

field. Precisely how much higher, the opponents of spontaneous generation leave an open question, and increase the demand with every failure of a supposed killing heat to prevent the development of life. A series of experiments made by Bastian some years ago, and never in any way invalidated by conflicting experiments, would seem, however, to have placed this question beyond further dispute, though his opponents are very apt to quietly ignore them. His method was briefly this: to take a test-fluid which never engendered life except when purposely inoculated with multiplying bacteria, and never failed to produce life when so inoculated; then after mixing the test-fluid with a bacteria-bearing liquid, heat the mixture after perfect isolation, and await the result. If life appeared, the heating was assumed to be insufficient to kill all the life introduced; if no life appeared, after repeated trials, the temperature was considered fatal. The heat which produced sterility in different fluids varied between 130° and 158° Fah., and the latter was found to be the maximum temperature which a growing and multiplying swarm of bacteria,—in all stages of growth and presumably including the hypothetical germs, if such there be,—could survive. When, therefore, this experimenter found other fluids (capable of spontaneous putrefaction in the open air) to swarm with bacteria after having been subjected to a temperature of 212° Fah. for hours, and thoroughly isolated from any possible contact with germ-bearing air, he claimed to be justified in the conclusion that there had been in such fluids a real origination of life not derived from antecedent life.

A great variety of animal and vegetable infusions, and some purely inorganic solutions have been used in such experiments, with varying results. While it has been found to be impossible to predict the behavior of any particular fluid from its composition, it appears from many observations that neutral or faintly alkaline fluids are more likely to putrify, after boiling and sealing, than acid infusions. Excess of alkali, however, prevents the development of life as well as an excess of acid; and some infusions are found to be almost always sterile unless exactly neutralized; yet positive results have been obtained in many instances, Bastian claims, with both acid and alkaline fluids. The fluids which he found to be most commonly successful were infusions of turnip and hay; the former fortified with a little cheese dust being almost certain to develop life.

It was with infusions of this character that the sceptical Dr. Burden-Sanderson tested Dr. Bastian's conclusions by a series of experimental tests made under his opponent's personal supervision; and failing to detect any flaw in the process, he frankly and publicly admitted that he had been mistaken in his previous doubts. The same experiments were thereupon repeated, and their results verified by Professor Huitzinga, of the University of Groningen, who afterwards made a series of fresh trials, using a mixture of grape sugar and soluble salts instead of the turnip infusion, and substituting soluble peptone for the cheese dust. In every instance, he declares, bacteria appeared when the ingredients were used in certain specified proportions. By altering the proportions of the ingredients he was able to keep his solutions sterile, although in other respects they were treated exactly as before; and he relied on this differential process to prove that any pre-existing germs in the liquid were destroyed and perfect isolation obtained, for the altered fluids were found capable of developing bacteria if once inoculated. Thus having two fluids, each capable of supporting bacteria, both were subjected to the same process of boiling and sealing. After repeated trials, in which one solution invariably swarmed with bacteria and the other as invariably remained clear, it was inferred that all germs had been destroyed by the heat and subsequently kept out by perfect sealing; and that the life developed in the one was due wholly to its proper chemical composition.

The only reply that the opponents of spontaneous generation can make to tests like these is that, in all cases where life appears, there has been either an insufficient exclusion of germs, or else that, owing to the composition of the solution, the contained germs were somehow protected and enabled to withstand a temperature which was fatal to those in the other solutions. Thus there always remains a possibility of doubt, and the result is disputed. A pretty illustration of the almost hopeless struggle which the spontaneous generationists have to wage with persistent doubt is seen in the last controversy between Bastian and Pasteur.

For a number of years Pasteur has held, in spite of Bastian's experiments in regard to the death-point of bacteria, that bacteria germs are not killed in acid fluids below the boiling-point of water, while in neutral or faintly alkaline fluids they are able to survive a somewhat higher temperature. In any case, however, he admits that a temperature of 110° C. is fatal; consequently no life can appear in fluids so heated and kept perfectly isolated. A short time ago, Bastian devised the following test of the alleged protective influence of alkalinity. He placed in a retort a measured quantity of urine of ascertained acidity; also in a small tube a quantity of liquor potassæ, somewhat less than enough to neutralize the urine—his experiments proving that a larger quantity was likely to overdo the matter. He then sealed the potash tube in a blow pipe flame, drawing out the sealed end so that it would break easily, and boiled the inclosed liquor potassæ to kill any possible germs it might contain. Then he placed the tube in the retort with the urine, which was boiled and hermetically sealed in the usual way.

