic affection. Thus he observes that Briquet in 1854 investigated the history of 1,103 persons, (403 men and673 women) comprising the families of 35 hysterical patients and found hysteria 214 times, epilepsy 13, insanity 10, somnabulism 3, convulsions 14, and apoplexy 10.

In Vol. VI of above work, E.J.Moyre M.D., points out/

out that the condition of Lymphatism is hereditary and consists in an exaggerated development of lymphoid tissue such as hyperthrophy of the tonsils, the glands of the neck, and of the nasal mucous membrane, thus explaining the occurrence of one or other of these in the different children of the same family.

The law of inheritance of certain characters exclusively by one sex among the offspring is not of such importance as the former.

Graves in "Clinical Lectures on the Practice of Medicine, Vol.I. p.660, observes that women very rarely stammer, and that in a family of his acquaintance stammering has been hereditary among the males for three generations, but the females have in no instance been similarly affected.

Both in Ichthyyosis and in Xeroderma pigmentosum the tendency to attack only one sex in a family is seen. Crocker Diseases of Skin, p.349.

Optic neuritis may without immediate cause attack many members of a family and this tendency may extend over several generations. It appears about the eighteenth or twentieth year and confines itself almost exclusively to the males. (Swanzy, "Diseases of Eye", p.384).

The last generalised fact of inheritance which can be applied to inherited diseases is that characters tend to be inherited at slightly earlier stages of development.

Gout and its manifestations is the most notable instance of this, although no very definite statistics have been recorded.

The question of the Inheritance or non-inheritance of tubercular disease requires separate consideration/

sideration . Some authorities affirm that tuberculous disease cannot be inherited.

Thus Treves says Vol.I. System of Surgery, p.355,

"The parent cannot hand down to its offspring the tuberculous process in its complete condition with its bacilli, its tubercles and its caseating districts. What the parent can unfortunately transmit to its offspring is a body whose tissues form a suitable soil for the development of the bacillus, should that microbe ever reach it in sufficient strength. It is only in this sense that tuberculosis can be said to be inherited. What is inherited, as a matter of fact, is not a disease, but a predisposition."

"There was a dogma" says Virchow "which, till quite recently, was considered almost indisputable, namely, the dogma of inherited tuberculosis. That is a logic which moves men in manifold ways. In my quality of physician I have often enough been consulted by anxious fathers and mothers as to whether they must not expect their children to be born tuberculous. When we see in many families how there are always new cases of tuberculosis occurring, how one generation dies off after the other, certainly the idea comes home to us that here is an inherited condition. I now dispute this heredity absolutely. For a course of years I have been pointing out that if/

if we examine the bodies of infants newly born who have had no life apart from the mother, we find no tuberculosis in them. I have the conviction that what looked like tuberculosis in the newly born was none of it tuberculosis. In my opinion there is no authenticated case of tubercle having been found in a dissected newly born infant. After the birth certainly, invasion can begin very rapidly. All the statistics and other scientific material that may be produced, I reckon as indifferent. If it cannot be found that tubercle bacilli exist in an infant that has had no communication with the outer world, then I maintain the outer world must be added, that is an infection from the outer world; whilst up till now it was believed without further question that the infection was conferred on the child from birth. Doubtless a breach must exist somewhere by means of which the tubercle bacillus was communicated to the newly born infant."

Loeffler states "Even admitting all the instances of proved transmission from mothers to offspring, the numbers would still be far too low to make bacillary heredity of tuberculosis comprehensible."

"On the other hand, transmission from the mother only takes place if she manifests tuberculous changes of the highest degree; the extraordinary preponderating majority of tuberculously infected mothers bring their/

their infants into the world at a period when the disease is in the first stages of development, and chiefly within local limits; therefore the probability of a hereditary transmission of tubercle bacilli in mankind is a remarkably small one. Consequently no practical importance can be attached to bacillary heredity as a means of spreading tuberculosis."

Mr Jonathan Hutchison, Vol.I. Clifford Albutt's System of Medicine, states that The possibility of inheritance as regards tuberculosis are, (1) a child may inherit tissue conditions prone to favour the development of the Tubercle Bacillus - without the Bacillus, or (2) the Bacillus without the tissue conditions, or (3) Both of these.

