have escaped an early death from tuberculosis, what procedure is indicated?

We can not always take refuge from the consequences of inaction under the plea of ignorance. There are few, if any, instances where public hygiene is utilizing to the full the knowledge that it might possess. Some responsibility rests upon those who are prosecuting bacteriological studies to see that the bearings of their investigations are not overlooked or neglected by those who are constituted the guardians of the public health. There is here no question of the sordid self-interest or commercial exploitation sometimes miscalled 'practical application.' In the long run the saving of life may play into the hands of the idealist. If John Keats had not died of consumption at the age of twenty-five the modern world would be a different place for many persons. It is not possible to estimate the loss to literature, science and art since the dawn of intellectual life which must be laid at the door of the infectious diseases. The relations of bacteriology to public hygiene, if properly appreciated and cultivated, will lead to an improvement in the conditions of life which will enhance both the ideal and material welfare of the race and will give greater assurance that each man shall complete his span of life and be able to do the work that is in him.

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Evolution of Weevil-Resistance in Cotton.

The complexity of biological problems finds another excellent illustration in the evolutionary history of the relations between the cotton plant and the so-called Mexican boll-weevil. The present indications are that both the cotton and the weevil originated in Central America. The parasitism of the beetle is certainly very ancient, if, as seems to be the case, it has no other breeding-place than the young buds and fruits of the cotton plant. Of the severity of the parasitism there is ample evidence in Texas, the weevils being able to totally destroy the crop when the climatic conditions admit of their normal increase.

It was to have been expected, therefore, that in humid tropical localities where all seasons of the year are alike favorable the cotton would have been exterminated long since, or at least that its cultivation as a field crop would be utterly impracticable unless there were means of protection against the ravages of the insect. A definite intimation of the existence of protective adaptations was incidentally gained in eastern Guatemala in 1902 when no weevils were found in a field of the dwarf cotton cultivated by the Indians, although they were extremely abundant on a perennial 'tree' cotton a short distance away. The opportunity of making a detailed study of the subject during the second quarter of the present year has revealed an interesting series of protective adaptations resulting from the long evolutionary struggle for existence between the cotton and the weevil.

Reference has been made in another place* to the extensive system of extra-floral nectaries by which the cotton of eastern Guatemala has secured the active cooperation of the kelep or weevil-eating ant, but the Central American cottons and the Indians who have been cultivating them for thousands of years have developed many other expedients of structure, habits and culture which are of more or less assistance in resisting or avoiding the weevil.

The large leafy involucre of the cotton may have been at first a protective adaptation, though the weevils later learned to enter it easily. In some of the Guatemalan sorts the bracts are grown together at the base as though the evolution of a closed

* Report No. 78, U. S. Dept. Agric., p. 4, 1904.

involucre had begun. The hairy stems assist the ants in climbing, but impede the weevils, and thus increase the chances of capture. Prompt flowering and determinate growth enable an annual variety to ripen more seed. A perennial kidney cotton also escapes extinction by producing nearly all its blossoms at one season. In the central plateau region of Salama and Rabinal another perennial variety is cut back annually to the ground. New shoots spring up and the new crop is set within a short time, while the plants are still small enough to be cared for by the chickens and turkeys.

Another of these protective adaptations proves to be of such potential significance as to call for announcement in advance of a detailed report. The issue is nothing less than that the cotton plant; in some of its varieties, has finally developed a practical means of resisting and destroying the weevil larvæ. The process is in the nature of a varietal characteristic subject to increase by selection. The efficiency of the adaptation is such that a variety in which it appeared uniformly would afford no opportunity for the weevil to breed, and would thus be a means of exterminating it.

The facts are simple and have been thoroughly established during the department's entomological studies of the weevil for the past decade, but they have not been interpreted as a protective adaptation, nor as a character subject to further selective development. Messrs. Hunter and Hinds have reported* that in some instances as high as 41 per cent. of the boll-weevil larvæ fail to develop, as a result of what they have termed a 'gelatinization' of the tissues of the young bud or 'square.'

In the later stages the injured buds often appear as though filled with a structureless exudation, and it was not unnaturally supposed that the abnormality was the result of some disturbance of nutrition, or of bacterial infection. The material failed, however, to yield cultures of bacteria or to respond to experiments with fertilizers. The opportunity of examining the earlier stages of the phenomenon show that the conditions are far less abnormal than have been supposed, and that the 'gelatinization' is simply the result of very active growth or proliferation of the loose tissue of the tube or column, which in the flowers of the mallow family surrounds the style and bears the stamens.

