probably been carried far into the interior. It is certain that the Tobas who massacred Crevaux's party are now provided with hatchets, knives, and Remington guns, which they have captured, partly from Crevaux, and partly from the Bolivian expedition of Col. Rivas. They are not, however, so formidable as might be supposed; since it seems their captive instructed them to aim in such a way as to render it almost impossible that any thing of a man's height should be hit by the ball; so that the guns are more terrifying than dangerous to their enemies. The second expedition sent under orders of Col. Fontana accomplished nothing. The third, organized by Col. Sola, and since commanded by Col. Hazetta, is at present penetrating the Chaco region, toward the banks of the Pilcomayo. Another better prepared Bolivian expedition was in contemplation under Col. Campu; but the writer, broken down by fever, was obliged to return to Corumba on his way to Buenos Ayres. He fears that all traces of the expedition of Crevaux are lost; that even their remains cannot be recovered, since the Tobas are in the habit of utilizing the bones as trophies or for religious purposes, so that they would be widely separated and unrecognizable. The vertebrae of the hated Christians are in special demand among the Toba women for use as rattles or rattling pendants worn during their dances. Altogether, the savagery of these Tobas seems to be more energetic than that of any other American aborigines. Milhôme has sent to Paris a complete collection of their arms, tools, instruments, and clothing, with an explanatory catalogue.

On the other hand, M. Paul Armand, in the Bulletin of the Marseilles society for December, without mentioning any date (but published before Milhôme's letter), says that the Argentine expedition to the Pilcomayo arrived safely in the early part of August, at the Bolivian town of Caiza, without the loss of a man, although having fought three battles with the Tobas. They ascended the Pilcomayo sixty leagues beyond the place where the Crevaux party was assassinated. The Bolivian congress has resolved that a colony named after Crevaux shall be established at that point, and that it shall be marked by a monument to the sufferers. Thouar arrived at Caiza on the 12th of July; having heard from some neutral Indians that two survivors, Haurat and Branco, were prisoners with the Choroti Indians of the Rio Abajo. He had had some communication with the Tobas, and obtained some relics, among other things a barometer which had belonged to Crevaux. He intended to leave Teyo about Aug. 10, and pass completely round the north Chaco, on the left bank of the Pilcomayo. In January it was stated to the Société de géographie that Thouar had arrived safely at Assuncion, and was about to embark for France, where he was expected before this time. Nothing further is said in regard to his search for Crevaux; but it is stated that the most important result of his voyage will be the opening of a practicable commercial route between Bolivia and Paraguay, giving opportunities for a reciprocal commerce now valued at twenty million dollars.

A NEW THEORY OF HEREDITY.

The law of heredity: a study of the cause of variation, and the origin of living organisms. By W. K. BROOKS. Baltimore, *Murphy*, 1883. 12+336 p., illustr. 16°.

JAEGER is quoted by Semper as saying that there has been enough Darwinist philosophizing, and that it is now time to subject the numerous hypotheses to the test of investigation. While this is undoubtedly true, some hypotheses are necessary; and even incomplete and erroneous ones may be of great service by offering a series of definite problems for solution, instead of a chaos of facts. "An honest attempt to reason from the phenomena of nature can hardly fail to result in the discovery of some little truth." This is the keynote of the book before us, which is therefore worthy of very careful consideration, however unsatisfactory it may prove to be as an explanation of the great problem of heredity.

The theory proposed in this book is a modification of Darwin's hypothesis of pangenesis, reconstructed with a view of avoiding the many difficulties in the way of that hypothesis. Brooks's theory, very briefly stated, is as follows. 1. The union of two sexual elements gives variability. 2. In all multicellular organisms the ovum and the male cell have gradually become specialized in different directions. 3. The ovum has acquired a very complex organization, and contains material particles of some kind corresponding to each of the hereditary species characteristics. 4. The ovarian ova of the offspring are the direct and unmodified descendants of the parent ovum. 5. Each cell in the body has the power of throwing off minute germs. During the evolution of the species, these cells have acquired distinctive functions adapted to the conditions under which they are placed. When the function of a cell is disturbed through a change in its environment, it throws off small particles, which are the germs or 'gemmules' of this particular cell. 6. These germs may be carried to all parts of the body, and penetrate to an ovum or to a bud; but the male cell has acquired a peculiar power to gather and store up germs. 7. When impregnation occurs, each gemmule impregnates that particle of the ovum which will give rise in the offspring to the cell corresponding to the one which produced the gemmule; or else it unites with a closely related particle, destined to produce a closely related cell. 8. In the body of the offspring this cell will be a hybrid, and tend to vary. 9. The ovarian ova of the offspring inherit the properties of the fertilized

