Evidently, therefore, in spite of the abnormally great frequency with which large deviations occur, the whole percentage of abnormalities, among crabs between 7 and 14 mm. in length, is less than it is in adult crabs; and there is a rough agreement between the result obtained from these measurements and that obtained by Bowditch from the measurements of human stature already referred to. So that among female crabs in Plymouth Sound, during the period of life to which these observations refer, there is no indication of any destructive agency which acts selectively upon the dentary margin. Whether such selective destruction occurs among males, or among females at a later period of life, is for the present an open question.

Variation in frontal breadth may, therefore, for the present be considered to be of more importance in the economy of female crabs than variation in the length of the dentary margin—a view which receives confirmation from the dimorphism already shown to exist ('Roy. Soc. Proc.,' vol. 54, p. 324) in the frontal breadth of crabs from Naples, while it is a striking justification of the accepted system of classification, in which the characters of the great groups into which the Brachyura are divided are almost entirely those associated with changes in this dimension.

In conclusion, an important feature of the method employed may be pointed out. The increase of death-rate, associated with a given abnormality of frontal breadth, has here been roughly determined; in the previous paper, already referred to, the effect of abnormality in this dimension upon several other organs of the body was determined; and by the method of that paper it would be possible to determine the effect of parental abnormality upon the offspring. These are all the data which are necessary, in order to determine the direction and rate of evolution; and they may be obtained without introducing any theory of the physiological function of the organs investigated. The advantage of eliminating from the problem of evolution ideas which must often, from the nature of the case, rest chiefly upon guess-work, need hardly be insisted upon.

II. "Remarks on Variation in Animals and Plants. To accompany the first Report of the Committee for conducting Statistical Inquiries into the Measurable Characteristics of Plants and Animals." By Professor W. F. R. Weldon, F.R.S. Received February 19, 1895.

1. The importance of variation as a factor in organic evolution is not seriously disputed; but, if one may judge from the expressions contained in recent essays, naturalists are not agreed as to the

manner in which variation among individuals is associated with specific modification.

The view originally put forward by Darwin and Wallace is that specific modification is at least generally a gradual process, resulting from "the accumulation of innumerable slight variations, each good for the original possessor" ('Origin of Species,' chap. xv). This view rests on the assumption that each of those small differences which are to be observed among a group of individuals belonging to the same species has generally some effect upon the chance of life. "Can we doubt (remembering that many more individuals are born than can possibly survive) that individuals having any advantage, however slight, over others, would have the best chance of surviving and of procreating their kind?" ('Origin of Species,' chap. iv).

Of late years, another view has received support from various writers. An examination of any series of animals of the same species preserved in a museum shows in most cases a large majority of specimens which are superficially alike: those individual differences, upon which stress is laid by Darwin and by Wallace, are often so slight as to escape attention unless minute comparison is made between individual and individual. But there will commonly be found a few individuals which differ so remarkably from their fellows as to catch the eye at once. Such large deviations differ from the smaller ones, at least in most cases, by their extreme rarity; but they have been extensively collected, and most museums contain numerous examples of their occurrence. Some naturalists have been led, from the striking character of such variations, to assume for them a preponderant share in the modification of specific character. These persons assume, if I understand them rightly, that the advantages or disadvantages which accompany the more frequent slight abnormalities are in themselves of necessity slight; and that the effect of such slight abnormalities may be neglected, in comparison with the effect produced by the occasional appearance of considerable deviations from the normal type. They regard change in specific character as an event which occurs, not slowly and continuously, but occasionally and by steps of considerable magnitude, as a consequence of the capricious appearance of "sports."

Without presuming to deny the possible effect of occasional "sports" in exceptional cases, it is the object of the present remarks to discuss the effect of small variations, as it may be deduced from the study of two organs in a single species.

The case chosen is the variation, during growth and in adult life, of two dimensions of female *Carcinus mœnas*, recently investigated by a Committee of the Royal Society; and what is here said may be considered an appendix to the report of that Committee.

2. The questions raised by the Darwinian hypothesis are purely statistical, and the statistical method is the only one at present obvious by which that hypothesis can be experimentally checked.

