at other times, when the wave of public confidence is high and strong, such a failure has no perceptible effect beyond those immediately concerned. To predict the time of the next panic it would be necessary first to determine the periodic laws of speculative eras, expansion and contraction of the currency, over production, and other principal causes, and then combine them to find when like phases coincide. Just as two rays of light of opposite phases may by interference annihilate each other, so two social movements or tendencies, both of great power and effect, may, when they enter as terms in the formula of another movement, cancel each other by reason of their opposite signs or phases. On the contrary, all of the greatest movements of the social world, such as the founding and spread of Christianity, the fall of Rome, the Reformation, the colonization of America, and the French Revolution, have been the result of the synchronous combinations of many causes or terms of the same sign and phase, so that the sum of the whole — even if we neglect the infinite number of small terms — is one of transcendent magnitude.

The great advantage of the philosophical study of history is that by this method the constituent elements of events and the movements to which they belong are made apparent, and for this purpose we must be provided with the data for expressing the trend and phase of all the political, philosophical, and religious movements to which they are related. The complexity of the problems involved is indicated by the fact that different scholars arrive at such contradictory conclusions. Nevertheless, it is believed that this modern method of investigation will revolutionize all the social sciences as it has already revolutionized political economy, and that after the method has been more systematically applied to modern statistics, and the number of terms considered has been increased, the conclusions or results reached by different authorities will be less and less discrepant, and that thus we may hope ultimately to reach a certainty and precision, in the social and metaphysical sciences, which will be comparable to the precision of physical data. If we throw a pebble into the air we can express mathematically the motion of the earth toward the pebble as well as the motion of the pebble toward the earth, and we might perhaps express in a similar way the effect which the repair of a roof in San Francisco would have upon the prices of building materials in New York, and *vice versa*. More than this, is it not possible that a new psychology will be able to weigh and measure the volitions, tastes, and emotions of the mind, so that this science as well as history and political economy may become partly quantitative?

The methods of mathematics can be applied to the metaphysical sciences more extensively than has been done heretofore. These methods have already been applied, in a limited way, to all subjects having much statistical data, also to logic. Indeed, mathematical forms and analysis may be used in any science, as chemistry, which is subject to quantitative treatment. The qualitative analysis must always precede the quantitative analysis in any science, but most subjects are now so fully developed that it is time for original research to be directed to the quantitative treatment. This is being done in a kind of tentative way at several universities, and it is believed that the comparative, quantitative method of investigation will be as useful in other sciences as it has already proved to be in political economy and philology.

NATURAL SELECTION AND USE-INHERITANCE.

BY VICTOR YARROS, BOSTON, MASS.

EVOLUTIONISTS will be extremely gratified to learn that Mr. Spencer has resumed the discussion of the subject of the factors of organic evolution. Since the publication, several years ago, of Mr. Spencer's controversial essays on this subject, the so-called pure-Darwinians have practically enjoyed a monopoly of the field; and some of the more rash biologists have even allowed themselves to advance the claim that the use inheritance hypothesis was utterly discredited. Mr. Spencer's unsatisfactory state of health, it was understood, necessitated his neglect of this and many other "unsettled problems" and the concentration of his attention on ethical questions,— the part of his synthetic philosophy rightly regarded by all as the crown of the whole. Students of evolution were anxious to hear "the other side," the answers to the formidable objections of Professor Weissman and his disciples or co-believers, and the announcement of Dr. Romanes's "Darwin and After Darwin," a part of which work was to treat elaborately the question of the number and relative importance of the factors of organic evolution, was received with great pleasure. But no one realizes more keenly the transcendent importance of the question of the inheritance of acquired characters than Mr. Spencer, and he is to be congratulated upon the kindness of fortune that has enabled him to spare some time and energy to the further consideration of the subject, use-inheritance *vs.* sexual selection. It will conduce to firmness of grasp and clearness of understanding to quote here certain passages from Mr. Spencer's preface to his "Factors of Organic Evolution."

"Though mental phenomena of many kinds," wrote Mr. Spencer, "and especially of the simpler kinds, are explicable only as resulting from the natural selection of favorable variations; yet there are, I believe, still more numerous mental phenomena, including all those of any considerable complexity, which cannot be explained otherwise than as results of the inheritance of functionally-produced modifications. What theory of psychological evolution is espoused, thus depends on acceptance or rejection of the doctrine that not only in the individual, but in the successions of individuals, use and disuse of parts produce respectively increase and decrease of them.