ovum directly, and the organisms to which they give rise will tend to vary in the same manner. 10. A cell which has varied will continue to throw off gemmules, and so cause variations in the corresponding parts of the bodies of descendants, until a favorable variation is seized upon by natural selection. 11. The ovarian ova will directly inherit the selected variation, and will transmit it as an hereditary race characteristic without the agency of gemmules. 12. The occurrence of a variation, but not its precise character, is due to the direct action of external conditions.

These positions Professor Brooks endeavors to establish by a great number of facts, taken almost exclusively from Darwin. He first combats the view that the sexual elements play similar parts in reproduction, and the objection seems to be well taken; though, when he says that it cannot be shown that either sex may transmit *any* characteristic whatever, he pushes his objection too far, as is demonstrated by a multitude of facts in the breeding of domestic animals.

Having stated the theory, the author devotes a large part of his book to the evidence in its favor. From the study of hybrids he concludes that hybrids and mongrels are highly variable; that the children of hybrids are more variable than the hybrids themselves; and that, from the evidence of reciprocal crossing in the case of hybrids, variation is caused by the influence of the male. The evidence from variation is then considered, showing that variation is more common in sexual than in asexual reproduction (in plants at least); that changed conditions cause variation, not directly, but in subsequent generations; that specific characters are more variable than generic; that parts excessively developed in males are more variable than parts especially developed in females. Professor Brooks next takes up the very complex subject of secondary sexual characters, and shows from various kinds of evidence that the male is more variable than the female; and that the male has led the way in evolution, while the female has followed. One of the most important aspects of the hypothesis, the author considers to be the manner in which it removes objections to the theory of natural selection, by showing that large numbers of animals vary similarly and simultaneously, and so give an opportunity for natural selection to come into play.

Now, how far can this ingenious and ably supported hypothesis be regarded as a permanently valuable contribution to science? One great objection is apparent at the very outset, — that the author has not gone to nature for his facts, but has taken them almost entirely from Darwin's works, as he candidly says. This must necessarily impair the value of his conclusions. The whole work bears the stamp of being merely an ingenious attempt to supplement Darwin's hypotheses, and re-arrange his facts, and might have been written by one whose knowledge of biology had been drawn almost entirely from Darwin's books. The objection which Mr. Lewes[1] made to pangenesis holds equally well against this hypothesis. "The hypothesis is thus seen to be one wholly constructed out of suppositions, each and all of which may be erroneous, every one of them being necessary to the integrity of the scheme." Thus, the existence of gemmules is a supposition; that cells throw them off when disturbed is a supposition; that the male cell has acquired a special power of gathering and storing these germs is a supposition. Scarcely a single proposition of the hypothesis can be regarded as in any way proved. Then, again, some of the apparently simple assumptions really involve a number of others, equally without evidence. Thus, when it is said that the ovarian ova, being the direct descendants of the fertilized egg, inherit its peculiarities, we have no explanation offered for what is perhaps as great a mystery as the main problem itself. The ovarian ova are derived from the fertilized ovum through an immense number of intermediate cells, most of which become indifferent epithelium. We must, then, assume that the gemmules are all segregated together, and transmitted unchanged from cell to cell till they finally reach the ovarian ovum, — surely a very forced supposition.

The evidence by which Professor Brooks endeavors to support his hypothesis is by no means convincing: usually all that can be said of it is, that it does not contradict the view. In spite of his evident candor, the author has not always resisted the temptation of straining his points to the uttermost limit, often preferring a far-fetched and doubtful explanation to an obvious one close at hand, as in the cases of the zebra and niata hybrids on p. 130. The statement that the peculiarities of the niata breed of Paraguay cattle are probably due to a *reversion* to the type of Sivatherium will be an amusing one to paleontologists.