In order to estimate the effect of small variations upon the chance of survival, in a given species, it is necessary to measure *first*, the percentage of young animals exhibiting this variation; *secondly*, the percentage of adults in which it is present. If the percentage of adults exhibiting the variation is less than the percentage of young, then a certain percentage of young animals has either lost the character during growth or has been destroyed. The law of growth having been ascertained, the rate of destruction may be measured; and in this way an estimate of the advantage or disadvantage of a variation may be obtained. In order to estimate the effect of deviations of one organ upon the rest of the body, it is necessary to measure the average character of the rest of the body in individuals with varying magnitude of the given organ; and by the application of Mr. Galton's method of measuring correlation, a simple estimate of this effect may be obtained. In the same way a numerical measure of the effect of parental abnormality upon abnormality of offspring may be obtained by the use of Galton's correlation function, and such measurements have been made, in the case of human stature, by Mr. Galton himself.

It is to be observed that numerical data, of the kind here indicated, contain all the information necessary for a knowledge of the direction and rate of evolution. Knowing that a given deviation from the mean character is associated with a greater or less percentage death-rate in the animals possessing it, the importance of such a deviation can be estimated without the necessity of inquiring how that increase or decrease in the death-rate is brought about, so that all ideas of "functional adaptation" become unnecessary. In the same way, a theory of the mechanism of heredity is not necessary in order to measure the abnormality of offspring associated with a given parental abnormality. The importance of such numerical statements, by which the current theories of adaptation, &c., may be tested, is strongly urged.

3. The report itself describes an attempt to furnish some of the numerical data referred to for two dimensions of the shore crab. The data collected give an approximation to the law of frequency with which deviations from the average character occur at various ages. The conclusions drawn are (*a*) that there is a period of growth during which the frequency of deviations increases, illustrating Darwin's statement that variations frequently appear late in life; (*b*) that in one case the preliminary increase is followed by a decrease in the frequency of deviations of given magnitude, in the other case it is not; and that (*c*), assuming a particular law of growth (which

remains, as is admitted, to be experimentally tested), the observed phenomena imply a selective destruction in the one case, and not in the other.

It is not contended that the law of frequency at various ages, adopted in the report, is exact. It is, however, hoped that the approximation is sufficiently exact to give numerical estimates of the quantities measured, which are at least of the same order as the quantities themselves, and for this reason it is hoped that the method adopted may prove useful in other cases.

III. "The Effect of Environment on the Development of Echinoderm Larvæ: an Experimental Inquiry into the Causes of Variation." By H. M. VERNON, B.A. Communicated by Professor J. BURDON SANDERSON, F.R.S. Received December 10, 1894.

(From the Zoological Station, Naples.)

(Abstract.)

The conditions of environment under which an organism develops are known to be of considerable influence in the production of variations. It was thought to be of interest to determine by exact measurement the effects which such slight changes in the environmental conditions as might occur naturally would produce in the growth of some organisms. The animal chosen was the larva or pluteus of the sea-urchin *Strongylocentrotus lividus*. These larvæ develop readily from artificial fertilisations, and they can, moreover, be obtained at all times of the year, irrespective of season. The method adopted was to shake pieces of the ovaries and testes of several sea-urchins in small jars of water, and then mix the two liquids. After standing for an hour, portions of the water containing the impregnated ova were poured into jars holding 2 to $3\frac{1}{2}$ litres of sea water, and these were transferred to a large tank of running sea water. The larvæ were generally allowed to develop for eight days, as the aboral and oral arms reach their maximum length in this time. The larvæ were killed by the addition of corrosive sublimate to the water, and were then, after washing in distilled water, preserved in 70 per cent. alcohol. They were mounted in glycerine and measured under the microscope, the body-length, the aboral arm-length, and the oral arm-length being in each case measured. The larvæ were measured in sets of fifties, and the means taken. The aboral and oral arm-lengths were calculated as percentages on the body-length. In all 10,000 larvæ were measured.

The effects of temperature on development were first studied. It