Harold C. Ernst, M.D., Professor of Bacteriology, Harvard, Twentieth Century Practice, Vol.XX. p.151 and seq. has the following among other observations, Wolff inoculated pregnant animals, and animals before pregnancy occurred with tuberculous sputum, in the latter case to obtain if possible a tuberculous infection of the ovum. Out of 42 foetuses of rabbits and guinea-pigs, not one showed any tuberculous change, no matter how highly tuberculous the mother was, and the microscopical examination of the internal organs was entirely negative. Wolff injected males as well as females, the former in /

in the testicles, and although the power of procreation was thus diminished, he succeeded in obtaining foetuses conceived by them; but none of the results gave any tuberculosis. In only one case that of a mother with many tuberculous nodules, in the internal organs, was it possible with an emulsion of the liver of the two foetuses to innoculate guinea-pigs; they died with tuberculosis of the internal organs, although the microscopic examination of the two foetuses was entirely negative, so far as showing any bacilli of tuberculosis was concerned.

Sanchez - Toledo reached negative results in the careful examination of 65 foetuses of tuberculous mothers.

Gaertner however, was more fortunate; of 18 mice with tuberculosis of the abdomen, he found two tuberculous young; of 9 canaries with abdominal tuberculosis of the parents two were tuberculous; and from six pregnant rabbits injected in the veins of the ear with bacilli of tuberculosis, one of the young was tuberculous. Experiments with females impregnated by males with tuberculous testicles, gave Gaertner negative results; of such, six young rabbits, thirteen young guinea-pigs and four ova were non-tuberculous. Wolff also reported the cases of three tuberculous mothers dead with the foetus in the/

the uterus, and here also the most careful microscopic and inoculation experiments were without result. That an occasional transmission of the tuberculous bacilli from mother to foetus may occur, seems to be demonstrated by a monograph of Birch-Hirschfield: but this occurrence must be of the rarest and the bacillary transmission of tuberculosis by this means plays a most insignificant part."

Dr J.W. Ballantyne in the Discussion on Heredity and Disease, thinks that the case recorded by Auché and Chambrelint forms an absolutely complete proof of foetal Tuberculosis. "In that case the mother had generalised tuberculosis and tubercle was found in large amount in the foetus in its liver and spleen (just where it was to be expected, considering that it entered by the umbilical vein), and to a small amount in the lungs. It was found also in the heart, in the form of tuberculous endocarditis."

Holt, Diseases of Children, p.1018, believes that intra-uterine infection is highly probable in many cases of children born of tuberculous mothers, the children developing the disease during the first few months of life, although they may show no evidence of it at birth. He himself, has had five cases which died of tuberculosis during the first three months. One of these born prematurely of a mother in advanced tuberculosis died when twenty days old.

Relying/

Relying upon (1) the case recorded by Birch-Hirschfield, in which the organs of the foetus, taken from a woman dying from general tuberculosis, were found to contain tubercle bacilli, although the organs presented no tuberculous lesions; bacilli were found in the capillaries of the liver; inoculations from the spleen and kidney produced the disease in animals; the placental trefts were filled with bacilli: and (2) Lehman's case in which there were tuberculous lesions in the child's organs as well as in the placenta, he believes that intra-uterine infection is possible, but rare compared with the frequency of infection after birth.

At the Congress for the study of Human and Animal tuberculosis, Paris, 1893, Dr Prioleau made the following remarks;

Il nous a paru que la tuberculose héréditaire résultait bien plus sûrement de tubercles génitaux, ou de conceptions faites durant les périods aiguës de la maladie, que d'etats tuberculeux chroniques avec peu de retentissement général. Nous avons acquis cette opinion en étudiant la tuberculose des tout jeunes enfants chez ceux que nous avons observés l'hérédité seule pouvait être mise en cause, car les conditions hygiéniques étaient bonnes et ils étaient éloignés de toutes causes de contagion (lactation artificielle; cohabitation avec les parents tuberculeux). Relativement à l'influence que peut avoir

le siège des tubercules sur l"éclosion de l'hérédo-tuberculose, nous relatons les deux observations suivantes;

1. Homme de 31 ans, ayant des tubercles de la vessie et des vésicules séminales. Il a eu successivement deux enfants morts de méningite tuberculeuse, l'un à trois mois, l'autre à huit mois.

2. Homme de 35 ans, déjà porteur de lesions pulmonaires assez peu avancées et stationnaires sans réaction générale en sommes c'est un de ces tuberculeux jouissant d'une santé relative. Dans cet état il a deux enfants qui vivent dans de bonnes conditions. Mais bientôt apparaissent des tubercles testiculaires et dès lois deux nouveaux enfants viennent au monde en bonne santé, mais meurent successivément a cinq mois et à sept mois de méningite tuberculeuse.