The question to be decided was this: Acid urine does not putrefy (that is, develop bacteria) after boiling; alkaline

urine sometimes does—the difference being attributed by Pasteur and his school to the protective action of the alkali. Now, if acid urine after boiling (by which process its inclosed germs are admitted to be destroyed) be neutralized by a liquor also made sterile by prolonged boiling, it ought not to develop life; if it does, the result cannot be due to any protective action of the alkali, which is not added until after the germs are killed.

After cooling, retorts as above described were shaken so as to break off the fragile end of the inclosed potash tube and allow the contained fluid to mix with and neutralize the boiled urine; then they were placed in an incubating bath kept at a temperature about 122° Fah., together with other retorts similarly treated, except that the potash tubes were not broken. After a day or two, the neutralized urine invariably putrefied, while the acid urine in the control flasks remained permanently barren. Having thus shown that the effect was the same, whether the acidity of the urine was reduced after or before boiling, Bastian insisted that the influence of the potash was not due to its alleged power of protecting the germs so as to enable them to bear a higher temperature, but to some vivifying chemical or molecular action, and claimed a victory for spontaneous generation.

Pasteur repeated the experiment with a like result, but was not satisfied; so he tried again, substituting solid potash for the liquor potassæ, and the result was negative; to which Bastian replied that the potash had been used in excess. Pasteur retorted with a charge of insufficient heating of the potash in Bastian's experiments, and challenged him to repeat the experiment with the single variation that the potash tube should be heated either for twenty minutes at 110° C., or for five minutes at 130° C.

Bastian did so, and more: he kept the potash tubes at the required temperature for twenty hours, and obtained life as before. To this Pasteur's only reply was a vehement protest that the alleged result was impossible.

The English opponents of spontaneous generation have more wisely endeavored to prove the impossibility of such a result by critical experimentation. Among these, Dr. Roberts, of Manchester, and Professor Tyndall, both claim to have repeated the experiments over and over again, and always without obtaining life. This is not the first time that Dr. Bastian's assertions have been flatly contradicted; and he knows from experience what it is to have his opponents afterwards admit, in the face of experimental evidence, that he was right and they were wrong. The issue has been so narrowed now that it ought not to be impossible for the opposing parties to agree to undertake together a series of crucial experiments. By mutual suggestion, skill, and watchfulness, the common charge of inexactness in manipulation, or prejudice in the interpretation of results, ought easily to be prevented, and the issue fairly and squarely met. Isolated partisan work, however skillful, will not force a conclusion nearly so quickly or satisfactorily as united effort; and to that test we hope, for the credit of science, the question will be speedily submitted.

THE PHYSICAL CHARACTERISTICS OF AMERICAN CHILDREN.

Some months ago we renewed the data relative to the height and weight of Americans, drawn from the records of the Provost Marshal General's Bureau, made during the late war. The conclusions reached were that, in point of stature, even the lowest mean obtained would entitle the American people to the first rank among nations. The results of measurements of nearly a million and a half of American born white men exhibited a mean stature of 67.646 inches. In the matter of weight it further appeared that Brother Jonathan is as heavy as the heaviest even in his youth: and the apparent slimness of his immaturity, due to his superior height, is fairly made up by the time he reaches his full development.

The above important series of investigations on the physical characteristics of Americans, has recently been supplemented by researches made by Dr. H. P. Bowditch, of Boston, Mass., in which the object of inquiry has been the growth of children. Both sexes are included, so that a direct comparison is instituted between them. About 24,500 observations were made upon the pupils of the schools in Boston and vicinity. These were tabulated according to nationality, etc., and from these tables graphic diagrams were constructed, exhibiting with great clearness the results obtained. Both tables and diagrams, together with Dr. Bowditch's report, are before us, in the recently issued Eighth Annual Report of the State Board of Health of Massachusetts. From the data obtained relative to the comparative rate of growth of the sexes, it appears that the greatest annual increase in height occurs for girls at 12 and for boys at 16 years of age, while the maximum increase in weight is, for boys at the same age, and for girls one year later than the maximum increase in height. In other words, at about the ages of 13 and 14 years girls are (during more than two years) both taller and heavier than boys at the same age, though before and after that period the reverse is the case. Dr. Bowditch points out, that on the principle enunciated by Carpenter and Herbert Spencer, that growth and reproduction are to some extent antagonistic properties, it may reasonably be supposed that at the age at which the organism becomes potentially reproductive, a period of excessive growth will not occur; and the data above noted seem to show that this is the case.