"Of course there are involved the conceptions we form of the genesis and nature of our higher emotions; and, by implication, the conceptions we form of our moral intuitions. If functionally-produced modifications are inheritable, then the mental associations habitually produced in individuals by experiences of the relations between actions and their consequences, pleasurable or painful, may, in the successions of individuals, generate innate tendencies to like or dislike such actions. But, if not, the genesis of such tendencies is, as we shall see, not satisfactorily explicable.

"That our sociological beliefs must also be profoundly affected by the conclusions we draw on this point, is obvious. If a nation is modified *en masse* by transmission of the effects produced on the natures of its members by those modes of daily activity which its institutions and circumstances involve, then we must infer that such institutions and circumstances mould its members far more rapidly and comprehensively than they do if the sole cause of adaptation to them is the more frequent survival of individuals who happen to have varied in favorable ways."

The above expresses Mr. Spencer's view of the profound importance of the indirect bearings of the purely biological argument upon the factors of organic evolution. Now that we have refreshed our memory on this point, let us proceed to give a brief but careful summary of Mr. Spencer's latest contribution to the controversy, to be found in an article, entitled "On the Inadequacy of Natural Selection," in the *Contemporary Review* for February. We preserve as far as possible Mr. Spencer's style.

Students of psychology are familiar with the experiments of Weber on the sense of touch. He found that different parts of the surface differ widely in their ability to give information concerning the things touched. By actual measurements he showed that the end of the forefinger has thirty times the tactual discriminativeness which the middle of the back has. Between these extremes there are gradations. The inner surfaces of the second joints of the finger can distinguish separateness of positions only half as well as the tip of the forefinger. The innermost joints are still less discriminating, their power being equal to that of the tip of the nose. The palm of the hand and the cheek have alike one fifth of the perceptiveness which the tip of the forefinger has, and the lower part of the forehead has one-half of that possessed by the cheek. The crown of the head is far less discriminating, and the breast still less.

What is the meaning of these differences? How, in the course of evolution, have they been established? If "natural selection" or survival of the fittest is the assigned cause, then it is required to show in what way each of these degrees of endowment has

advantaged the possessor to such extent that not infrequently life has been preserved by it. It is reasonable to assume that the parts have not become so widely unlike in perceptiveness without some cause, and, if the cause alleged is natural selection, it becomes necessary to show that the greater degree of the power possessed by this part than by that has conduced so much to the maintenance of life that an individual in whom a variation had produced better adjustment to needs, thereby maintained life when some others lost it, and that among the descendants inheriting this variation there was a derived advantage such as enabled them to multiply more than the descendants of individuals not possessing it. Can anything like this be shown?

That the superior perceptiveness of the forefinger-tip has thus arisen, might be contended with some apparent reason, as such perceptiveness is an important aid to manipulation. But how about the back of the trunk and its face, or the tip of the nose, or the thigh? The survival of the fittest cannot explain these differences of perceptiveness. But if there has been in operation a cause which it is now the fashion to deny, the various differences are at once accounted for. This cause is the transmission of inherited traits or characters.

(Here Mr. Spencer records some experiments which show that constant exercise of the tactual nervous structures leads to further development, to greater discriminativeness. The perceptiveness of the finger-ends of the blind who read from raised letters and of compositors is greater than that of the finger-ends of other people.)

Now, if acquired structural traits are inheritable, the gradations in tactual perceptiveness are the result of the gradations in the tactual exercises of the parts. The trunk has but little converse with external bodies, and it has but small discriminative power; what power it has is greater on its face than on its back, corresponding to the fact that the chest and abdomen are more frequently explored by the hands, this difference being probably in part inherited from inferior creatures. The middle of the forearm and the middle of the thigh are obtuse, having rare experience of irregular foreign bodies. The tip of the nose has considerable tactual experience, hence its greater perceptiveness. The inner surfaces of the hands are more constantly occupied in touching than are the back of the hand, breast, forearm, forehead, while the tips of the fingers come into play not only when things are grasped, but when things are felt at or manipulated. If then it be that the extra perceptiveness acquired from extra tactual activities, as in a compositor, is inheritable, the gradations of tactual perceptiveness are explained.

The tip of the tongue exceeds all other parts in power of tactual discrimination; why such perceptiveness? Its functions of moving food during mastication and of making many of the articulations constituting speech, are not materially aided by extreme perceptiveness, and natural selection cannot have caused it. But assume inheritance of acquired traits, and there is no difficulty, for the tongue-tip has, above all other parts of the body, increasing experiences of small irregularities of surface. It is in contact with the teeth, and either consciously or unconsciously is continually exploring them. There is hardly a moment in which impressions of adjacent but different portions are not being yielded to it by either the surfaces of the teeth or their edges. No advantage is gained; it is simply that the tongue's position renders perpetual exploration almost inevitable; and by perpetual exploration is developed this unique power of discrimination.