He also records a few cases of general tuberculosis in which the father impregnates his wife and the child dies after birth of tuberculosis, and the case of a woman who has general tuberculosis during pregnancy, the child dying shortly after birth of tuberculosis.

Baumgarten believes that tuberculosis in general is in the majority of cases the pathological sequence of an infection which may occur through the sperm, or through the ovum or by the placenta. According to this authority the number of the bacilli would be/

be few and therefore at birth lesions would be rare; but if in large numbers lesions might more readily occur. The period of latency is explained by the resistance of embryonic tissue.

M. Vernevil, Congres pour l'Etude de la Tuberculose Humaine et animale, Paris, 1893 believes that the evolution of Congenital tubercular lesions is as follows;

1. Infection du sang, des humeurs ou des tissues des procréateures par le principe virulent (sous une forme malheureusement mal comme encore.)

2. Transmission de ce principe au produit de la conception, embryon ou foetus dont le sang, les humeurs ou les tissues soit désormais infectes, comme ceux des générateurs.

3. Infection du produit se continuant après la naissance pendant un temps indeterminé à l'état latent absolu, c'est - a - dire sans altération appréciable de la santé ou se traduisant sous forme de dyscrasie indécise.

4. Intervention fortuite du traumatisme ouvrant au sang infecté les espaces conjunctifs, les cavitiés séreuses, les réseaux lymphatiques, c'est - a - dire les milieux de culture éminesemment favorables à la multiplication des germes à l'agglomération des bacilles.

5. Inoculation/

5. Inoculation de ces milieux où apparait enfin le tubercle de macroscopique avec ces caractères anatomiques et ses propriétés specifiques.

The theory of heredity which in my estimation is best fitted to explain the various processes of inheritance, being in harmony with most if not all of the known facts, and which has the further merit of having followed sound Baconian principles is Weismann's Theory of the Germ Plasm. In one point Weismann seems to have erred when he supposes mitosis can divide the chromatin of the daughter nuclei both equally and unequally, all the evidence tending to show that division of the chromatin is equal. The writers upon inductive logic all assert, as does Mill, that any conception in the mind regarding facts if it is to convey any knowledge relating to them, it must be a conception of something which is in the facts, some property which they actually possess.

On the other hand, the discovery by Weismann in 1885 that a single polar body is expelled from the parthenogenetic summer egg of Polyphemus Oculus, was the result of inference, based upon the conclusion that nuclear substance determines the nature of a cell. Weismann believed that a nucleoplasm directs the development of the ovum and stamps upon it a specific character, and then germ-plasm takes its place and compels the egg to undergo development into an embryo.

If the ovogenetic nucleoplasm of the egg-cell can be derived from the germ-plasm, but cannot be re-

retransformed into it, we must conclude, says Weismann, that the germ-plasm first of all originates an ovogenetic nucleoplasm which controls the egg-cell up to the point at which it becomes mature, its place is then taken by the rest of the nucleoplasm - germ-plasm - and the former is removed from the egg in the form of polar bodies; hence the formation of polar bodies signified in Weismann's opinion the removal of the ovogenetic part of the nucleus from the mature egg-cell. And consequently polar bodies must also be found in parthenogenetic eggs, these possessing a specific histological structure equal to that found in eggs requiring fertilisation. (On the number of polar bodies and their significance in Heredity . Essays on Heredity Vol.I.)

Nägeli was the first to treat inheritance as produced by the transmission, not of a cell considered as a whole, but of a particular substance the idioplasm contained within the cell and forming the physical basis of heredity. Nägeli believed that idioplasm forms a network which extends through the whole body and he endeavours to make his theory independent of the whole conception of cells. Weismann in his hypothesis, starts with the germ-cells and considers that Nägeli's idioplasm includes the germ-plasm and cannot agree with Oscar Hertwig when he identifies Nägeli's idioplasm with the nucleoplasm/

nucleoplasm of the germ cell.

The germ plasm according to Weismann is only a certain kind of idioplasm, viz. that contained in the germ-cell. The germ-cells alone transmit the germ-plasm from one generation to another, and it is the hereditary substance which contains all the primary constituents of the whole organism. The protoplasm of a cell contains according to Nägeli two plasms and Weismann adopts this view; they are (1) the vital substance of the cell, formative plasm or morphoplasm or trophoplasm of Nägeli and (2) the idioplasm.