The usual program would be for the young squares to fall to the ground when the larva has hatched and begun to eat out the pollen of the young bud. Proliferation involves the opposite procedure. Instead of ceasing to develop, the soft tissues of the staminal tube are stimulated in a manner analogous to that by which galls and other vegetable excrescences are formed. The cavity eaten out by the larva is filled and the little miscreant is either smothered in paste or, more likely, starved by the watery tissue which is certainly no equivalent for the highly organized protoplasm of the pollen, the normal infant-food of the young larva. But whatever may be the actual cause of death the practical fact is that the larva is killed, and apparently in every instance in which proliferation occurs.* A very little of the new tissue may be effective. When the cavity eaten out by the larva is small it is often neatly plugged by the new growth, and the flower may develop with no very great distortion, though the corolla generally shrivels up before reaching more than half the normal length. The young boll is not always

* Bull. 45, Bureau of Entomology, U. S. Dept. Agriculture, p. 96, 1904.

* In a few cases living weevil larvæ were found in squares which gave evidence of gelatinization, but there was always a second puncture from the outside, indicating that another egg had been deposited.

blasted, though it is often small and irregular in shape, perhaps as a result of deficient pollination. The stigma sometimes projects from the injured flower and might be fertilized normally, but in other instances the withered staminal tube and corolla remain closely wrapped about it, so that pollen could scarcely have entered. It would not be surprising if the more rapid and persistent growth which favors the new protective tissue were also accompanied by a tendency toward parthenogenesis. Or it may be that the irritation resulting from the presence of the larva stimulates the ovary as well. Moreover, proliferation is not confined to the bud; the same or a closely similar formation of tissue sometimes appears in the bolls, when these have been attacked by the weevils.

It is thus not merely a coincidence that the proliferation is most frequent in the quick-growing early varieties of cotton which are now prized in Texas as the best means of securing a crop. The weevil has conducted, as it were, a selection for rapidity of growth and early fruiting, and a further accentuation of vegetative energy has introduced the new protective habit. The destructive insect has, in effect, overreached itself, and induced a condition which with man's assistance may accomplish its own destruction.

It is not easy to conjecture any means by which the weevil could survive the general planting of a variety of cotton having proliferation as a constant character. If only the squares would 'gelatinize' the weevil might develop an instinct of postponing the egg-laying period until the young bolls could develop. The advantage might be partly temporary, though it would take many years for the weevil to meet the new demand, and it could never reach its present destructiveness because the delay of the breeding season, even for a week or two, would be an effective handicap, particularly if the weevils should continue to waste most of their ammunition on the squares, as they probably would.

How long it will take to secure a completely resistant cotton by selection can only be conjectured, since it is not known as yet how constant a character proliferation is in the plants which possess it. To lose no unnecessary time is, of course, of the greatest practical importance, not only for the industry at large but especially for the sake of the growers of the long staple cotton in South Carolina and Georgia. The longer season required by the Sea Island cotton will render entirely ineffective the cultural expedients by which a part of the crop of the upland varieties can be saved from the weevil; if the insect be permitted to reach the Atlantic coast Sea Island cotton will soon become an agricultural tradition.

This change of view regarding the nature of 'gelatinization' greatly alters the prospect of finding in tropical America a variety of cotton resistant to the weevil, a hope which seemed to be lessened by the discovery of the kelep or Guatemalan cotton-protecting ant. It is by no means impossible that varieties already exist in which proliferation has become a fixed character, and if not it will still be highly desirable to secure those in which the tendency is most strongly pronounced. In the ant-protected variety of eastern Guatemala, proliferation takes place very frequently, at least in the bolls, and the plant has other desirable features of quick, determinate growth and early bearing which may make it of value in Texas. It has the good qualities of King and other related varieties in accentuated form, though with a longer staple.

The dwarf Guatemalan cotton represents, as it were, the highest known development of the upland type. Even the annual character which has been looked

upon as a result of cultivation in temperate climates is a further instance of protective adaptation long ago secured in the tropics by the unconscious selection of the Indians. It was from the Central American region, evidently, that the other upland types came, but they represent an earlier stage of development, or have deteriorated because selection for resistant qualities has been relaxed in regions where the weevil was absent, as in our southern states. Other things being equal, the Indians would undoubtedly prefer the perennial 'tree' cottons, which continue to be cultivated in Mexico and Peru in localities so arid as to exclude the weevils, though it is not certain that they exist in Peru. Possibly there has never been a connected series of agricultural communities along which the weevil could follow into South America; the pest might never have reached the United States if cotton culture had not been extended into southern Texas.