From the tables exhibiting effect of race on size and rate of growth, it appears that, almost without exception, Amer-

ican children are both taller and heavier than children of the same age and sex whose parents are of other nationalities. One of the most curious facts brought out by Dr. Baxter in the investigations referred to in our initial paragraph, was that natives of foreign countries enlisting in the United States, possessed a greater average height than natives of the same countries enlisting at home. Dr. Baxter explained this circumstance by a difference in the average age of the individuals mentioned, but Dr. Gould, through other statistical investigations, has shown that, even making allowance for this difference of age, the same result holds true. Now, Dr. Bowditch presents the opinion that the superiority of stature is owing to the greater average comfort of the people of this country, as compared to that of inhabitants of European States, and the observations of Quetelet, Villerme, and Cowell, which are referred to, seem further to show that in a given community the children of the wealthier classes are, as a rule, larger than those of the poorer classes.

But it is evident that an important question is, whether similar conclusions to those reached by Drs. Baxter and Gould for adults are applicable to growing children, and in order to eliminate the possible effect which comfort or misery may have on the rate of growth, it is necessary to select for comparison, sets of observations made upon children belonging to corresponding classes in the communities in which they live. To this end, the pupils of certain select schools in Boston were compared with those belonging to non-laboring classes attending English public schools and universities; and the two sets of figures show the marked superiority of the American boy, both in size and weight. Hence the superior size of American children may be taken as due partly to the greater comfort surrounding them, and partly to difference of race and stock.

One of the most interesting portions of the entire investigation is that which deals with the relation of height to weight in growing children of both sexes and of various races. Growing boys are heavier in proportion to their height than growing girls, until the height of 58 inches is reached. Above that point the reverse is the case. The difference between children of American and those of foreign parents is constant in one direction for all ages. Boys of German parentage, who are uniformly heavier in proportion to their height than American boys, form the exception to the rule. The deprivation of the comforts of life, curiously enough, exercises a greater tendency to diminish the stature than the weight of the growing child. And finally Dr. Baxter's conclusion "that the mean weight of the white native of the United States is not disproportionate to his stature," is, as far as boys are concerned, as applicable to growing children as to adults.

Dr. Bowditch appends to his report reference to the formulæ determined by Professor Lanza; and based on the observations of President Runkle, of the Massachusetts Institute of Technology, expressing the relation between the weight and height of growing children from five to eighteen years of age. In the case of boys ranging in height from 42 to 66 inches inclusive, the formula is $y=0.002428 x^{2.11}$; and in that of girls ranging in height from 42 to 61 inches inclusive, the expression is $y=0.001277 x^{2.15}$, y representing the weight in pounds, and x the height in inches, in both cases. These formulæ are quite accurate, as the greatest difference between calculated and observed values is, in the case of boys, 0.65 lbs., and in that of girls, 1.41 lbs., with one exception, where it is 3.01 lbs.

Dr. Bowditch's investigations are replete with suggestions for future statistical research, the results of which can scarcely fail to be of the highest value to the community. To those who may undertake the necessary inquiries, the following subjects are commended. Drs. Gould and Baxter having shown that the size of adult Americans is very different in different States of the Union, and even in different parts of the same State, it would be interesting to determine, by observations of children, how early in life this difference becomes apparent; in general, what is the influence of geographical and climatic conditions of growing children? What number of generations is necessary for the complete development of the influence of changed climatic conditions on the rate of growth of a given race? This examination might be conducted on emigrants and their descendants, coming from some limited region of the old world. What effect (if any) does the season of the year have on rate of growth? And what is the comparative effect of city and of country life on the same? What is the relation between diseases and the rate of growth? Dr. Bowditch suggests that it would be especially interesting "to inquire whether in the rapid growth, which is said to follow certain diseases, especially fevers, the height and weight increase in normal ratio: whether this accelerated growth after the disease is simply a compensation for a retardation during the disease; whether abnormally rapid growth causes a predisposition to disease, and whether any connection can be traced between the rate of growth and the frequency with which certain diseases of growing children (*e. g.*, chorea) occur at different ages." Finally, by systematic comparative study of the physique of the growing population in different localities, the effect of local hygienic conditions might be determined.

IN OUR SUPPLEMENT of this week particulars and engravings are given of a remarkably powerful and fast little steam launch designed by H. S. Maxim. Boiler 26 inches length, 20 inches diameter. Test pressure, 450 lbs. per inch. Length of boat, 21 feet. Speed, 10 miles per hour.