Protoplasm being a complex substance which is not homogeneous but consists of different molecules, we therefore, says Weismann, cannot speak correctly of a molecule of protoplasm but we must come to the conclusion that protoplasm consists of groups of molecules each of which is composed of different kinds of chemical molecules. Those he calls biophors, and they are his smallest material units, and to those are due the fundamental qualities of life; assimilation, metabolism; and multiplication by fission. He does not regard these biophors as hypothetical. "They must exist" the says "for the phenomena of life must be connected with a material unit of some sort" (The germ-plasm: a Theory of Heredity, 1893, p.441. Each of the earliest and lowest/

lowest organisms must have been neither more nor less than the equivalent of one biophor - that is a group of molecules on which the phenomena of life depend. Biophors, he insists, constitute all protoplasm - the morphoplasm differentiated into the cell - substance as well as the idioplasm contained in the nucleus - the latter being a far more complex structure than the former, the idioplasm alone being capable of giving rise to differently constituted cells during the course of embryogeny.

Weismann believes with Wilhelm Roux that the Principle of Selection applies to the parts of an organism just as they do to the species. Processes of Selection must thus take place among every kind of units within the organism - not only in cells and tissues but also in the biophors.

Everywhere equivalent parts are contending one with another and everywhere it is the best which prevail. We can describe this process, he says as intra-individual selection or intra-selection. (Romanes Lecture. Effect of External Influences upon Development, 1894).

Weismann observes that protoplasm which does not yet contain inherited qualities does not seem to him to be inconceivable. This would be the case in the Monera of Häckel, whose morphological value is that of a cytode or cell without a nucleus. Historical properties of the protoplasm, observes

Weismann/

Weismann i.e. its special hereditary tendencies, are not connected with the primary vital forces - assimilation, metabolism and so on, - the latter must exist independently in all protoplasm.

The morphoplasm of each cell is controlled and its character decided by the idioplasm of the nucleus and Weismann accepts tDe Vrie's solution viz. that minute, specific, vital particles migrate from the nucleus into the cell-body and exert an influence on the cell and he maintains that the nuclear matter becomes a store-house for the various kinds of biophors which enter into the cell-body and are destined to transform it.

Heredity having to account for the transmission of parts which are variable, it follows that just as many independent and variable parts exist in the germ-plasm as are present in the fully formed organism; and the independently and hereditarily variable parts of the body, therefore, serve as an exact measure for determining the number of ultimate particles of which the germ plasm is composed and likewise any particular character which is independently variable from the germ onwards is also represented by a special element in the germ-plasm. The germ-plasm must therefore be composed of as many units as there are transmissible parts in the body which are independently variable. These units cannot/

cannot be smaller than a biophor and must be of the nature of biological elements.

Weismann designates the cells or groups of cells which are independently variable from the germ onwards as determinants or hereditary parts, the particles of the germ-plasm corresponding to and determining them as the determining parts or determinants.

In all the more highly differentiated animals there can be little doubt that thenumber of determinants is always very much less than that of the cells which are the factors in the process of ontogeny. He defines a determinant as a primary constituent of a cell or group of cells and thus a determinant is always a group of biophors and never a single one, the biophors combining to form a higher unit, namely , the determinant which is a vital unit of a higher order than the biophor possessed of special qualities.

These determinants are hypothetical, and according to Weismann there are probably many groups of cells in the higher animals the constituents of which are not represented individually in the germplasm; e.g. more or less extensive regions of the hairy covering are represented each by one determinant, these regions are not large as is shown by the stripes and spots on the coat of such animals as/

as tiger or leopard; while all the nerve-cells of the brain do possess their special determinants as otherwise the transmission of such fine shades of mental qualities in man would be inexplicable.

Groups of determinants each representing a separate vital unit form ancestral germ-plasms or ids, several of which ids, capable of growth and multiplication by division constitute each idioplasm which architecture is transmitted by heredity and forms the basis of the entire ontogenetic development of the idioplasm. The ids correspond to the microsomata in the nuclear architecture, while the chromosomes which are equivalent to a series of ids he calls idants. ibid., p.67.