But even if the varieties already known in Texas were to be utilized as the basis of selection, it is by no means beyond the limits of probability that a resistant, regularly proliferating variety could be secured within a decade, or even within five years, since cotton has been found to respond rather promptly to selective influence. The urgency of the matter would certainly justify an extensive campaign of selection, the problem being to find among the millions of plants which will be grown next season, some which possess in the highest degree the tendency to proliferation, and to secure seeds from them. The task, however, is peculiar, and more difficult than such experiments usually are, because there is little or nothing in the way of an external clue to the desired character. It may be necessary to cut open each infested square in succession to make sure that the plant is allowing no weevil larvæ to develop. And after the most promising plants have been located it may be possible to obtain seed from them only by artificially protecting them from the weevils. Otherwise the best stock might be lost if the weevils were very abundant. Indeed, this suggests a reason why 'gelatinization' has not become a fixed character already. Selection thus far has only been in the direction of proliferation in the bolls, since the proliferation of tissue in the buds would give a particular plant no advantage over its neighbors in the matter of seed production. It would enjoy no immunity from subsequent attack because it had not allowed any weevils to reach maturity. Weevils from other plants would continue to come to it, and the chances of ripening seeds would not be increased. There has been, in other words, no selective inducement for 'gelatinized' buds to become a uniform character except as they might be correlated with 'gelatinized' bolls, in spite of the fact that for killing the weevil proliferation in the buds is more important than that in the bolls.

These considerations reveal still another episode of evolutionary history, and may explain why it is that the variety protected by the ants, and the other 'upland' types which have originated in the same region, have the additional protective adaptations. It was only where the ants protected the cotton and thus perpetuated it as a field crop that these other considerations could have a cumulative effect. The other adaptations by which the tree cottons have maintained a desultory existence are of suggestive interest, but of apparently little practical importance, since no field culture of a perennial cotton seems to be maintained in any weevil-infested district.

In eastern Guatemala the cultivation of cotton as a field crop is strictly limited to localities suited to the ants, where they exist in such numbers as to give practical

protection. In Texas, however, cotton is grown under a great variety of conditions. The climatic vicissitudes of heat and cold, drought and flood are many times as great as in Guatemala, so that notwithstanding the unexpectedly great adaptability of the kelep it can not be expected to thrive equally well in all parts of the state, any more than does the weevil. Even if it be found that the ants can thrive, breed and establish new colonies in Texas, they will probably require many years to take full and effective possession even of the more favorable localities of this vast agricultural empire. Such a mitigation of the weevil's injuries would be, of course, of great practical value, and the work of the ants in destroying the larvæ of boll worms and leaf-worms might be only slightly less important in some districts. If, however, the hope of exterminating the weevil is to be cherished, or that of staying its ravages before it has laid the entire cotton industry of the South under tribute, there would seem at present to be no other alternative than to secure by discovery or development, within the next few years, a variety of cotton in which the larvæ of the boll weevil can not mature.

The present brief outline of the results of our study of cotton in Guatemala may be summarized by saying that the tendency to rapid growth and early fruiting, the large extrafloral nectaries which attract the ants, and the proliferation of the tissues of the young buds and bolls which kills the weevil larvæ, are protective adaptations, developed as a result of long contact between the cotton plant and the boll-weevil. The proliferation is not a mere pathological abnormality, but represents a definite evolutionary tendency, capable of further increase by selection. If this interpretation of the facts be correct it affords an intimation of a successful solution of the weevil problem by means of a resistant variety of cotton.

O. F. Cook.

Washington, November 4, 1904.

SCIENTIFIC BOOKS.

Dr. J. Frick's Physikalische Technik oder Anleitung zu Experimentalvortragen sowie zur Selbstherstellung einfacher Demonstrationsapparate. Siebente vollkommen umgearbeitete und stark vermehrte Auflage von Dr. Otto Lehmann. Friedrich Vieweg und Sohn. 1904. Pp. xxiii + 630.

The previous edition of this well-known standard work appeared in 1890–5 and consisted of two volumes, one of 725 pages, the other of 1,054. It is most interesting to note that there exists such a demand for a book of this character as to encourage the publishers to undertake the present seventh edition on such an enormous scale. This is to consist of two volumes; and of these the first part of the first volume only has so far appeared, having been published during the past summer. This is a volume of 630 pages and is illustrated with over 2,000 cuts. The scope of the present work as compared with previous editions may be estimated when it is noted that the subject matter contained in the volume under review had devoted to it in the last edition only 132 pages and 65 cuts.

As the title of the work indicates, it has a twofold object: one to suggest suitable experiments for class demonstrations, the other to give accurate instruction in the use of instruments, tools and technical methods. The subtitle of the first part of the first volume is 'The Rooms of a Physical Laboratory and their Equipment, together with an Introduction to the Use of the Latter.' There are five chapters: (1) 'Physical Demonstrations and the Laboratory Building'; (2) 'The Large Lecture Room'; (3) 'The Preparation Room and the Smaller Lecture Room'; (4) 'The Rooms for Apparatus and Assistants'; (5) 'The Rooms for the Mechanician and Janitor.'

There are numerous subdivisions of the chapters and full information is given in regard to almost every conceivable detail.