Thus the law holds throughout, from this highest degree of perceptiveness of the tongue-tip to its lowest degree on the back of the trunk; and no other explanation of the facts seems possible.

But some biologists might contend that *panmixia* affords an adequate explanation of the facts. So Mr. Spencer, after pointing out that the explanation by *panmixia* implies that these gradations of perceptiveness have been arrived at by the dwindling of nervous structures, and hence makes an unproved and improbable assumption the basis of the argument, proceeds to establish that, even with this objection passed over, it may with certainty be denied that *panmixia* can furnish an explanation. As this part of the essay is left unfinished, it would be unwise to attempt an abstract of the Spencerian criticism of the *panmixia* explanation. We shall return to the subject as soon as Mr. Spencer brings his argument to a close.

FEEDING-LINES OF A LIVING LAND GASTEROPOD ON LICHENED SLATE.

BY J. B. WOODWORTH, SOMERVILLE, MASS.

IN searching for fossils in the Carboniferous rocks of Attleboro, Mass., about three years ago, I found on the surface of a vertical stratum of micaceous slaty sandstone, in an old quarry, what at first glance appeared to be annelid trails resembling the form known as *Nereites* common in the Silurian. Further examination showed me at once, however, that these markings were caused by the gnawing away of a drab-colored crust of lichens and dust which concealed the real appearance of the rock. The trails were in the form of bands about one-quarter of an inch wide, wandering over the surface of the outcrop, or curved back and forth on each other, so as to approach but rarely cross. These bands or trails were made up of a series of crescentic cross-markings united alternately right and left with the next adjacent in the series so as to form a continuous, closely pressed, sigmoid line, which in itself constituted the whole of the trail. The trail was evidently the feeding-line of some animal. Another occurrence which I have more recently observed in Bristol County, Mass., exhibited a trace of slime along the feeding-line, such as is left by slugs or land snails, thus showing that the feeder was probably a gasteropod.

Ebenezer Emmons, in the *Agriculture of New York*, Vol. I., 1846, p. 68, describes a trail found upon the surface of the fine green slate of Salem, Washington Co., N. Y., included in his "Taconic System," to which he gave the name *Nemapodia tenuissima*. The figure of this trail on pl. 14, fig. 1, of that work, agrees closely with the Attleboro trails. In an explanatory note, p. 365, Emmons states that this trail has been shown, he thinks, satisfactorily by his friend Dr. Fitch, "to be formed by some living unknown animal." It seems to me highly probable that the trail observed by Emmons, and shown to be not a fossil by his friend Dr. Fitch, was also that of a gasteropod. Conchologists may be familiar with the animal which makes these tracks, if I am right in thinking that they are made by gasteropods at all. As yet I have been unable to catch the animal at its work.

NOTE ON THE GENERIC NAME CHIROTES.

BY LEONHARD STEJNEGER, CURATOR DEPT. REPT. AND BATR., U. S. NAT. MUSEUM, WASHINGTON, D.C.

THE application of the law of priority necessitates the abolition of Cuvier's name *Chirotes* for the "Two-handed Ground Worm." No less than three generic names, formally proposed and diagnosed, have priority over *Chirotes*, none of which is preoccupied, and which in turn would have to be adopted, should any of the older ones for some reason become unavailable.

Bonnaterre seems to have been the first to give a Latin name to La Cepede's Cannelée, and to recognize its generic distinctness. However, by sheer carelessness he neglected to do so and a solitary "*B*" stands for the generic name he intended to impose. It may be assumed that he meant to call it *Bipes*, but we have nothing to do with assumptions. At the same time he included as the second species of his intended genus, Pallas's *Lacerta apus*, under the name *B sheltopusik*.

Latreille, however, saw the incongruity of uniting the two in the same genus, and expressly restricted[1] the name *Bipes* to the *B. canaliculatus*. The genus was thus formally established, named, diagnosed and restricted in 1802 as *Bipes*. Bonnaterre's other species he made a separate genus, *Sheltopusik*,[2] renaming Pallas's species *Sheltopusik didactylus*.[3] The latter will therefore stand as *Sheltopusik apus* (Pall.). It will be observed that this

[1] "Nous ne connoissons encore qu'une seule espèce bien distincte de ce genre."

[2] Latreille, Hist. Nat. Rept., II., 1802, p. 271.

[3] Latreille, tom. cit., p. 273.