Then it is not at all clear, from the evidence presented, that this hypothesis will account more satisfactorily for the greater development of the male in those species in which the sexes differ than does Darwin's theory of sexual

[1] *Fortnightly review*, new series, vol. iv., p. 508.

selection: for, admitting Professor Brooks's doctrine, that each individual inherits *all* the characteristics of the species, and that the female function prevents the development of the male characters (though they may appear when that function is destroyed), it is plain that those characters are either incompatible with the female function or useless to the female, and hence there is no reason why she should acquire them; while their presence in the male, to which they are of obvious advantage, is in most cases to be accounted for by sexual selection. On the other hand, it is obvious that all the complex apparatus of uterus, placenta, and similar organs, must have originated with the female. We cannot agree with Professor Brooks, that the presence of mammae in the male is an indication that the mammary function was originally a male characteristic, any more than that the presence of rudimentary stridulating organs in female Orthoptera shows that these were first acquired by the female. Why should Professor Brooks adopt exactly opposite explanations for precisely parallel cases?

The propagation of cells by means of gemmules is not only purely hypothetical, but, apparently at least, opposed to what we know of the mode of cell-formation. Cells arise only by division of some pre-existing cell, and never seem to arise spontaneously, as would very probably be the case if their propagation by gemmules were at all common. Nor does the process of impregnation, as actually observed, lend support to the new hypothesis; for the head of the spermatozoon coalesces with the nucleus of the ovum, apparently without loss of bulk, or in any way indicating an emission of gemmules. The influence of the male element seems rather to consist in modifying the action of the egg-nucleus.

Mr. Conn's very obvious objection (given on p. 294), that in many cases unfavorable conditions would not act upon certain cells, causing them to emit gemmules, but would result in the destruction of the animal, seems entitled to more weight than the author is inclined to give it. Any hypothesis that fails to account for so large and important a class of facts cannot be called complete.

Want of space compels the omission of many other objections, as well as the consideration of Professor Brooks's views on reversion, natural selection, and the intellectual differences between men and women.

But, in spite of all that has been said, Professor Brooks is entitled to the thanks of all students of biology for his clear statement of the problem, and the many suggestive fields for investigation here opened. The student of heredity will find in this book just what he needs to give him a clear conception of how the problem is to be attacked. The book is one of remarkable ability. The way in which apparently disconnected series of phenomena are brought together and shown to be special cases of one general principle, is indeed masterly. Even if every single proposition of the hypothesis should prove to be without foundation, and the hypothesis entirely untenable, Professor Brooks must always be credited with having made a most important step in advance. Assuming that the problem of heredity is at all capable of solution, some such preliminary clearing of the field is a necessity. If different observers will devote their energies to following up the various lines of inquiry which Professor Brooks has so ably suggested, we may be sure of most valuable and fruitful additions to our knowledge. To use Mr. Lewes's words, "even should the hypothesis prove a will-o'-wisp, it is worth following if we follow circumspectly, for it hovers over lands where we may find valuable material. As an hypothesis, it so links together wide classes of facts that it may be a clew to great discoveries."

WATTS'S MANUAL OF CHEMISTRY.

A manual of chemistry, physical and inorganic. By Henry Watts. Philadelphia, *Blakiston*, 1884. 16+595 p. 8°.

Few text-books of chemistry have been more successful than the 'Manual of elementary chemistry' first published in 1845 by Professor George Fownes. Fownes, who was but thirty years of age at the time, held the chair of chemistry in University college, London. His work had marked success from the very beginning, and he was called upon to prepare three editions in the succeeding four years. The third, however, appeared posthumously; for Fownes died in January, 1849, at the early age of thirty-four. Under the editorship of the late Dr. H. Bence Jones, and afterwards of Dr. A. W. Hofmann, the work appeared at frequent intervals in six editions; and, notwithstanding the constant additions of large amounts of new and important matter, the familiar name 'Fownes's chemistry' was retained. The tenth edition was edited by Dr. Bence Jones and Henry Watts, and appeared in 1868; another edition, by Henry Watts, followed in 1872; and finally a twelfth, greatly increased in size, and issued in two volumes devoted to inorganic