Division of the nucleus depends on the longditudinal splitting of the idants, in which process each of the special ids, assuming these to correspond to the "microsomata" become halved. The construction of the whole body and the transmission of characters determining the structure of an animal, as well as those characterising the class, order, family and genus to which it belongs are due to a complicated process of disintegration of the determinants in the id of germ-plasm. The determinants in order to control the cell break up into its constituent biophors. The determinants grow and multiply and their disintegration into biophors occurs/

occurs when the id only contains the single determinant which controls that particular kind of cell whose histological differentiation in the embryogeny should and does occur. ibid. p.76.

The bodies of metazoa are differentiated into two groups of cells, the somatic cells and the germ-cells, the latter containing the germ-plasm - the undying part of the organism, so that, says Weismann, we may contrast the germ-cells as the undying part of the metazoan body with the perishable somatic cells. If the nature and character of a cell is determined by the substance of the nucleus, and not by the cell-body, then the immortality of the germ-cells is preserved although only the nuclear substance passes uninterruptedly from one generation to another. Essays on Heredity, p.209.

The germ-cells according to Boy Tessier retain their power of attraction and are enabled to perpetuate themselves and he quotes Butschlis explanation of the"immortality" of the germ-cells, viz. that fecundation in Metazoa is an act similar to that which occurs in Infusoria, the latter when in process of decadence acquiring new force by the phenomena of conjugation.

Butschli assumes that in Metazoa the egg which alone is capable of being rejuvenated is renewed by the spermatid which alone is capable of rejuvenating/

ating . Art. Old Age. Twentieth Century Practice.

Instances of Reversion according to this theory "must be attributed to the presence of old unmodified determinants in the germ-plasm, which take the place of the younger homologous determinants as regards obtaining the control of the cell or region of cells in question."

Germ-plasm p.317.

"Although we are unable to give a detailed account of the way in which atavism happens, and of the circumstances under which it takes place, we are at least able to understand how it becomes possible; for even a very minute trace of a specific germ-plasm possesses the definite tendency to build up a certain organism, and will develop this tendency as soon as its nutrition is, for some reason, favoured above that of the other kinds of germ-plasm present in the nucleus. Under these circumstances it will increase more rapidly than the other kinds, and it is readily conceivable that a preponderance in the quantity of one kind of nucleoplasm may determine its influence upon the cell-body." Essays on Heredity, p.182.

That Weismann's hypothesis of the germ-plasm, with some modifications, which in no way alter the fundamental postulates of the theory gives an adequate explanation of many of the facts and problems of/

of heredity will be apparent to all who have read the "Penicuik Experiments".

It only remains to notice how this theory is applied to diseased conditions which at the same time are heredtiary. Weismann insists that many diseases transmitted from one generation to another are in all probability the result of infection of the parental germ-plasm with microscopic parasites and ought to be called infections of the germ.

This is the case in Syphilis, "The father, as well as the mother, is capable of transmitting this disease to the embryo, and the only possible explanation of this fact is, therefore, that the specific bacteria of Syphilis can be transmitted by the spermatazoon." "Germ-plasm" p.388.

As regards the transmission of tuberculosis, Weismann states that a large number of facts support the view that infection of the germ plays the chief part in the process.

That transmission of tuberculosis by infection of the germ can and does occur has been shown in previous paragraphs, but it will be necessary for any such theory as that if the germ-plasm to account for the other side of the question which bulks so largely in the minds of clinicians, viz. the transmission of a tissue condition which renders the individual who inherits it prone to infection.

Professor/

Professor Hamilton thinks that the special vulnerability "resides in the epithelial protective coverings of the body being too little resistant, too easily stimulated by external agencies, too readily penetrated by the parasite of the disease" Discussion on "Heredity in Disease" , Edinburgh Medico - Chirurgical Society, March 7th, 1900. This vulnerability, he suggests, is handed down from one generation to another,"as inherently bound up with the hereditary tendency of tuberculosis."

These conditions, he thinks, are "the lineal descendants of a variation which took place far back in our history, that the variation has occurred irrespective of surroundings or external agencies, and that its influence has been propagated in the descendants ever since." Ibid.

The same explanation he gives regarding the origin and heredity of gout, the gouty habit of body arising as a variation, and as such is hereditarily transmissible.

Professor Weismann believes that in hereditary diseases and habits of body prone to disease what is transmitted is an "anomolous state of the germ-plasm itself "Germ-plasm, p.388.

This is quite in accordance with his postulate of the continutiy of the germ-plasm, and gives a tentative explanation of the hereditary diseases.

Further/

Further investigations may yet reveal exactly what these anomolous conditions of the germ-plasm are, subsequently to show how they originate will probably be an easier matter for solution.